EDITORIAL

Activities 2003-2004

The activities of the Nut Network have been affected by the assessment and evaluation phase of the European System of Cooperative Research Networks in Agriculture (ESCORENA). This system was established in 1974 by FAO and European research institutions, and currently consists of eleven active networks. Due to budgetary reductions, FAO is no longer in a position to provide the ESCORENA secretariat for servicing the Networks nor of supporting activities. Nonetheless, most of the planned activities under the FAO-CIHEAM Interregional Cooperative Research Network on Nuts could be implemented through the support provided by the FAO’s Regional Office for Europe and some FAO technical services (AGPS) and financial support provided by INIA of Spain, INRA of France and the co-sponsor and partner CIHEAM permits the most planned activities to be finally developed for example the publication of this Newsletter and the Inventory of Walnut Germplasm, Research and References. In addition, some researchers from developing or transition countries have been supported to participate in different meetings and congresses.

During 2003 and part of 2004 a number of other activities was implemented within the framework of the FAO-CIHEAM Interregional Cooperative Research Network on Nuts. In June 2003, the XIII GREMPA Almond and Pistachio Meeting was held in Mirandela, Tras os Montes, Portugal and the proceedings will be published in the Options Méditerranéennes Cahiers by November 2004. In June 2004, the VI
ISHS International Congress on Hazelnut was held in Tarragona, Spain and the proceedings will be published in Acta Horticulturae. During 2004 two more Symposia are planned: (i) the III ISHS International Symposium on Chestnut to be held in October in Portugal, Chaves, Vila Real; and (ii) the V ISHS International Walnut Symposium to be held in Sorrento, Italy in November.

The Network’s Coordinator participated in two Scientific Committee Meetings and the Convention of the International Tree Nut Council (INC) held in Berlin (Germany) and Las Vegas (USA) respectively. The importance of promoting the healthy component of nut consumption in the human diet through advertisement was stressed. This is considered essential for successful marketing and to sustain demand. Worldwide nut production is increasing over the years and its supply is taken by the also increasing world consumption. It seems that nut markets can be further developed. The INC expressed an interest to collaborate and work closely with the Nut Network. The issues of preventing and reducing kernel’s aflatoxin contamination through better crop preharvest and postharvest management is of paramount importance for the INC.

ESCORENA’s review
The ESCORENA networks can be classified into three groups according to the field of agricultural activity: crop production, animal production and environment. The 23rd Regional Conference for Europe (Nicosia, Cyprus, May 2002) recognized the importance of ESCORENA as the research networks brought added value not only to European scientists and their research institutions, but also to partners and beneficiaries beyond European borders. Furthermore, the Conference endorsed the recommendation of the 32nd Session of the European Commission on Agriculture (ECA) that an assessment and evaluation be undertaken for each network. During 2003, this assessment was carried out by M. Larbier, a visiting scientist seconded to FAO by INRA, and his report and proposals for the future were submitted to the 33rd Session of ECA held in Rome in March 2004. Our Research Network on Nuts was considered among those ten to be retained and for having good potential for continuity in the future. This conclusion was reached due to dynamic coordination, adaptation of research towards the aim of sustainable development, importance of the programme and quality of the scientific and technical communication means used.

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The Nut Network’s future
Nut tree production, trade and industry is an important economical activity related to sustainable agriculture, often in marginal lands, in both European and Near Eastern Regions. Nuts are of major importance and are typical components of the traditional and healthy Mediterranean diet. To accomplish sustainable development and food security, a future combined effort in R&D, environmental management and communication is needed.

Due to overall budgetary constraints, the Network on Nuts has in recent years, undergone a restructuring exercise which is now fully implemented. Thus, the Network has reorganized and simplified its structure and is trying to focus more on development oriented issues rather than its previous strong genetic resources collection, description and improvement. In addition, as a result of the assessment carried out in 2003 mentioned above, two working groups: Genetic Resources and Economics were suggested for elimination.

Considering the current and future relevance of the Network, it is generally seen by its members as a useful tool for better collaboration, and the opportunities to come together are viewed as very important for project development. Accordingly, recent Network developments are focused on research issues which are of priority importance for developing countries and for countries in transition, particularly in the Balkans, Caucasus and North Africa, but also beyond, wherever research results are relevant to stimulate growth and alleviate poverty and hunger. The relevance and potential usefulness of our Nut Network is based on the availability of considerable genetic resources and technical experience for the development of nut tree crops in Europe and the Near East regions. In addition, useful contributions to rural development and the global genetic resources understanding can be made. Major research areas of broad interest, which should be addressed are: food safety, biodiversity, biotechnology and sustainable management of natural resources, including low-input agriculture. To strengthen FAO’s support to our Network it is necessary to adopt a “project approach” of activities. This should be carried out in collaboration with relevant FAO Units.

Genetic resources inventories
Three Inventories on Germplasm, Research and References have been already published: Almond (1997, RTS 51), Hazelnut (2000, RTS 56) and Chestnut (2001, RTS 65). These inventories published in the REU Technical Series (http://www.fao.org/regional/europe/PUB), are important compilations of the currently available species genetic resources and information on ongoing research projects and bibliographies. In addition, more inventories are being compiled and are at different stages of completion. The Inventory on Walnut being compiled by E. Germain is to be published shortly and the Inventory on Pistachio is being collated by N. Kaska and B.E. Ak. All these catalogues are being supported by FAO’s Regional Office for Europe and the Seed and Plant Genetic Resources Service (AGPS) together with CIHEAM-IAMZ.

In addition, a draft Descriptors List for Hazelnut has been developed by members of the Network and has now been submitted to IPGRI for assessment and eventual editing and publication.

Changes in the FAO Regional Office for Europe
As mentioned above, Mr. Michel Larbier, a visiting scientist seconded from INRA, France, took the task to evaluate and suggest a proposal to re-organize ESCORENA. The efforts made by M. Larbier in reviewing the whole ESCORENA system are acknowledged. Ms. Jutta Krause, Regional Representative for Europe (FAO Regional Office for Europe in Rome) is the FAO contact person for ESCORENA.
The Nut Network on the web

In addition to the already existing information on the Nut Network at http://www.iamz.ciheam.org/ingles/nuts.htm, and on the previous FAO web page created in 2000, the FAO European System of Cooperative Research Networks in Agriculture (ESCORENA) and the Nut Network web page has now been closed due to lack of commitment from coordinators to make use of the interactive system for data entry and lack of resources from FAO to take over this role. However, essential information on network coordinators, major network publications (e.g. REU Technical Series), ESCORENA reports and links to existing network websites such as the nut network is included in the REU website (see http://www.fao.org/world/regional/REU/content/escorenana/index_en.htm).

NUCIS on the web

A short version of the Newsletter (editorial, contents and back page) from issue number 6 and onwards, is available on the Internet web pages of both FAO (http://www.fao.org/regional/europe/public-e/nucis.htm) and CIHEAM (http://www.iamz.ciheam.org/ingles/nuts.htm#publisher). A full electronic version of NUCIS is available from issue number 9 and onwards (http://www.iamz.ciheam.org/ingles/nucis9.pdf). The contents of this Newsletter can be browsed through and also copied and printed.

Contributions to NUCIS

As in past NUCIS editorials, it is again stressed that this Newsletter must be an effective vehicle of communication for all the Network members. The pages of this bulletin are open to all readers who would like to suggest ideas or to express their opinion about the work developed by the Network (activities carried out and planned) or to publish short articles and reports on relevant horticultural subjects of general interest. A sufficient number of contributions are received from the Mediterranean Basin and overseas for the articles and reports section. However, the sections on news and notes and also on congresses and meetings are usually difficult to cover due to the scarce information received and thus, contributions are most welcomed. Otherwise, the Editor has to report on the issues he is aware of, but certainly there must be many more issues on-going throughout the year which merit reporting. Also, the place for ‘grey’ bibliography (references and documents which are difficult to search like Masters or Ph. Theses) is scarcely filled.

The NUCIS Newsletter is distributed worldwide free of charge to 1,400 readers from over 60 countries. The dissemination of information originated by the Network is of paramount importance and through this bulletin has been largely successful. The first NUCIS was published in 1993, this issue of the NUCIS Newsletter is number 12 and during these eleven years great editing effort has been made. I acknowledge and gratefully thank all contributors for their efforts and interest to produce and send me valuable information. The exchange of information between Network members through the pages of this Newsletter is the basis for developing collaboration. The editing task in the even NUCIS issues already published has been huge (NUCIS 1, 9 pages; 2, 20 pages; 3, 24 pages; 4, 28 pages; 5, 36 pages; 6, 52 pages, 7, 44 pages, 8, 46 pages 9, 68 pages, 10, 48 pages, 11, 48 pages and 12, 52 pages). In order to reduce the time consuming formal editing contributors who send articles, news, notes, bibliographic references, etc. to the different sections are asked to provide them well organized and elaborated. Information should be sent in satisfactory English. Contributions could be sent through Internet using the Editor’s email. The alternative is to provide them on diskette and also in printed format. This bulletin is reproduced in black and white only, including pictures. Please send your contributions for the next issue, number 13 by the end of October 2005; however it cannot be guaranteed that the article will be published due to the uncertainty of funding. We apologize to readers for the delay in printing this issue due to late funding. We thank all who have contributed to this issue.

The Editor

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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Contributions should be written concisely in English. Please send contributions on paper and diskette (Microsoft® Word or Word Perfect®). Authors are responsible for the content of their papers. Reproduction of the articles is authorized, provided that the original source is clearly stated.
ARTICLES AND REPORTS

CONSUMERS’ ACCEPTANCE OF INDUSTRIAL PRODUCTS MADE WITH HAZELNUTS AND ALMONDS

INTRODUCTION
Hazelnuts and almonds are used to make industrial products like snacks, turrons, marzipan or chocolates. Although there is wide information about their chemical composition and the influence of many processes on the products’ final characteristics, there is a lack of information about consumers’ acceptance of these types of products when hazelnut and almond varieties change.

For these reasons IRTA started in 1999 a research programme in order to analyze the importance of selecting different nut varieties to make different industrial products, as a consequence of consumers’ acceptance. This information could be relevant not only to producers but also for the confectionery industry. Results for different nut products have been published in several scientific reports (see references). An overall analysis of hazelnut and almond commodities is made in this article. Variety is used as synonym of cultivar.

METHODOLOGY

Chocolates and bonbons were made in collaboration with the industry “L’Art de la Xocolata” (El Vendrell, Tarragona), while marzipan and turrons were made in the industry “Turrons i Mel Alemany SL” (Os de Balaguer, Lleida). Hazelnut and almond samples came from IRTA’s collections, while ‘Tomboul’ hazelnuts and ‘Nonpareil’ almonds were purchased on the market.

Each commodity was assessed for industrial facility, final quality and consumers’ acceptance. Commodity acceptance was evaluated using the consumers panel from IRTA (table 1), including over 670 people (almost 300 families), and distributed all around Catalonia (Spanish NE).

Consumer’s answers were weighted by age and education level in order to extrapolate conclusions to Catalonian people.

MAIN RESULTS
Results show that there are statistical differences in variety acceptance, depending on the industrial product studied. Sometimes these differences can be solved changing the technological process, although this has been observed for roasted hazelnuts and not for other products.

For example, dark chocolate (Figure 1) was the most accepted, mainly for ‘Pauetet’ hazelnut variety and for ‘Masbovera’ almond variety. ‘Negret’ and ‘Tomboul’ hazelnuts and ‘Desmayo Largueta’ and ‘Francolí’ almonds showed a very good technological behaviour to make bonbons (figure 2). ‘Marcona’ almonds were the best accepted to make marzipan (Figure 3) and hard turron (Figure 4), while ‘Negret’ variety was the most accepted for hard turron made with hazelnuts. Finally, soft turrons (Figure 5) were most accepted when they were made with ‘Marcona’ or ‘Desmayo Largueta’ almond varieties.

The overall analysis of the results also shows that sensorial characteristics from hazelnuts and almonds must be considered to make an industrial product. In most of them, sensorial profile from roasted nuts should be known while in a few of them the most important is the profile from raw nuts. Even though, when a product includes sugar in its recipe the differences in taste are not relevant enough, but it is still important that nut taste can be identified.

Table 1.- Consumers distribution by sex, age, education level and city size in both the IRTA panel and the Catalanian people.

<table>
<thead>
<tr>
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<th>IRTA’s panel</th>
<th>Catalonia</th>
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<tbody>
<tr>
<td><strong>Sex:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>49.7</td>
<td>48.8</td>
</tr>
<tr>
<td>Women</td>
<td>50.3</td>
<td>51.2</td>
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<tr>
<td><strong>Age:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 30 years old</td>
<td>23.5</td>
<td>36.7</td>
</tr>
<tr>
<td>30 to 65 years</td>
<td>68.6</td>
<td>46.1</td>
</tr>
<tr>
<td>&gt; 65 years old</td>
<td>7.9</td>
<td>17.2</td>
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<tr>
<td><strong>City habitants:</strong></td>
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<td></td>
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<tr>
<td>&lt; 30.000</td>
<td>40.4</td>
<td>43.6</td>
</tr>
<tr>
<td>&gt; 30.000</td>
<td>59.6</td>
<td>56.4</td>
</tr>
<tr>
<td><strong>Education level:</strong></td>
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<tr>
<td>Basic</td>
<td>34.9</td>
<td>69.3</td>
</tr>
<tr>
<td>Middle</td>
<td>22.9</td>
<td>20.7</td>
</tr>
<tr>
<td>High</td>
<td>42.2</td>
<td>10.0</td>
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</table>
Raw hazelnuts and almonds homogeneity is very important. Even though, this point should be studied in more detail for such kind of products where nuts are grounded, not roasted or sugar enriched. Main defects to be considered in raw nut bulks are rancidity, bitterness or burnt kernels. Some hazelnut and almond varieties seem to show serious difficulties to be adapted to some industrial processes, due to a very high fragility or strength, an excess of splits generation, an inadequate surface to volume ratio, bad roasting aptitude, etc.

Finally, both hazelnuts and almonds seem to show the same acceptance at consumers level for those particular products studied. This could confirm that they can substitute each other depending on the marked price, as it is usually assumed. However, it should be further confirmed for other products.

ACKNOWLEDGMENTS
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REFERENCES

DIFFERENTIAL FLOWERS AND FRUIT DAMAGES BY SPRING FROSTS IN ALMOND

INTRODUCTION
Flowers and young fruits of almost all deciduous tree varieties are vulnerable to frost damage (Andrews et al., 1983). Consequently spring frost injury is a major limiting factor in the production and the distribution of horticultural crops (Ashworth, 1992). The anatomical, physiological and biological aspects of this damage have been reviewed in fruit trees (Rodrigo, 2000). In Prunus, fruit damage is detectable by observing ovule browning, ice formation (Saunier, 1960), and browning of the petals and pistils.

Almond (Prunus amygdalus, Batsch) is an early blooming species. As a result, almond cultivation was restricted to regions with low risk of spring frosts. However, the expansion of the culture into inland Mediterranean areas, where the occurrence of spring frost is common and overlapping with bloom of most almond cultivars, increased the risk of reducing or even nullifying yield (Socias i Company et al., 1999). Thus, almond breeding aimed to create and select late blooming cultivars (Kester and Assay, 1975). Nevertheless, this solution is not enough to overcome spring frost damages, and frost hardness is also considered a selection objective in our breeding programme (Socias i Company et al., 1998).

In almond, little is known about the minimum threshold temperature causing damages in flowers and young fruits. However, differences among several commercial almond cultivars were described by Felipe (1988), concluding that at –2.5°C some cultivars suffered heavy production losses. Our aim was to assess spring frost damage in the flower and young fruits of several almond selections and their consequences on final fruit set.

MATERIALS AND METHODS
The study was carried out during the winter-spring of 2003 on 21 self-compatible selections from CITA’s breeding programme at Zaragoza. They were grafted onto the almond x peach hybrid rootstock ‘Garnem’ (Gómez Aparisi et al., 2001). The situation of this orchard, in relation to spring frost, was considered of high risk, because of the frequent incidence of frost (Felipe, 1988).

To evaluate the damages caused in flowers and young fruits, samples were collected two days after frost occurrence, placed in polyethylene bags, and taken to the laboratory. Damage evaluation was based on the morphological symptoms, such as brown discoloration of the style base in flowers or browning of the ovule in young fruits. To assess the effect of frost on fruit set, all bud flowers were counted on two branches of each selection before bloom, thus much before frost incidence. Fruit set was recorded in June. Bud density was also measured according to Socias i Company (1988).

RESULTS AND DISCUSSION
A frost of –2.5°C during five hours took place in the early morning of March 18, 2003. On that day, the almond selections were at different phenological stages and can be separated in two groups (Fig. 1). The first group comprised 12 selections whose bloom was already over, thus the frost affected young fruits. The second group comprised 9 selections that on that day were opening early flowers; consequently, the frost only affected buds and young fruits. The behaviour of both groups was different and needs to be examined differently for each group of selections.
Early blooming selections: Frost damage on small fruits ranged from 20% (G-6-39) to 77% (H-3-39) and produced a heavy reduction of fruit set, which was practically nil in some (G-1-38 and H-3-37) and economically insufficient in others (G-2-23, G-2-7, G-5-18, G-6-24, and H-3-39). These could be due to the fact that these selections had a young developing fruit, which is considered the most vulnerable stage to frost (Proebsting and Mills, 1978b).

In addition, some selections showed an intermediate fruit set, although not commercially acceptable (G-6-39, I-1-95, and I-2-12), and selection G-1-58 showed very high fruit set (33.5%), of a commercial level (Kester and Griggs, 1959). These differences, observed in selections that were at the same phenological stage, could be due to a differential resistance of these selections to frost damage. The same observation was reported for other almond cultivars previously studied (Felipe, 1988), as spring frost damage on reproductive organs depends mainly on the cultivar (Proebsting and Mills, 1978a) and on the intensity and duration of the low temperature (Mazur, 1969). In fact, differences in yield losses have been observed among almond cultivars at different critical low temperatures (Felipe, 1988). This suggests that selection G-1-58 has suffered lighter losses than the other selections of this group with a temperature of –2.5°C.

A high negative correlation was observed between the percentage of fruit damage and fruit set (-0.65), showing how the amount of damaged fruits significantly reduces fruit set. There was also a high negative correlation between the percentage of damaged fruits and bud density (-0.63), showing that the effect of spring frosts is higher in selections with a lower bud density. Moreover, a significant positive correlation was found between bud density and fruit set (0.42), thus, fruit set of selections with a medium to high bud density is higher than that of selections with a low bud density (Fig 2). This could be due to the fact that a high potential to produce bud flowers may compensate the spring frost damages, and, together with a good frost resistance, as in the case of selection G-1-58, could maintain the fruit set at a commercially acceptable level.

Late blooming selections: flower and bud frost damage ranged from 2% (G-2-2) to 47% (G-3-5), generally lower than the fruit damage on selections of the early flowering group, confirming that frost damage is highly dependent on the stage of bud development, as selections of the late flowering group (Fig 1) were in the early blooming stages, C, D and a few E (Felipe, 1977) when the frost happened. Also, the flower hardness of each selection (genotype) reflects the differences among selections at the same phenological stage (Westwood, 1993).

In general, the amount of damages caused by frost in selections at the beginning of bloom (late flowering group) were slight in comparison to the damages caused in early blooming selections (early flowering group), confirming that frost damage is highly dependent on the phenological stage of the bud/flower/fruit, the early developing fruit being the most susceptible stage (Proebsting and Mills, 1978b). Furthermore, differences observed among selections for the amount of flower and fruit losses show different frost hardness for each selection. Consequently, only tolerant or resistant genotypes (cultivars or selections) can produce a crop when frost takes place at or later than blooming time.

In some cases frost produced the complete loss of the crop, and in others an important reduction of fruit set and, consequently, of yield. Moreover, selections having a high bud density gave a fruit set from medium to acceptable. Hence, a high bud density seems to compensate spring frost damages.

These data were not enough to explain the effect of spring frost damage on fruit set, because fruit set in almond depends on several factors, including other weather conditions (such as rain), insect activity among inter-compatible and overlapping blooming cultivars or the ability for natural autogamy in self-compatible cultivars (Socias i Company and Felipe, 1992). However, a wide variability of responses to frost were observed in these selections, showing that even with this frost some genotypes can reach a 25-40% fruit set, considered as the economically acceptable threshold for a commercial crop (Kester and Griggs, 1959). Consequently, selection for frost resistance can be efficiently undertaken to obtain...
cultivars adapted to the harsh weather conditions of many almond growing regions in continental climates.

ACKNOWLEDGMENTS
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**Prunus webbii AS A WAY TO LOOK INTO SELF-COMPATIBILITY IN ALMOND**

**INTRODUCTION**

Almond [Prunus amygdalus Batsch or P. dulcis Miller (D.A. Webb)], derives from one or more wild almond species (such as P. fenziliana, P. bucharica, P. kuramica, P. triloba) that evolved in the deserts of Central Asia. By 450 BC, almond started spreading in the Mediterranean basin and countries like Italy, Spain, France, Portugal, Morocco, Tunisia became important centres of production (Kester and Ross, 1996).

The fact that almond is mainly a self-incompatible species accounts for the great diversity found and also for the differences among populations of different origins (with distinct histories of hybridization). Furthermore, as pointed out by Socias i Company (2002) it is expected that hybridizations with wild Mediterranean species (such as P. webbii) may have taken place during almond expansion, resulting in the almond populations that can be currently found in this region.

**SELF-INCOMPATIBILITY**

Many flowering plants display self-incompatibility (SI), a genetically determined characteristic which prevents inbreeding by promoting outcrossing. Self-incompatibility is determined by a single multiallelic locus, the S locus. Whenever there is a match between the S alleles expressed in the pistils and those of the pollen, fertilization is hampered. In the families Solanaceae, Rosaceae and Schrophulariaceae, the products of the S locus in the pistil are S-RNases that are thought to destroy the RNA of incompatible pollen (Wang et al., 2003).

Even though SI is believed to have played an important role in the success of Angiosperms, it represents a limitation to plant breeders when fruit production is important. In almond, SI is almost 100% effective, which means that unless compatible cultivars are present in an orchard, nut production will never be achieved. It has long been the desire of almond breeders to obtain self-compatible (SC) cultivars that are, at the same time, good almond producers.

**SELF-COMPATIBILITY IN ALMOND**

Some self-compatible almond varieties have been identified and the self-compatibility trait is usually attributed to the presence of a self-fertility allele Sf. (Raynaud and Grasselly, 1985). The Italian cultivar ‘Tuono’ is the best characterized SC almond cultivar and analysis of stylar RNAse activity indicate that Sf is inactive in ‘Tuono’ styles and in its SC progeny (Boskovic et al., 1999). The Sf gene sequence segregating with SC was isolated from ‘Tuono’ (Ma and Oliveira, 2000, 2001; Channuntapipat et al., 2001) though so far it is not known why there is no corresponding RNAse activity. Breeding tests confirmed segregation of Sf sequence and lack of RNAse activity with the SC phenotype (Ortega and Dicenta, 2003). Apparently, other SC almond cultivars display only one S-RNase in their styles (i.e. they lack one S-RNase) but the corresponding genes have still not been isolated.

**THE ORIGIN OF SELF-COMPATIBILITY IN ALMOND**

‘Tuono’ is originally from Italy, from the region of Apuglia (Herrero et al., 1977) where other Prunus such as P. webbii co-exist. Because P. webbii is reported as a SC species, it has been assumed that SC trait was introgressed into almond from this wild relative (Godini, 1979, 2000), probably through S (Socias i Company, 2002). A consequence of this assumption is that P. webbii would have to carry the S allele. Furthermore, if Sf was the only cause of self-compatibility, all SC P. webbii would contain this (or similarly non-functional) allele(s). If, on the other hand, P. webbii would have functional S alleles still being SC, then other loci should also be implicated in SI/SC in this species.

**THE Sf ALLELE IN P. webbii**

When testing for the presence of Sf (using Sf specific primers in six ecotypes of P. webbii (one from Spain and five from Apuglia) two were shown to carry the Sf allele (Sanchez and Oliveira, unpublished results), which could account for their self-compatibility. Since no RNAse activity in the pistil can be attributed to Sf, at least half of the pollen grains would be able to grow in the pistil and set seed. Such Prunus webbii plants may have, at some point, crossed with cultivated almond originating cultivars as ‘Tuono’ that carry S. It must be noted that the hybridization must have occurred several generations ago since, as assessed by molecular markers, ‘Tuono’ is more closely related with almond than with P. webbii (Martins et al., 2003), that is to say, ‘Tuono’ is not an F1 hybrid and further crosses with cultivated almond must have been taken place in the origin of this cultivar. The fact that other ecotypes of P. webbii do not contain the Sf allele but are still SC dismisses the notion that the presence of Sf is a sine qua non condition for self-compatibility.

**OTHER S ALLELES IN P. webbii**

By using primers designed for the conserved regions of Rosaceae S alleles (Signal peptide, C1 and C5) on P. webbii genomic DNA, it was possible to isolate other S alleles besides Sf in this species (Sanchez and Oliveira, 2003). Thus, for four of the six ecotypes tested, two S alleles were isolated. As expected one of these alleles was Sf in the two ecotypes already shown to carry Sf. For the two remaining ecotypes, only one S allele was found. The fact that P. webbii genome contains S alleles does not constitute in itself a surprise. If SI was the original condition in Prunus and SC plants are derived from SI plants, it could be expected that all plants of this genus may carry S-RNase genes though some may be in a relic non-functional form. Nevertheless, testing S-gene expression on pistil RNA from four varieties by RT-PCR, amplification was successful. This means that at least some P. webbii S-alleles are pistil-expressed suggesting that genes may be functional, a feature that could be confirmed by testing the RNAse activity of P. webbii pistils.

**S-ALLELES AND SELF-COMPATIBILITY**

How plants carrying the Sf allele could be self-compatible was already explained. Similarly plants carrying a single S allele may be accounted for if we consider that not being able to isolate a second S allele is due to either its absence from the genome or (more likely) an allele mutated to such an extreme that it is no longer recognizable by the primers and therefore it is most likely non-functional. The possibility that these individuals are homozygous for the S-locus (since P. webbii is SC this would be possible) and therefore to identify S-alleles are present which would not be distinguishable by PCR. As for the ecotypes that carry two distinct S-alleles that as judged by their sequence seem to code putatively functional S-RNases, the cause of SC may be due to a lack of (or reduced) expression of the S-genes (one or both) or SC may be a result of the action of other genes outside of the S-locus. It has long been known that the genetic background also affects the self-incompatibility response.

Self-fertile varieties of SI species are known in other plants and in many cases mutations in the S-RNase coding region or low expression levels of this protein can explain self-fertility (Koyama et al., 1994; Royo et al., 1994; Sassa et al., 1997). However other factors such as mutations on the putative S-pollen counterpart or at modifier loci can account for SC in the presence of fully functional S-RNases (Ai et al., 1991; Golz et al., 1998; Tao et al., 2002 and Tsukamoto et al., 2003). Similar situations are not to be discarded in Prunus webbii.
ALMOND GENES IN P. webbii

Analysis of P. webbii S-allele sequences showed that three ecotypes carry alleles identical to almond functional S-alleles. The observation that self-compatible P. webbii carries alleles known to confer SI in neighbouring P. webbii trees. Alternative hypotheses put forward by Socias i Company (2002) that at least to some extent, gene flow probably occurs (or has occurred in the past) between the cultivated almond (P. amygdalus or P. dulcis) and the Spanish ecotype shares alleles with the ecotypes collected in Italy. This could reflect the ancient nature of the S-alleles that would be present in the original population of P. webbii or shows exchange of plant material between these two European regions.

CONCLUSION

In conclusion, S-RNase coding genes could be isolated from a self-compatible species, Prunus webbii, suggesting that this species may have been self-incompatible in the past. The fact that the S-allele known to confer self-incompatibility in almond was found in some ecotypes of P. webbii provides evidence to the suggestion of this species being the origin of the S-allele of 'Tuono'. This gene introgression must be a result of ancient hybridization events. Furthermore, probably S-gene flow also occurred in the opposite direction since almond S-alleles are present in P. webbii. Finally, self-compatible plants do not necessarily carry the S-allele previously identified, so other causes for SC may exist that could be exploited in breeding SC almonds.

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APPLICATION OF MOLECULAR MARKERS IN ALMOND BREEDING PROGRAMMES

INTRODUCTION

Developing new cultivars is a long and tedious process in almond (Prunus dulcis (Mill.) D.A. Webb), involving the generation of large populations of seedlings from which the best genotypes are selected. Whereas the capacity of breeders to generate big populations from crosses is almost unlimited, its management, screening and selection of seedlings are the main limiting factors in the generation of new releases. The development of molecular markers to be used in early selection of seedlings in the almond breeding programmes, is interesting for the selection of these new cultivars.

Most of the work to develop molecular markers in almond has been carried out in setting up the different techniques and mapping the genome of the species, nevertheless the application in breeding programmes has been more reduced. Different types of molecular markers, including isoenzymes, RFLPs, RAPDs, and SSRs, have been applied for the genetic characterization of germplasm, the establishment of genetic relationships between cultivars and species, and the construction of genetic maps. In addition, methodologies for the analysis of marker-assisted selection include the use of mapping populations segregating for desired characters and bulk segregant analysis.

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Currently there is a good knowledge about the almond genome, which together with the quantity and suitability of plant material raised from almond breeding programmes, can allow the development of useful molecular tools to apply to the selection of genitors and seedlings.

In this work, a review of the application of molecular markers in almond breeding is presented, with special emphasis on the development of marker assisted selection strategies.

MOLECULAR CHARACTERIZATION AND GENETIC RELATIONSHIPS

Traditionally, the identification and characterization of almond cultivars has been based on morphological and agronomical traits. However, such traits are not always available for analysis and are affected by changing environmental conditions. Molecular marker technology offers several advantages over the use of conventional traits. Molecular markers also offer a powerful tool to study genome evolution, and for understanding genome structure and determinants of genetic diversity (Wünsch and Hormaza, 2002).

Isoenzymes: Isoenzymes were among the first genetic markers to be widely utilized. They have been used for cultivar identification in almond because of their environmental stability, their codominant expression, and their good reproducibility. Nevertheless, their utilization is limited by the small number of loci that can be analysed with conventional enzyme staining methods, as well as by a low variation in some loci (Arulsekar et al., 1986; Hauagge et al., 1987; Cerezo et al., 1989; Sathe et al., 2001). More recently, isoenzymes in combination with DNA-based markers were applied to develop genetic maps for woody perennials (see "Genetic mapping" below) and for the genetic characterization of multiple embryos in almond (Martínez-Gómez and Gradziel, 2003).

RFLPs: Restriction fragment length polymorphism (RFLP) markers are based on the differential hybridization of cloned DNA to bulk DNA fragments from restriction-enzyme digestion. RFLP markers are codominant. RFLPs can detect a virtually unlimited number of markers, thus providing an efficient method for discovering linkages among markers and for constructing genetic maps. RFLP have been assayed in almond for map-based selection (Viruel et al., 1995). However, RFLP analysis has important limitations: it is laborious and time-consuming and it often involves the use of radioisotopes.

RAPDs: Random amplified polymorphic DNA (RAPD) markers are based on the PCR amplification of random locations in the genome. RAPDs are characterized by using arbitrary primers. A single oligonucleotide is used for the amplification of genomic DNA. In contrast to isoenzymes and RFLPs, RAPDs are dominant markers. This feature, as well as their variable degree of repeatability and problems in transferring across populations, limits their use primarily to map construction. RAPD techniques have been successfully used in almond for identifying cultivars, estimating genetic diversity and assessing possible origins for selected genotypes (Bartolozzi et al., 1998; Martins et al., 2003).

SSRs: PCR-based, simple sequence repeat (SSR) markers (microsatellites) are becoming the marker of choice for fingerprinting and genetic diversity studies for a wide range of plants. Because of their high polymorphism, abundance, and codominant inheritance, they are well suited for the assessment of genetic variability within crop species, and for the genetic relationships among species (Powell et al., 1996). In the case of Prunus species, primer pairs flanking SSRs have been cloned and sequenced in different species including peach, apricot, and cherry (Aranzana et al., 2003). These SSR markers have been used for the molecular characterization and identification of almond cultivars (Martínez-Gómez et al., 2003a) and related Prunus species (Fig. 1) (Martínez-Gómez et al., 2003b); and elaboration of genetic maps (Joobeur et al., 2000; Bliss et al., 2002) (see "Genetic mapping" below).

Electrophoresis in polyacrylamide with radioactive and silver staining was the first method used in the analysis of the PCR amplified fragment of DNA obtained from the SSR markers. Electrophoresis in Metaphor® agarose was a method used as alternative to the polyacrylamide due to its easier application (Fig. 2). More recently, new methods for the PCR amplified DNA have been developed including the use of automated sequencers.

**Metaphor® Agarose**

**Polyacrylamide**

**Figure 1. Genetic relationship among peach and almond cultivars and related Prunus species obtained by a study with SSR markers (Martínez-Gómez et al., 2003b). Unrooted dendogram obtained by Neighbour Joining cluster analysis.**

**Figure 2. Allelic segregation of UDP96-013 SSR marker in almond cultivars using Metaphor® agarose and Polyacrylamide. First and last samples correspond to a 1 kb DNA ladder.**
GENETIC MAPPING

Several intraspecific and interspecific almond maps have been developed using different types of molecular markers. The use of PCR-based markers made it possible to map and tag a wide range of traits (Arús et al., 1994; 1999). The analysis of cosegregation among markers eases linkage analysis between markers and major or quantitative loci controlling horticulturally important traits.

Different research groups have released linkage maps using morphological traits, isoenzymes, RFLPs and RAPDs in almond (Viruel et al., 1995; Joobeur et al., 1998; 2000; Jáuregui et al., 2001; Bliss et al., 2002). In addition, SSRs have been used for mapping in almond (Joobeur et al., 2000; Bliss et al., 2002; Aranzana et al., 2003). The similar arrangement of markers observed in different Prunus maps suggests a high level of synteny within the genus (Aranzana et al., 2003). This homology among Prunus species partly explains the low level of breeding barriers to interspecific gene introgression and supports the opportunity for successful gene transfer between closely related species (Gradziel et al., 2001).

MARKER-ASSISTED SELECTION

Selection by molecular markers is particularly useful in fruit, nut, and other tree crops with a long juvenile period, and when the expression of the gene is recessive or the assessment of the character is difficult. Marker-assisted selection (MAS) is emerging as a very promising strategy for increasing selection gains. If sufficient mapping information is available, MAS can highly shorten the number of generations required to “eliminate” the undesired genes of the donor in backcrossing programs (Arús and Moreno-González, 1993). Marker loci linked to major genes can be used for selection, which is more efficient than direct selection for the target gene (Arús and Moreno-González, 1993).

The principal approach for the analysis of marker-trait association in almond is the use of mapping populations segregating for the characters of interest. The different linkage maps developed in almond include markers associated with several traits of horticultural value. Mapping quantitative characters by identifying quantitative trait loci (QTL) is also becoming an important tool in tree breeding. QTLs are generally recognized by comparing the degree of covariation for polymorphic molecular markers with phenotypic trait measurements. Important characters and QTLs that are presently being mapped in almond include bloom time, self-incompatibility, shell hardness, or kernel taste (Asins et al., 1994; Viruel et al., 1995; Ballester et al., 1998, 2001; Joobeur et al., 1998; 2002; Bliss et al., 2002) (Table 1). The high degree of genome synteny observed among Prunus species should also facilitate the successful transfer of sets of markers and coding sequence among species (Aranzana et al., 2003) (Table 1).

Bulk segregant analysis (BSA), where two pooled DNA samples are formed from plant sources that have similar genetic backgrounds but differ in one particular trait, is another promising approach for the analysis of molecular marker-horticultural trait association. A strategy combining different markers with bulk segregant analysis was used to identify markers linked to loci of specific characters in peach x almond crosses (Warburton et al., 1996), and three RAPD markers associated with a gene conferring delayed bloom in almond (Ballester et al., 2001) (Table 1).

A very promising application of molecular marker assisted selection is the manipulation of self-compatibility in almond. This species is predominantly self-incompatible. Self-incompatibility is of the gametophytic type and acts to prevent self-fertilization. This character is controlled by a single locus with multiple codominant alleles (Dicenta and García, 1993), and is expressed within the styles of flowers as S-RNases glycoproteins (Bošković et al., 1997; 2003) that are responsible for the subsequent inactivation of self-pollens tube growth. Almond self-incompatibility alleles (S-alleles) were initially identified in the field through controlled crosses with a series of known S-genotypes (Keser et al., 1999). More recently, molecular methods have been developed in two areas: identification of stylar S-RNases by electrophoresis in vertical polyacrilamide gels (Bošković et al., 1997, 2003), and the amplification of specific S-alleles using appropriately designed primers for PCR and electrophoresis in horizontal agarose gels (Tamura et al., 2000; Channuntapipat et al., 2003). This technique is being routinely used for the identification of cross-incompatibility groupings for current almond cultivars and for efficiently breeding self-compatibility into new cultivars (Gradziel et al., 2001b; Ortega and Dicenta, 2003).

ACKNOWLEDGMENTS

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Table 1. Markers associated to main agronomic traits in almond.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Symbol</th>
<th>Marker</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-incompatibility</td>
<td>SI</td>
<td>RFLP</td>
<td>Joobeur et al. 1998</td>
</tr>
<tr>
<td>Self-compatibility</td>
<td>SI</td>
<td>RFLP</td>
<td>Arús et al. 1999</td>
</tr>
<tr>
<td>Kernel taste</td>
<td>Sw</td>
<td>RFLP</td>
<td>Bliss et al. 2002</td>
</tr>
<tr>
<td>Shell hardness</td>
<td>D</td>
<td>RFLP</td>
<td>Arús et al. 1999</td>
</tr>
<tr>
<td>Late blooming</td>
<td>Lb</td>
<td>RAPD</td>
<td>Ballester et al. 2001</td>
</tr>
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### Fusicoccum CANKER IN ALMOND ORCHARDS – BIOTECHNOLOGY TOOLS FOR EARLY SELECTION OF TOLERANT GENOTYPES

Fusicoccum CANKER IN ALMOND

Almond is an important crop in the Mediterranean region, reaching about 28% of the world production. However, its susceptibility, particularly to certain fungal diseases such as brown rot blossom blight, constriction canker and almond scab, which can cause severe damage on foliage and branches of the tree, can be a major impediment for almond production.

Regarding Fusicoccum canker or constriction canker, this is a damaging and economically important fungal disease in almond orchards in the Mediterranean region, caused by *Phomopsis amygdali* (Del.) (perfect stage) Tuset and Portilla, formerly classified as *Fusicoccum amygdali* Delacr. (imperfect stage). Besides almond, this fungus also infects peach trees. Symptoms of this disease usually appear in early summer and become increasingly evident as more infected shoots appear through late summer. In almond mainly two types of symptoms are visible, on shoots and on May spurs. Infected twigs and shoots wilt, and eventually die, because of elongate, brown, sunken cankers, often with a well delimited oval pattern (Grasselly and Duval, 1997) (Fig. 1).

The group of leaves that form May spurs will due to the infection, caused on that spring or on the previous autumn. It is also possible to observe cankers on the internodes of these spurs. Leaves in general can also be affected, showing necrosis that usually appear as big brown spots with circular or irregular shape. Gumming is commonly associated with the cankers, although it is not a good diagnostic characteristic since other agents may also be responsible for this sign. Constrictions formed at the base of infected shoots and leaf symptoms produced well beyond the infection site result from a translocatable toxin, fusicoccin, a phytotoxic terpenoid glucoside. Fusicoccin, increases the influx of potassium on guard cells inducing the permanent opening of the stomata and the consequent high loss of water can eventually lead to plant death (De Boer, 1997).

The development of *Fusicoccum* canker is favoured by high nitrogen levels in the soil and by wet weather, since this disease is transmitted by rain (Rosenberg, 1996). Most infections occur during
Fusicoccum canker control (Barbé, 1993). In spring, the trees can be severely affected, exhibiting numerous terminal dead zones spread through the tree canopy (Grasselly and Duval, 1997). These effects can lead to significant losses on fruit production in almond cultivars.

The management of infected orchards should involve the implementation of fungicide application programmes and pruning (elimination) of infected limbs to reduce inoculum. Winter pruning of cankered shoots, followed by pruning of young shoots showing symptoms of the disease in spring, are important practices to help Fusicoccum canker control (Barbé, 1993).

Fungicides, applied just before budbreak (February-March) and in autumn, may be necessary in orchards where the disease is present (Grasselly & Duval, 1997). Keeping nitrogen at low to moderate levels in the soil contributes to minimize the severity of the infection (Rosenberg, 1996).

Wide differences on Fusicoccum tolerance between cultivars have been observed (Grasselly and Crossa-Raynaud, 1980; Romero and Vargas, 1981) and should be taken into consideration when new orchards are planned.

Almond populations are found in most Mediterranean countries, where weather conditions mainly in coastal orchards are usually favourable to Fusicoccum development. Therefore, the use of tolerance to Fusicoccum as a selectable trait in almond breeding programmes and in the establishment of new orchards can be of great importance.

MARKER ASSISTED SELECTION (MAS)

Genetic markers, as transmissible entities associated to economically important traits, can be used by breeders as important selection tools (Darvasi & Soller, 1994). After a decade of marker assisted selection in vegetable crops, increasing availability of genomics-derived information is starting to allow the use of molecular markers as tools to support classical breeding programmes in fruit tree species.

Identification of molecular markers closely linked to genes controlling traits of interest are essential in marker assisted selection. The closer the linkage, less is the probability of recombination between the marker and the gene(s) that control the trait of interest, thus the higher will be the efficiency of selection.

The best perspectives for MAS application may rely on breeding programmes aiming for disease resistance improvement, particularly in systems where several genes are involved, with complex interactions, and where gene pyramiding is desirable (Kelly, 1995). Markers for disease resistance offer the additional advantage of permitting selection for resistance in the absence of the pathogen(s) (Mehlenbacher, 1995). Another possible application can be on recurrent selection of the cultivated genotype when the aim is gene introgression from wild individuals.

The construction of a linkage map of a certain population allows the study of segregation of markers with genes responsible for the variability found in that population, making possible the identification of major genes or loci of quantitatively characters (QTLs) on the map (Arús et al., 1999). Genetic maps developed in almond (or almond x peach) have been used to identify markers linked to genes with important effects on the morphology and physiology of the plant, for example self-incompatibility, shell hardness or almond bitterness. Integration in these maps of new markers closely linked to genes of interest and their routine use on current or future breeding programmes, is of high interest. However, despite its potential benefits, MAS applied to almond breeding will likely be restricted to a limited set of traits and parents where data for segregating populations are available. Examples of applied MAS reported in the literature are still scarce, mainly because private companies are the main users of MAS, therefore information is more difficult to be available. Moreover, the costs and elaborated technology required for most of the markers available make MAS application of limited use in breeding programmes.

MAS applied to woody plants such as almond would be extremely important, mainly for allowing the selection of characters of interest on an initial stage of plant development, which would only be expressed after 2 to 5 years in the field, hence representing a significant reduction on time and area used when compared to species with a shorter life cycle.

SEARCH AND IDENTIFICATION OF MOLECULAR MARKERS – THE CASE OF Fusicoccum LINKED MARKERS IN ALMOND

Plant breeding programmes require relatively low-cost methods that can be used for hundreds or thousands of individuals, with a reliability of at least 95% (Rafalski & Tingey, 1993), these criteria make PCR based techniques very attractive. Due to their low cost, simplicity and easy detection, RAPD (Randomly Amplified Polymorphic DNA, Williams et al., 1990) markers are frequently chosen for this kind of study. However, a poor specificity and lack of reproducibility can sometimes be associated to this technique. In order to overcome these deficiencies, RAPD fragments can be converted into SCAR markers (Sequence Characterized Amplified Region, Paran & Michelmore, 1993), more reproducible and sometimes codominants, or to CAPS (Cleave Amplified Polymorphic Sequences, Konieczny & Ausubel, 1993; Jarvis et al., 1994).

Michelmore et al. (1991) showed that RAPD bands linked to a trait of interest would be easily identified through the use of two samples of bulked DNA from a population segregating for that trait: within each pool, or bulk, the individuals are identical for the trait or gene of interest but are arbitrary for all other genes. Any polymorphism between the two pools.
should be linked to the trait being analysed. Mapping on a segregating population may confirm the markers found. This technique, identified as “bulk segregant analysis” (BSA), is now commonly used to map simple traits with RAPD markers. A variation of this technique, known as “bulked DNA analysis”, uses also two samples of DNA mixtures, one of individuals that express the trait, and another of individuals that do not express it, but without using a segregating population.

Once a marker is identified as being related to a trait of interest, the development of SCAR or CAPS markers results in a higher specificity and reproducibility of the fragments obtained. RAPD analysis followed by SCAR or CAPS development has been used to identify markers associated to traits of interest in plants, such as downy mildew resistance in lettuce (Paran & Michelmore, 1993), the locus that controls flower doubling in carnation (Scovell et al., 1998), a new resistance gene to leaf stripe in barley (Tacconi et al., 2001), and the genetic nature of tolerance to Fusicoccum in almond (or related species like peach) is not yet defined, and further studies are necessary to determine the model that can be applied to almond. Although artificial inoculation with Fusicoccum is currently being tested in almond (Cabrita et al., 2003), any procedure has been established, so far, to efficiently evaluate tolerance or sensitivity of almond plants to Fusicoccum canker. Therefore, the identification of molecular markers linked to tolerance or sensitivity to Fusicoccum, is of particular importance since, to our knowledge, this is the only method that will allow the early selection of tolerant plants from breeding programmes, as well as the certification of tolerant cultivars to be implemented in new orchards. Symptoms development of the disease in plants grown in the field derived from breeding programmes taken about 4 to 5 years under natural conditions of high atmospheric humidity as it happens in the Mediterranean coast (I. Battile, personal communication). Finally, it is important to highlight that the balance and coordination among the use of molecular technologies and the fieldbased work, are essential for the success of breeding programmes (Scorzà, 1996).

In our study, the RAPD technique was combined with bulked DNA analysis to select markers associated to either tolerance or sensitivity to Fusicoccum in almond. Fourteen almond cultivars classified as tolerant (T) or sensitive (S) to Fusicoccum were screened with 120 RAPD primers. Polymorphic bands were assessed for co-segregation with tolerant or susceptible phenotypes using 30 seedlings obtained from a cross of ‘Masbovera’ (T) x ‘Lauranne’ (S). Three RAPD markers were identified, two linked to tolerance (OPD-19 and OPA-08) and one linked to sensitivity (OPD-19). Some RAPD markers were identified, two linked to tolerance (OPD-19 and OPA-08) and one linked to sensitivity (OPD-19). SCAR markers were developed and segregation of SCAR markers was tested, however, polymorphism between the two groups (tolerant versus susceptible) was lost in this process. The development of CAPS markers as a possible way to recover the lost polymorphism will be analysed.

Cosegregation analysis using the adequate populations is essential to confirm the genetic base of the markers linked to a certain trait. In the case of almond, a new segregating population of some 120 seedlings derived from a cross ‘Primorskyi’ (T) x ‘Lauranne’ (S), is currently being evaluated in the field, at IRTA, Centre Mas Bové (Tarragona, Spain), for tolerance or sensitivity to Fusicoccum. This material will allow the confirmation of which fragments correspond to markers associated to the disease. In this case it would be of high interest to evaluate the possibility of inserting these markers in the reference European Prunus genetic map, almond ‘Texas’ x peach ‘Earlygold’ (TXe) (Joobeur et al., 1998).

The genetic nature of tolerance to Fusicoccum in almond (or related species like peach) is not yet defined, and further studies are necessary to determine the model that can be applied to almond. Although artificial inoculation with Fusicoccum is currently being tested in almond (Cabrita et al., 2003), any procedure has been established, so far, to efficiently evaluate tolerance or sensitivity of almond plants to Fusicoccum canker. Therefore, the identification of molecular markers linked to tolerance or sensitivity to Fusicoccum, is of particular importance since, to our knowledge, this is the only method that will allow the early selection of tolerant plants from breeding programmes, as well as the certification of tolerant cultivars to be implemented in new orchards. Symptoms development of the disease in plants grown in the field derived from breeding programmes taken about 4 to 5 years under natural conditions of high atmospheric humidity as it happens in the Mediterranean coast (I. Battile, personal communication). Finally, it is important to highlight that the balance and coordination among the use of molecular technologies and the fieldbased work, are essential for the success of breeding programmes (Scorzà, 1996).

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VIRUS SCREENING FOR AUSTRALIAN ALMONDS

SUMMARY

As part of the Australian almond breeding programme, work is conducted on breeding parents and progeny to screen for viral pathogens. Transmission of virus of up to 23% has been recorded when infected parents are used. As a service to industry the University also test the Monash almond budwood facility.

INTRODUCTION

An important aspect of the Australian almond breeding programme is the detection of plant viruses in the breeding stock and progenies (Sedgley & Collins, 2002). The two most important viruses present in Australia in almond (Prunus dulcis Mill.) are Prunus necrotic ringspot virus (PNRSV) (Callico) and prune dwarf virus (PDV). Infection of nursery stock results in poor bud-take and retarded growth, and in commercial orchards growth and crop yields are affected. Leaf symptoms of PNRSV include chlorotic and necrotic leaf spots, mosaics, ringspots, and line patterns.

There are other viruses, plum pox virus (PPV) (Sharka); tomato black ring virus (TBRV) (Enation); and tomato ringspot virus (ToRSV) (Peach yellow bud mosaic), which are present in Europe and America but not in Australia, however imported almond material is tested by AQIS for viruses on arrival. As a service to the Australian almond industry the University also regularly tests the Monash almond budwood repository for viruses thus ensuring that only tested material is used for budding in nurseries. The Monash facility consists of 601 almond trees representing all major cultivars grown in Australia including those newly introduced from Europe and the USA.

ELISA TESTING AND WOODY INDEXING

When screening began for PNRSV and PDV in 1997 the methods used were the antibody-based enzyme-linked immunosorbent assay (ELISA) technique and woody indexing, where almond budwood is grafted onto the indicator plant Prunus serrulata cv. Shirofugen, then monitored for diagnostic symptoms. The detection of PNRSV by ELISA was shown by Bertozzi et al. (2002) to be most sensitive when plant material was collected in spring.

Table 1. The percentage of progeny testing positive for PNRSV.

<table>
<thead>
<tr>
<th>Progeny</th>
<th>Both parents</th>
<th>Pollen parent</th>
<th>Seed parent</th>
<th>Both parents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-ve</td>
<td>-ve</td>
<td>-ve</td>
<td>+ve</td>
</tr>
<tr>
<td>1997</td>
<td>0.4%</td>
<td>0</td>
<td>6%</td>
<td>22.6%</td>
</tr>
<tr>
<td>1998</td>
<td>0.1%</td>
<td>1.4%</td>
<td>1.8%</td>
<td>12.5%</td>
</tr>
</tbody>
</table>
Figure 4. Agarose gel showing some cultivars with a positive reaction to PNSRV primers. 
Lane 1: molecular marker ladder, lane 2: Carmeli(-ve), lane 3: Fritz (+ve), lane 4: Johnston (-ve), lane 5: Mission (-ve), lane 6: Nonpareil (+ve), lane 7: Nonpareil (-ve), lane 8: Parkinson (+ve), lane 9: Peerless (+ve), lane 10: Price (+ve), lane 11: Price (-ve), Lane 12: negative control.

MONASH

The ELISA technique was used to screen all the Monash trees for PNSRV and PDV over 1997, 1998, & 1999 and half the trees in 2000. PDV was not detected in any of the trees, however PNSRV was detected in 34 trees in 1997, 33 trees in 1998, and 36 trees in 1999. Where trees test positive one year and negative the next, this may be due to uneven distribution of the virus in the plant, or seasonal fluctuations of viral concentrations due to extremes of temperature. The increase from 1997 to 1999 may be attributed to an increase in the virus titre of these trees to levels able to be detected by ELISA, or may represent new infections.

RT-PCR TECHNIQUE

A DNA based technique for virus detection was developed by G. Collins. This technique is based on the reverse transcription-polymerase chain reaction (RT-PCR) and is more sensitive than ELISA. The technique involves extracting ribonucleic acid (RNA) from fresh leaves and using specially designed primers that can detect the viral coat protein within the plant cells. This technique was used on trees at Monash in 2000, 2001, 2002 and 2003. Generally RT-PCR confirmed the results of ELISA, however some trees were positive for PNSRV where ELISA gave negative results. This is due to the more sensitive nature of RT-PCR, and has the added advantage that plant material can be tested at any time throughout the growing season.

ACKNOWLEDGEMENTS

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THE PISTACHIO INDUSTRY IN ITALY: CURRENT SITUATION AND PROSPECTS

INTRODUCTION

Pistachio (Pistacia vera L.), is a dioecious and deciduous species native to western Asia and Asia Minor. It was introduced into Italy from Syria in 30 A.D. by the Roman Governor of that Province, Lucius Vitellio, at approximately the same time it was introduced in Spain (Minà Palumbo, 1882). Its introduction into Sicily, which nowadays accounts for almost the entire Pistachio industry in Italy, probably occurred some time later, following an initial period of cultivation in Campania which at that time represented the roman “country-side”. Its cultivation in Sicily began to spread during the Arab domination (827-1040 A.D.) together with other major fruit and vegetable species and in parallel with the improvement of the agronomic techniques. As a matter of fact, the Sicilian dialectal term for Pistachio tree (Fastuca) is of arab derivation (Fustug). However, very little is known until recent times about its distribution over the region. Historic references onto Pistachio cultivation are documented by the XVIIIth century, even if first official records of the economic importance of Pistachio industry are referred to the first decades of the XX century.

Soon after the second world war the entire structure of the Sicilian Pistachio industry underwent significant changes. The relative importance of the traditional cultivation areas (Agrigento, Caltanissetta and Palermo) strongly decreased with the abandonment of large part of the Pistachio cultivation which was partially compensated by a parallel increase of the production in the Catania Province (Fig. 1).

Currently more than 90% of the total Italian Pistachio area is concentrated in only few territories in the eastern Sicily (western slopes of Mount Etna volcano), mainly located in the districts of Bronte and Adrano (Catania Province), onto approximately 4.500 hectares. Few residuals of the past cultivation can still be found in Caltanissetta and Agrigento Provinces, in small and scattered surfaces (as a whole, 130 ha in specialized cultivation and 210 ha in mixed cultivation).

Despite this ancient origin and the long period of cultivation, only few female varieties of Pistachio are now grown in Italy (about ten) together with an even more restricted number of unnamed male selections. Among the female cultivars, ‘Bianca’ (synonym: Napoletana) is practically the only cultivar grown, other varieties, namely ‘Femminella’, ‘Natalora’, ‘Agostana’, ‘Silvana’, ‘Insolia’, ‘Cerasola’, ‘Cappuccia’, representing not more than 3% of the total (Barone et al., 1985) can still be found, mostly in scattered, abandoned settlements. This genetic pool is probably the result of a two step introduction process of genetic material (Barone et al., 1996) coincident with the earliest introduction from Syria of the reddish ‘Cerasola’ by the Romans and the later introduction carried out by the Arabs. The reasons of this low number of varieties is thought to be the exclusive use by the growers of vegetative propagation since ancient times due to the long juvenility period of P. vera seedlings, the long life-span of the trees and easy hybridizations with other Pistacia species. Nevertheless, within the Sicilian Pistachio germplasm, some valuable fruit characteristics such as colour, flavour and nut quality are highly appreciated in trade, specially the greenness of the kernels and the rich oily nut-like flavour (Woodroof, 1967). Most of these appreciated characteristics have been maintained also by cultivars obtained in the United States from Sicilian seeds imported in the early 1900’s such as ‘Bronte’ and ‘Trabonella’ (Joley, 1969).

In spite of these valuable characteristics of the Italian pistachios, the contribution of Italian production represents nowadays only less than 0.6% of the world production. Nevertheless, with respect to product destination, it is remarkable that Ita-
lian pistachios maintain a dominant market position for the uses other than direct consumption (snack), since they are almost entirely used, and highly appreciated, by the confectionery and ice cream industry.

Due to this fact Italian pistachio exports, between 1000 and 2000 tons per year (Anonymous, 2000), are represented mainly by shelled and peeled pistachios, whereas imports (about 9000 tons) consist mainly of in-shell pistachios, consumed as salted and roasted snacks for domestic markets and, partially, for re-exportation.

**THE BRONTE AREA**

This area of the eastern Sicilian province of Catania currently represents the main Pistachio growing area in Italy. From the ecological point of view this area (Fig. 2) is of great naturalistic importance due to the proximity to the Etna Volcano and the inclusion in the Regional system of parks and naturalistic reserves ("Parco dell'Etna", 59,000 ha, established in 1987).

Pistachio production in Bronte represents one of the main economic resources of the entire territory. A total of 3,300 ha of specialized Pistachio orchards are located in this area and 1,500 ha in the neighborhood territories (Adrano, Biancavilla). The altimetry is comprised between 350 (along the Simeto river bank) and 900 m a.s.l.. The climate is typically Mediterranean with fall and winter rainfall (annual average: ~550 mm). Average monthly temperatures of the area are between a minimum of 6.0 °C (February) and a maximum of 32.6 °C (July) (Fabbri and Valenti, 1998). Most of these Pistachio orchards are defined as "natural Pistachio plantings" because they have long been obtained by grafting in situ spontaneous Terebinth (Pistacia terebinthus) plants spread in the particular soils of the area, consisting of rocky, volcanic soils derived in the centuries from the Mount Etna activity, in steep slopes (Barone et al., 1985). This traditional planting system took advantage of the extraordinary characteristics of environmental adaptation of Terebinth to poor, dry, shallow soils of the area, where no valid cultural alternatives are available, except for few other fruit species such as Prickly Pear and Fig.

Thus, "natural Pistachio plantings" are characterized by the absence of regular plant spacings and by a wide range of plant density (50-500 trees per ha). Also the age of the trees is consequently highly variable. Successive interplanting of nursery terebinth seedlings is a common practice to replace dead plants and to increase orchard density. A few local small nurseries are active in the area of Bronte and supply plant material mainly as seedling P. terebinthus rootstocks to be grafted directly in the orchard. Small quantities of grafted P. vera/P. terebinthus pot plants are also produced. In such kind of conditions cultural operations are necessarily carried out by hand, since mechanization is almost impossible also due to the training system adopted that can be defined as an "open vase" with three-four main irregular branches very close to the soil surface. Pollination is ensured by spontaneous male P. terebinthus plants or by scattered male P. vera pollinizers and also by natural hybrids between the two above mentioned species. Fruitset problems are likely to occur, specially when pollination largely relies onto spontaneous source of pollen, since male/female ratio generally adopted in the Bronte area is particularly low (1/20). Besides natural orchards, new plantations are also present in the area. In this case rational orchard design (6m x 8m or 8m x 8m) and common cultural practices are adopted.

‘Napoletana’ (syn. Bianca) is the only cultivar widely utilized both in the "natural" or in the regular plantations and Terebinth is the only rootstock. Following the descriptors’ list for Pistachio (Barone et al., 1997), ‘Bianca’ cultivar can be defined of low-intermediate vigour. Growth habit is
though variable from year to year, is generally low and, therefore, unsatisfactory for direct commercialization and consumption. Nevertheless, the deep green colour of kernels and their excellent quality are world-wide appreciated (Woodroof, 1967). The overall characteristics of the Italian Pistachio germplasm are, therefore, more suitable for industrial transformation (Barone and Caruso, 1996).

The average pistachio farm surface in the area of Bronte is of approximately 1-2 hectares, corresponding to a total of about 3000 farms. As a whole, 3000 to 3800 tons of in shell pistachio is the productivity of the Bronte area, corresponding to an average yield of about 1-1.2 tons per hectare. Exceptionally, maximum yield of 4 tons per hectare has been recorded. The average prices paid to growers for in shell product in the last commercial campaigns ranged between 4 to 5 €/kg. During "off" years price tends to be higher (approx. 7.5 €/kg). Pistachios are harvested with the help of tarpaulins. Fruits are normally hulled with small equipment (Picture 1), with an operating capacity of 400-500 kilos/day, and sold soon after sun drying process (3-4 days) performed directly in the farm. They are bought by about ten local industries that proceed to further transformation. Three kinds of end-products are therefore obtained: in shell, shelled (yield 40-45%) and peeled (Pictures 2-3). The prices of the first two categories of products are of about 7 and 15 €/kg, respectively. Shelled pistachios are normally commercialized in packages of 25, 12, 1 and 1/2 kg to domestic and foreign markets. The average operating potential of this kind of processing plant is of about 500 kilos of shelled pistachios per day. Some processing plants further process the fruit to obtain pistachio flour, pesto (condiment), cream and paste for pastry and ice-cream. Like in other producing countries, Italian pistachio industry and market are negatively affected by alternate bearing problem. A particular cultural practice is generally followed by the growers to face the alternate bearing pistachio habit. It consists, every second year, of the total inflorescence bud removal carried out during harvest time, in the "on" year. This traditional practice is exerted with the aim of obtaining a complete "off" year in order to maximize the yield of the "on" year and to minimize the cultural expenses of the biennium. By this way a biological control of some main pests (bud borer Acrantus (=Chaetoptelius) vestitus, among the others) is made by interrupting the natural cycle of the insects. This practice requires about 30 hrs/ha and include also lateral shoots suppression. Other cultural practices carried out by the growers consist of winter pruning (February and March), fertilization (mostly with N and P fertilizers), chemical weed control, orchard floor management (with mechanical hoe) and plant protection. Total cultural requirements in terms of hand labour (including harvest) range between a minimum of 150 to a maximum of 400 hrs/ha. Among the diseases in the area Cytospora terebinthi, Septoria pistaciae are generally considered the most dangerous (Granata et al., 1993). Megastigmus pistaciae, together with Acrantus (=Chaetoptelius) vestitus, can be considered the main pests (Greco, 1998). During storage Plodia interpunctella attacks to the fruits have to be controlled generally by storage room spraying.

PROSPECTS

Italy imports annually about 9.000 tons of roasted and salted (or to be salted in Italy) pistachios for direct consumption (snack) (Anonymous, 2000). About one third of this import is from USA. For the snack market, other well-known cultivars from USA (‘Kerman’) and, lastly, also from Australia (‘Sirora’), represent nowadays the market standard. Italy maintains a certain importance for Pistachio production utilized in the confectionery and ice-cream industry as well as for special destination such as for “mortadella” (bologna). The overall structure of Italian pistachio industry in the years is relatively stable and no particular changes are expected in the near future. Quality of Sicilian pistachios is undoubtedly of high value, but other Mediterranean countries, with similar cultivars and lower production costs, are rapidly becoming potential strong competitors. Even if, under the point of view of environmental suitability, there will be no obstacle to a further diffusion of the culture in other areas of Italy without the natural limits characteristic of
the Bronte area, very few new plantations have been established in the recent years. The major constraints are, perhaps, the long unproductive period of the culture (full production is normally reached by the 12th or 13th year), together with the lack of sufficient experimentation on new orchard design, alternative rootstocks, mechanization and availability of less alternate bearing cultivars. The question that arises is also related to the aim of new plantations: whether for industrial transformation, following the present specialization, or for direct consumption, as in the rest of the emerging producer countries. In the first case we have genetic material, market opportunities and enough know-how to imagine an easy development. In the second case, other varieties should be tested for the Sicilian environmental conditions, together with the best suited cultural techniques. For this last option, strong concurrence, especially for the cost of production, has to be faced. In both cases there is a strong need for research. At the Dipartimento di Colture Arboree of the Università di Palermo researches on alternate bearing phenomenon, rootstocks and germplasm evaluation are underway, in some cases from the 80’s. Some results of these research activities have been recently presented to the last GREMPA meeting held in Mirandela, Portugal (Barone et al., 2003; Caruso et al., 2003).

Although currently the pistachio industry situation, as mentioned before, could be considered stable, great opportunities are expected from the diffusion of mechanization, specially for harvest and other cultural practices. This is more likely to be implemented in areas of new plantations where there are not the environmental constraints of the Bronte area. For this last area a strong impulse is expected by obtaining the trade mark DOP (protected origin denomination) for the pistachios of Bronte, acknowledging that is underway. Finally, even if cooperation has recently become stronger than in the past, a further development of cooperation and, possibly, the establishment of an unique pistachio association among the growers are highly advisable to promote the Italian pistachio industry, as already done in other producing countries.

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PISTACHIO PRODUCTION IN TUNISIA

INTRODUCTION

Pistachio (Pistacia vera L.) is a dioecious species, widely present in the Mediterranean area. Its introduction in Tunisia may have been made by Carthaginians, however other introductions were made by Romans and Arabs (Jacquy, 1973). Several species are scattered in different parts of Tunisia (Jacquy, 1973; Nabi, 1989): Pistacia terebinthus and Pistacia lentiscus grown naturally in the dorsal hill from the north-west (Ghardimaou) to the north-east (Zaghouan). Pistacia atlantica spreading from the dorsal hill on the north to the Saharian Atlas in the south with important frequency in the predesert area of the center and south of the country (Sened, Meknassy, Guettar...). Pistacia vera, the edible pistachio is found also from the north to the south with some trees four to five hundred years old (Guettar oasis) and others two hundred years old (Sfax – Mahres regions). Despite this long history, development of pistachio production in Tunisia starts only during the last 30 years.

CURRENT SITUATION

Pistachio is a hardy tree resistant to drought which can valorize poor soils, and therefore a lot of resources were put into its development. Some development projects were carried out with the support from international organizations like FAO during the period of the seventies. From less than 100 ha of pistachio orchard fifty years ago, the growing area is now more than 43.000 ha localized mainly in the...
center and the south of the country (Fig. 1). Gafsa, Sidi Bouzid, Kasserine and Sfax are the most important producing regions with respectively 19,800 ha, 9,188 ha, 7,668 ha and 3,290 ha.

Despite this acreage increase the production is still very weak reaching only 1.170 t with important differences between irrigated and rainfed orchard and also regions (table 1). The north region represents less than 1% of the growing surface producing more than 16% of the national yield (fig. 2).

To understand this weak yield and characterize the current situation of pistachio crop in Tunisia, a survey was carried out in the important Tunisian pistachio growing zones (Ghrab et al., 2002b). The most important observations were:

- Inappropriate distribution of male and female trees on the orchard. Different ratios of male to female varying from 2% to 90% were observed reducing the profitability of the orchard.
- Inadequate planted material that is supposed to be ‘Mateur’ as female and males A40 and A25 cultivars. However the observations made revealed significant phenotypic differences between trees.
- A shift of the flowering periods between A25 and A40 male cultivars and ‘Mateur’ inducing an inefficient pollination. Those cultivars were selected on the north of the country for their production, quality and overlapping flowering period however under the central and southern climatic conditions the flowering period of the male cultivars does not overlap with the blooming period of ‘Mateur’.
- Since pistachio tree needs more than five years to bear under the central and southern semi-arid conditions, some growers opted for other species and quit their orchards without any management.
- For some pistachio growers, management operations such as fertilization, pruning, pollination, pest and disease control were ignored and considered without any benefit for this crop.

### CULTIVARS AND ROOTSTOCKS

The most commonly cultivated variety in Tunisia is ‘Mateur’ (Fig. 3), selected in the North as well as two corresponding pollinators A40 and A25 (Mlika, 1980). Almost all the development of the pistachio industry in Tunisia is based on this cultivar. Few other local varieties are cultivated in specific localities from which it took its names as ‘Meknassy’ cultivars in the region of Meknassy (Sidi Bouzid), ‘El Guettar’ from the region of El Guettar (Gafsa) and ‘Nouri’ and ‘Thyna’ from Sfax region.

As rootstock, *P. vera* is almost the only used by growers for its good germination rate. *P. atlantica* and *P. terebinthus*, in spite of their good characteristics as rootstock are barely used because of their seed germination difficulty.

### CULTURAL CONSIDERATION

**Propagation**

T-budding is the most common propagation method. The budding is performed in July at the nursery on seedling of *P. vera*. The following winter trees are planted in the orchard.

**Pruning**

The training system used for pistachio is usually the open vase, however a lot of orchards were grown without any training. The annual pruning is also rarely made. If it is made it is mainly to remove dried, diseased, infected, pest damaged, and non-fruiting old shoots.

**Pollination**

Pistachio trees are dioecious, with male and female flowers borne on separate trees. The designed orchard should ensure an adequate pollination. Male trees are often planted in the center of a 3 m x 3 m square of females, yielding an 8:1 ratio (Jacquy, 1973). Additional male trees are sometimes planted in border rows. Naturally, wind transports pollen from male flowers to female flowers. Efficient pollination was assured when the flowering periods of males is long enough to overlap with the female flowering. But under Tunisian conditions, a high percent of black fruit is obtained, and natural wind pollination is proved inefficient and artificial pollination was widely adopted (Mlika, 1974). The male panicle is harvested and kept on a dry, shaded place. The pollen is collected and mixed with talc (1/9 ratio) and sprayed on the female panicle early in the morning. Three to four sprays are made during the female flowering period to insure a good pollination rate.

**Pest and disease**

Pest and disease decrease quality and quantity of pistachio crop through their direct and indirect damages. Few important

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**Table 1. Pistachio production in Tunisia (2002).**

<table>
<thead>
<tr>
<th></th>
<th>Surface (ha)</th>
<th>Number of trees</th>
<th>Yield (t)</th>
<th>Yield (kg/tree)</th>
<th>Density (trees/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated crop</td>
<td>1.065</td>
<td>135,500</td>
<td>148,3</td>
<td>1,1</td>
<td>125</td>
</tr>
<tr>
<td>Rainfed crop</td>
<td>41.983</td>
<td>2,888,618</td>
<td>1,029,5</td>
<td>0,4</td>
<td>70</td>
</tr>
</tbody>
</table>

(Source: DGPA, 2002)
pests and diseases are observed for the Tunisian pistachio orchards. Eurytoma pests and diseases are observed for the Tunisian pistachio orchards. Eurytoma pest and disease management is going on in Tunisia such as: chios and Almonds. Acta Hort., 591: 395-398.


Fertilization and irrigation
Few growers fertilize and irrigate their orchards despite that the important growing areas are located on semi-arid zones with annual rainfall ranging from 150 mm to 300 mm. This could explain the low yield obtained. Some growers irrigate their orchards only during the first years of plantation.

Harvesting
In Tunisia all orchards are hand harvested from late August to early October depending on the climate and the region.

CONCLUSION
In Tunisia the culture of pistachio exists since antiquity. But, in spite of this, its development started only thirty years ago with large planting programmes. However, its production is still low and research work should be done for pistachio production improvement. Based on this statement, different researches on pistachio are going on in Tunisia such as:

- Developing micropropagation techniques for Pistacia species for rootstocks use (Chelli Chaebouni and Gouta, 2002; Chelli Chaebouni and Drira, 2002).
- Selection of male trees for Mateur cultivar under the central and southern conditions (Ghrab et al., 2002a).
- Survey and characterization and conservation of Tunisian pistachio germplasm.
- Evaluation of introduced cultivars under Tunisian conditions.

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MONOECIOUS PISTACHIO CULTIVARS

INTRODUCTION
All Pistacia (Anacardiaceae) species are dioecious and wind is the pollinating agent (Zohary, 1952). For commercial pistachio orchards, approximately one male tree is necessary for 8 - 11 females (Maranto and Crane, 1982). As a result, approximately 10% of a typical pistachio orchard is not productive. In the literature, only three cases of exceptional sex types in Pistacia were reported. Firstly, Özbek and Ayfer (1958) found two hermaphroditic trees in Gaziantep province of Turkey. They supposed that these trees were either seedlings of Pistacia vera L., or hybrids between P. vera and P. terebinthus. The second report by Crane (1974) described three trees with exceptional phenotypes: (I) a branch bearing staminate flowers on a P. atlantica female tree, (II) a hybrid between P. vera and P. atlantica bearing approximately equal numbers of stamine and pistillate inflorescences that are mostly on separate branches, and (III) a similar hybrid, predominantly stamine, but several branches bear pistillate inflorescences. Recently, Kafkas et al. (2000) reported a few monoecious P. atlantica trees in the Yunt Mountains of the Manisa province of Turkey. The distribution of stamine and pistillate inflorescences was found variable between trees. They found nine monoecious trees with three different types: (Type I) all branches of one of the trees were ‘fully monoecious’ i.e., they bore a mixture of male and female inflorescences. (Type II) three trees had several branches with only stamine flowers, while the rest of the branches bore pistillate inflorescences. (Type III) Five other trees had inflorescences of both sexes on several branches, and pistillate inflorescences on the remaining branches. The authors tested pollen germination of monoecious trees and used them for pollination with P. vera. The pollen germination rates were similar with normal male trees of P. atlantica and the hybridization with P. vera resulted normal fruit set and viable seed production.

By using the preliminary results on these monoecious trees, a project supported by The Scientific and Technical Research Council of Turkey (TUBITAK) was started in the spring of 2001 by planning of a large scale of crosses with the aim to develop monoecious pistachio cultivars and to understand sex mechanism in Pistacia. In this paper, current status of the project is reported.
MATERIALS AND METHODS

Type I (all branches bore a mixture of male and female inflorescences) and Type II (a tree has several branches with only staminate flowers, while the rest of the branches bore pistillate inflorescences) monoecious trees found by Kafkas et al. (2000) are the main materials of this study. Figure 1 shows some pictures from the fully monoecious tree (Type I). These trees were used both as female and male parents in this study. Additionally, two female P. vera cultivars (cvs ‘Siirtl’ and ‘Ohadi’) with a dioecious female P. atlantica tree as maternal tree, and dioecious male P. vera and P. atlantica trees were used as pollinators. Totally, twenty different crosses were performed between five female and four male parents.

Before the stigma becomes receptive, female inflorescences were closed with a paper bag (Figure 1D). To collect pollen from male parents for artificial pollination, staminate branches of four pollinators were cut and put in water-containing pots in the laboratory to perform pollen tests and cross-pollination. In the following two days, pollen was collected and stored at -20°C until pollination. Wheat flour was used as a mixing agent with pollen at a ratio of 1:1.

The harvested nuts were stratified for 60 days and then they were germinated in the greenhouse. Germinated plantlets were transplanted into the five liter plastic bags. The plants were transplanted to the orchard in the autumn of 2003 and drip irrigation is to be set up in 2004.

Besides artificial pollination, the parents used in this study were described morphologically. The progenies between P. atlantica genotypes and four pollinators were also characterized. The distribution of male/female branches/inflorescences in the monoecious trees was observed year to year by labeling them within the tree as well. When the progenies will reach the reproductive stage, they would be tested for their sex type, and they will be used as breeding parents to try to obtain monoecious cultivated pistachios with high quality nuts. The segregating populations will also be used to understand sex mechanism in Pistacia and will be used for molecular studies to clone gene(s) that are responsible for sex determination.

RESULTS AND DISCUSSION

Artificial pollination was made during three years. In 2001, the crosses between P. atlantica and four pollinators, in 2002 the crosses between P. vera and the pollinators, and in 2003 additional crosses were performed to increase plant numbers. The crosses between P. atlantica and four pollinators were made in Manisa province, whereas the crosses between P. vera and the pollinators were performed in Gaziantep Pistachio Research Institute placed 1200 km far from Manisa province. The pollens were transported to Gaziantep province in dry ice. Table 1 shows targeted and current plant numbers in this project. We aimed to obtain 500–700 seedlings from the crosses between P. vera cvs and monoecious P. atlantica Type I, 100–200 seedlings from the crosses between P. vera cvs and monoecious P. atlantica Type II, 50–100 seedlings from rest of the crosses. Totally it is targetted to have 2000–3400 seedlings in the project. Currently, we completed all the combinations and we have totally 3054 seedlings in plastic bags. However, we also did additional crosses in (2003) to increase plant numbers especially between P. vera and monoecious genotypes.

Table 1. Targeted and current plant numbers in the crosses.

<table>
<thead>
<tr>
<th>No</th>
<th>Female</th>
<th>Male</th>
<th>Targeted plant numbers</th>
<th>Current plant numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P. atlantica</td>
<td>*M-PA-Type I</td>
<td>50-100</td>
<td>108</td>
</tr>
<tr>
<td>2</td>
<td>P. atlantica</td>
<td>M-PA-Type II</td>
<td>50-100</td>
<td>108</td>
</tr>
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<td>3</td>
<td>P. atlantica</td>
<td>P. vera</td>
<td>50-100</td>
<td>108</td>
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<tr>
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<td>P. atlantica</td>
<td>P. atlantica</td>
<td>50-100</td>
<td>108</td>
</tr>
<tr>
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<td>M-PA-Type I</td>
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<tr>
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<td>58</td>
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<tr>
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<td>P. vera</td>
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<td>120</td>
</tr>
<tr>
<td>20</td>
<td>P. vera cv. Siirt</td>
<td>P. atlantica</td>
<td>50-100</td>
<td>111</td>
</tr>
</tbody>
</table>

Total plant numbers

2000-3400

3054

M-PA: Monoecious P. atlantica

Figure 1. (A) The fully monoecious P. atlantica tree, (B) a view from branches of the fully monoecious tree (F: pistillate inflorescences, M: staminate inflorescences), (C) close up view of the staminate and pistillate inflorescences in a branch, (D) P. vera cv. Siirt cultivar tree with bagged branches.
During the last three years, we have observed also hermaphrodite flowers in some inflorescences of the fully monoecious tree. But they were not stable, because the numbers of anthers in a flower changed from 1 to 6. Figure 2 shows variations in the hermaphrodite flowers of Type I tree. In this tree, only several of the inflorescences were fully hermaphrodite and a few of the others showed not only hermaphrodite flowers but also had staminate pistillate flowers as well. In some inflorescences, one side showed staminate flowers and the other side had pistillate flowers, and hermaphrodite flowers were in the middle of them. Also, several stamens having stigma as in the pistils (Figure 2C) were found. In 2001, these inflorescences were bagged without pollination and obtained 6 nuts raising five P. atlantica seedlings. In 2002, open pollinated nuts of these inflorescences were germinated yielding 50 seedlings. In 2003, these inflorescences were bagged and pollinated with Type I pollen and now we have 48 seeds.

A pistachio cultivar that has both staminate and pistillate or hermaphrodite inflorescences in a single tree, together with high yield of quality nuts, would eliminate the need for male trees in the orchard and increases the yield per hectare by about 10%. Furthermore, proandroidy is a very common problem in pistachio orchards in Turkey and also in some of the other pistachio producer countries. Therefore, the importance of a developing monoecious pistachio cultivar in pistachio production and cultivation is clear. In the first cycle, we are not expecting to have a monoecious genotype with high yield and quality nuts because of the hybridization of P. vera with the wild species. But, having segregating monoecious populations in the first cycle and isolating the related genes and transferring them or performing second cycle crosses, there may arise a cultivated monoecious pistachio cultivar with high yield and quality.

Sex determination mechanisms in plants are diverse, and may involve either sex chromosomes such as in Actinidia (Mcneillage, 1991) or individual sex gene(s) as in Cucumis (Perl-Treves, 1999). In Pistacia, the genetic mechanism of sex determination is still unknown. But, knowing the segregation of sex types in the progenies of this project may explain sex inheritance and mechanism in Pistacia.

ACKNOWLEDGMENTS
The authors acknowledge the support of S. Karaca during the cross pollination study in the Manisa province of Turkey. This project is supported by The Scientific and Technical Research Council of Turkey (TUBITAK).

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Despite of pistachio resistance to different well-known environmental stresses (drought, salt, unfavourable soils), this tree suffers from some serious stresses like spring chilling. This injury can even negatively affect crop yield. This stress specially affects many temperate-zone orchards of pistachio every year in Iran, causing significant yield losses and general tree weakness, and severely alternate bearing. Varying regarding on different temperatures; these damages occurred through decreasing fruit set rate as effective pollination period (through stigma and style deterioration, decreasing ovary reception period and flower age, and increasing pollen tube growth period), female flower abscission, inflorescence die back, and flower buds’ death and abscission could occur.

A research project has been directed to study the effects caused by this stress, strains, and the level of damages in different temperatures. Here, some results are briefly presented.

The project involves simulated chilling stress in laboratory, simultaneous to outdoor temperature decrease, resulting in remarkable effects on pistachio flowering and pollination in early spring 2003, we could compare our lab results with field observations and records.

In order to study the stress, shoots containing flower buds from cultivar “Ohad” in different phenological stages (bud, blooming and full-bloomed inflorescence) were collected and transferred to a controlled low temperature chamber. Temperature was reduced to 2°C in one hour. Every hour, some bud and shoot samples were assessed looking for macro- and microscopic visible injuries.

Chilling could adversely affect the reproductive structures in different thermal based and morpho-anatomical levels. The most severe injuries (from lower to higher temperatures) were complete flower buds, current spring shoot (containing inflores-
Injury level analysis
Flower buds: their chilling resistance is the highest among all reproductive structures and organs. Their resistance, however, decreases as they finish their dormancy period, especially before bloom. Light injury (low to about -4°C for about 2h) could lead to their delayed bloom with some blooming and flowering abnormalities. Deeper injury (about -4 to -6°C for about 6-8h) resulted in the necrosis and deterioration of very young pistils in closed buds (Picture 1).

Inflorescences: in the first visible injury level, the tip vegetative growth (on the inflorescence shoot) became darker green in color. In this stage, the fertilization rate and subsequent fruit set can decrease, possibly because of negative effect of the low temperature on the pollen tube growth and shortening physiologically effective age of the pistil. With more temperature reduction (low to about -2°C for about 2h), stigma, and then style showed morphological necrosis and anatomical deterioration, which resulted in pollen germination and tube growth inhibition (Picture 2). Complete necrosis of flowers, and then, inflorescence, caused by about -4°C for about 2h, was observed (Picture 3).

Comparing this simulated pattern of injury in laboratory, with injuries records from orchards, showed that we can predict and determine injury level and subsequent events in fruiting and abscissions based on field temperature data. For example, due to temperature drop, down to 2°C for about 2 hours, it could be foreseen that a decrease in fruit set would happen as result of delayed pollen tube growth, without visible symptoms. In some areas, lower temperatures caused visible injuries of stigma, resulting in problemmes in fertilization. We are developing a model based on environmental temperature (with other climatic parameters) data and females’ injuries, to make our cultivations ready for next years potential spring chilling stress. By the way, since the early season cultural practices may affect phe-nology of female flowers, especially the time of bud bloom, this model can also be useful for reliable cultural programming.

UNDERGROUND DRIP SYSTEM:
THE NEW IRRIGATION METHOD FOR PISTACHIO AND ALMOND ORCHARD IN TURKEY

It is well known that pistachio trees (Pista-cia vera L.) are drought resistant. In Turkey the crop was not irrigated until recently. During the last decade seminars and meetings on Pistachio production and management were given by Prof. Kaska and Ak to farmers. They both tried to convince farmers to irrigate pistachio trees, when water supply is available. Farmers believe that pistachio trees should not be irrigated, because they would die. This belief is only true when a wrong irrigation method is applied.

Commercial orchards are budded onto Pistacia vera rootstocks. This rootstock is susceptible to some diseases. We tell growers the usefulness of applying a sound irrigation system. Some farmers have started to irrigate by tanker system. They have seen that irrigation is useful for pistachio trees. They recognized its effects on reducing alternate bearing.

When irrigating pistachio trees some changes could occur as below: Tree growth will be higher, leaf size will be bigger, the number of current year’s shoot length will be increased, yield will be increased, nut size will be higher, splitting percentage will increase, blank nut rate will be reduced, and less alternate bearing.
Irrigation by underground drip systems are being used on olive plantations in Spain. This system has been started to be used for pistachio and almond orchards in Turkey. However farmers are not confident with this method. The advantages of underground drip irrigation system are mentioned as follows: lower water consumption, better water distribution, greater uniformity, waste water can be used, less evaporation, greater transpiration, location of fertilizer, less calcification, less diseases, possibility of tillage, reduction of labour, longer lasting, no vandalism.

All above advantages are valid for all kind of fruit trees. In fact, currently this system is experimentally being used in pistachio orchards at Ceylanpinar State Farm (South Anatolia). The yield seems to become more regular, as there is strong alternate bearing, especially in the ‘Kirmizi’ cultivar. This underground irrigation system was established in 200 areas where the adult trees are 30 years old, using ‘Siirt’ and ‘Kirmizi’ cultivars. The depth of the watering line is at approximately 20-25 cm deep, under the soil surface.

In Sanliurfa, a private investor, established a new almond orchard in 2002 by using this underground drip irrigation system. There were planted 30 ha of almond trees budded 6m x 6m onto bitter almond rootstocks. The cultivars were ‘Ferragnes’, ‘Ferraduel’, ‘Lauranne’, ‘Berta’ and ‘Felisia’. The new orchard for pistachio cv ‘Siirt’ and old orchard cv. ‘Kirmizi’ and ‘Ketengömeği’ have been started to irrigate with an underground drip irrigation system.

As a result, irrigation is a big revolution for pistachio industry in Turkey. In the future the beneficial effects of irrigation will be clear and all possible trees will be irrigated. The researches on this subject are being developed at the Pistachio Research Station in Gaziantep, the University of Kahramanmaraş and Pistachio Research and Application Center, University of Harran in Sanliurfa. In addition, almond orchards are expanding at South-eastern part of Turkey. The ecology is very suitable and the farmers prefer almond trees because of their many advantages.

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INTRODUCTION

In recent years, improvement and optimization of different stages of pistachio production, processing and handling, has been important and has affected most research, extension, and governmental programmes and activities. These significant efforts have been directed to increase the quality and health of pistachio product regarding different aspects: harvest, post-harvest, processing, transportation and marketing. This is based on international standards, and taken place in order to protect public health of domestic and foreign pistachio consumers. Here, we summarize Iranian programmes and activities to reach this aim.

GOVERNMENTAL AND ADMINISTRATIVE WORKS

The government of Iran, as one of the effective and active members of WHO, is committed to supply healthy and safe products to international markets, and tries to use modern technology in various stages of production:

- Organizing the pistachio committee in the Ministry of Agriculture and by attending the representatives from related ministries and organizations (Ministry of Health and Medical Education, Customs, Ports and Shipping, Iranian center for development of export, Ministry of foreign affairs, Iranian institute of standards, Pistachio research institute etc.)
- Organizing the pistachio staff and aflatoxin committees
- Preparation and distributing of manuals and technical publications plus 90,000 sheets of posters, 85,000 sheets of tracts, more than 500 m wall writings, and several extensional films among the pistachio growers.
- Holding training workshops in order to retraining horticultural exports and promoters.
- Convening nationwide seminars on aflatoxin in pistachio
- Convening executive and applied workshops and seminars for growers to develop modern and standard cultivation (e.g. pruning, methods of fertilization e.g. microelement application and deep placement fertilizer), harvesting (to develop on time harvest with proper equipment and proper transport), processing (specially drying process) etc.
- Huge investment to develop establishment, mobilization and equipping current processing terminals and 634 new lines of hygienic processing of pistachio.
- Organizing product forewarning networks with cooperation of research centers, Iranian Ministry of Health and Medical Education and Academic departments of plant protection, in pistachio cultivating provinces, in order to study and announce the most proper time of harvest. This action has lead to significant decrease of pistachio early split and aflatoxin contents.
- Implementing the national project of "pistachio production structural improvement in country" within the last few years in ten main pistachio cultivation provinces. This project covers applying different technical methods to decrease and remove the risk of aflatoxicity of the crop.
- Persuasion of pistachio growers to change their traditional methods of all pistachio cultivation practices, specially a decrease of pesticides (which lead to reduce to 37.5% per surface unit).
- Establishing the nationwide union of pistachio production cooperative companies in order to organizing and activating the cooperative companies in pistachio cultivation areas.

RESEARCH ACTIVITIES

In recent years many projects have been developed and directed to find and adapt approaches to improve pistachio quality. A huge effort has been spent to carry out many research and research-extensional projects and activities aiming to develop most proper ways of production and processing. Their results have been applied to obtain higher quality product, and now we can see the results of all the referred activities.

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Pistacia vera L. 1753 IN IRAN

INTRODUCTION

The history of pistachio production and business in Iran is long. The reason is that the origin of pistachio trees was the Iranian plateau and the first pistachio trees were first grown by Iranians. The widest natural pistachio forests have been found in Iran. Expanding of pistachio gardens and improved quality and quantity of Iranian pistachio products have not acquired all at once. But it is the result of nonstop efforts and creativity of Iranian farmers and gardeners during the last centuries.

The wild species of Pistacia vera is the origin of all domesticated pistachio cultivars in Iran. Since thousands of years ago, the nuts or scions of this wild species have primarily transferred to Khorasan and then to other parts of Iran. Abrishami informed that at Safavieh times the pistachio nuts and scions were introduced to Kerman province for the first time (Abrishami 1994). Today, Kerman and Rafsanjan are the main pistachio producing regions in Iran.

The study of the ecological distribution and genetic diversity of Iranian wild pistachios might be a functional mean to select convenient and resistant rootstocks for Iranian domestic pistachios (Behboodi 2003).

BOTANICAL CHARACTERISTICS OF P. vera

The genus Pistacia belongs to the Anacardiaceae family. There are two synonyms for P. vera, which are P. reticulata Wild 1797 and P. trifolia L. 1753. P. vera is a dioecious plant and the only distinguishing trait between female and male trees are their flowers at flowering time.

Trees 3-8 (-10) m high, cortex brownish, becoming gray. Leaves deciduous, coriaceous, imparipinate. Leaflets 1-2 (-3) pairs, sometimes with only one leaflet, glabrous or along the mid rid puberulent, upper surface smooth, lower surface opaque, ovate or orbiculate, apex abruptly acuminate, acute, rarely obtuse, 5-10 (-12) cm x 3-6 (-8) cm; rachis terete, puberulent. Fruiting panicle upright straight. Drupe 10-20 cm x 6-12 mm, oblong-linear or ovate, apiculate (Rechinger 1969).

DISTRIBUTION OF P. VERA FORESTS

Native P. vera forests are placed in northeastern part of Iran, particularly in Sarakhs, Zoor-Abad, Jam and Tayebad.

The forest of P. vera in Sarakhs
These forests extend to Bokhara and Samarghand in Turkmenistan from the north, to Balkh, Thaleghan, and Harat in Afghanistan from the east. In Sarakhs region, more intense forests are seen at Tchahtchahe, Khabeh, and Ameneh Mo-rad-Tappeh. These jungles have sporadic sparse of trees with diffuse spread of pistachios. Male and female pistachios are mixed through these forests.

The extend of P. vera forests have been estimated about 75,000 ha and the main forest of Sarakhs is about 17,500 ha. In the last century, these forests have faced intensive human damages. The grassed grounds of P. vera forests have encountered overgrazing of livestock belonging to the different Iranian tribes who live in this region and the wood of pistachio trees has been used for their thermal requirements. For these reasons, the extension of P. vera forests have dramatically reduced and the distance between pistachio trees has enlarged.

P. vera is not found as forest in other regions of Iran. Thus it seems that these trees have been adapted to the ecologic condition of this region. P. vera is the origin of all cultivated Iranian domestic cultivars. The Gazvini cultivars, regarding nut appearance, are similar to wild P. vera, in which both of them have small nuts. In addition, the nuts of P. vera are similar to those of small Badamy cultivars.

**Distribution of P. vera according to ecological factors**

P. vera species is extended from north-west to south-east of Sarakhs region at 300-1500 m high. The average yearly rainfall in these regions is about 200-300 mm and the average daily temperature is between 10-20 ºC. Considering resistance of P. vera trees regarding the change of day and night temperatures, its low water requirement, and the absence of Gummous disease for wild P. vera, it is possible to use it as resistant rootstock for pistachio or to cross it for hybridization to improve the quality of cultivated pistachios in the future.

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**Pistacia atlantica**

**Desf. 1800 in Iran**

**Introduction**

Three important Pistacia species P. vera, P. khinjuk and P. atlantica are found in Iran. For this reason Iran is regarded as pistachio origin and rising. The synonym species of P. atlantica is P. mutica Fisch and C.A. May 1838. This species has three subspecies in Iran, which are different in their botanical appearance.

**Botanical Characteristics of P. atlantica**

Trees up to 7 m high. Leaves deciduous, imparipinnate, leaflets 2-4 (-5) pairs, form and size very variable, rotundate-ovate, oblong, or lanceolate, (2-)
Leaves of *P. atlantica* sub-sp. *mutica*

Leaves of *P. atlantica* sub-sp. *kurdica*

Leaves of *P. atlantica* sub-sp. *cabulica*

2.5-8 cm x 0.7-2 (-2.5) cm, obtuse or blunt at apex, never mucronate, at margin ciliate, becoming glabrous, nerves inconspicuous or slightly conspicuous. Rachis marginate or narrowly winged. Male inflorescence paniculate, 2-8.5 cm x 6-9.5 cm, different in subspecies. Flowering time early spring. Fruit drupe, with aromatic pericarp, seed oily (Rechinger 1969).

**WORLD GEOGRAPHIC DISTRIBUTION OF *P. atlantica***

*P. atlantica* is located in the Atlantic region, Turkey, Iran, Caucas, Afghanistan, Pakistan, Iraq, Syria, north Africa, and Algeria. However its origin is Iran, but it has expanded from east to southwest of Europe and from southeast to North of Africa and the Canary islands.

**P. atlantica subspecies in Iran**

Rechinger classified *P. atlantica* into three subspecies: *mutica*, *kurdica*, *cabulica* (Rechinger 1969). However non-Iranian botanists have not accepted this classification.

**P. atlantica subspecies *mutica*** (Fish and May) Rech. 1969

Rachis winged up to terminal leaflets, leaflets narrowly oblong, 3-8 cm x 1.5-3 cm, at margin ciliate. Drupe slightly broader than long. This subspecies is located in Turkey, Iran, and the Caucus. In Iran, it is found in northwest, northeast, center, east and south including Azerbaijan, Esfahan, Kohkiloeye Va Boyer-Ahmad, Fars, Kerman, Khorasan, Yazd, Semnan and Tehran provinces.
P. atlantica subspecies kurdica (Zohary) Rech. 1969
Rachises winged up to terminal leaflets, leaflets ovate, 4-9 x 2-5 cm, glabrous or rarely ciliate at margin. Fruits depressed-globouse, 5-8 mm x 8-10 mm. This subspecies, apart from Iran, is distributed in Iraq, Syria, and Turkey. In Iran it is native in Azarbaygan, Kurdestan, Kermanshan, Kohkloyeh Va Boyer-Ahmad, and Tehran provinces.

P. atlantica subspecies cabulica (Stocks) Rech. 1969
Leaflets (2) 3-4 pairs, which are lanceolate, attenuated at the ends, 3-4 times longer than broad. Drupe globose, with equal long and broad. This subspecies is found in Afghanistan, Pakistan, and Iran. Its distribution in Iran is mainly limited to southeast and central parts of the country where Hormozgan, Kerman and Balochestan provinces are placed.

Ecological distribution of P. atlantica subspecies
P. atlantica subspecies mutica is found between 900-2800 m of height. The mean yearly rainfall is between 200-400 mm in these regions and the mean of yearly day temperature is between 15-20 ºC.

P. atlantica subspecies kurdica is distributed in heights between 900-2800 m where the yearly rain mean is about 500-600 mm and the average of yearly day temperature is flanked by 5-15 ºC. The distribution of P. atlantica subspecies cabulica is essentially restricted to Iran southeast where the height of lands alters from 50 m to 2500 m. The subspecies cabulica is able to grow in poor soils. The mean rainfall in its growing places is yearly lower than 100 mm and increases to 200 mm as maximum. The average day temperatures are 15-25 ºC yearly. It is the most tolerant subspecies regarding low water requirements and standing high temperatures (Behboodi 2003).

CONCLUSIONS
The subspecies cabulica’s tolerance is higher than in other P. atlantica subspecies regarding enduring of xerothermic and warm weather. Thus to improve domestic pistachios we suggest to use subspecies cabulica rootstocks for breeding with cultivated rootstocks or to produce new rootstocks using P. vera x P. atlantica subspecies cabulica or P. khinjuk x P. atlantica subspecies cabulica hybrids (Behboodi 2003).

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INTRODUCTION
The scientific name of *Pistacia khinjuk* derives from the Persian word “Khennjok” and the origin of this word is the Korasan province of Iran. This species is the synonym of the species *P. acuminata* Boiss and Bushe 1860. *P. khinjuk* is described as “Lentisque de Bombay” in French language, as “Östindischer Mastix” in Germany, and in English as “East Indian Mastiche”. The *P. khinjuk* trees are widely distributed in several mountainous regions of Iran. It is resistant against xerothermic conditions and hot and cold weather. These properties suit it for grafting of pistachio trees (Behboodi, 2003).

BOTANICAL CHARACTERISTICS OF *P. khinjuk*
Trees are dioecious, 3-7 m high, cortex smooth, grey coloured. Leaves deciduous, imparipinnate, sometimes (var. populifolia Boiss.) reduced only to one terminal leaflet, pubescent, velvety, becoming glabrous in age, petiole terete, leaflets 1-2 (3) pairs, 3-10 cm x 1.5-7 (-8) cm, broad ovate, oblique, narrowed suddenly into a ± acuminate apex, on the upper surface shiny. Fruiting panicle straight. Drupe 4-6 mm x 4-5 mm, globose, subcompressed, suboblique, apiculate (Rechinger 1969).

DISTRIBUTION OF *P. khinjuk*
*P. khinjuk* is reported to spread in Iran, Turkey, Pakistan, Iraq, Syria, North Africa, and Palestine.

DISTRIBUTION OF *P. khinjuk* IN IRAN ACCORDING TO ECOCLOGICAL FACTORS
*P. khinjuk* is distributed in west, center, east, south, and east-south of Iran, in Kurdistan, Lorestan, Esfahan, Kohkilo-yeh Va Boyer-Ahmad, Farse, Hormozegan, Kerman, Balotchestan, Khorasan, Semnan and Tehran provinces. Only a thin north band in Gillan and Mazandaran provinces, on the coast of Caspian sea is blank of this species. *P. khinjuk* spread at 700-2000 m heights on hills, flats and on medium heights of Alborze and Zagrose mountains. This species withstands to most trouble weather situations. The average rainfall of its growing areas alters from 100 mm to 600 mm and the mean temperature varied from 10 ºC to 25 ºC. *P. khinjuk* is the most interesting pistachio species in Iran as it grows in different regions and diverse climates. It is exclusively distributed as continuous populations or accompanying with subspecies of *P. atlantica*. Distribution of this species is not affected by wide ranging changes in day and night temperatures, height, and low rain. It is adapted to xerothermic weathers, soil sorts, and difficult environmental situations (Behboodi 2003).

Using *P. khinjuk* rootstocks alone, or utilizing its hybrids such as *P. khinjuk × P. atlantica* subspecies mutica or *P. khinjuk ×
P. atlantica subspecies cabulica or P. khinjuk x P. vera may assist breeding programmes to obtain resistant pistachio rootstocks.

GERMLASM COLLECTION OF *Pistacia* AT THE JACOB BLAUSTEIN INSTITUTE FOR DESERT RESEARCH. PHENOTYPIC TRAITS AND MOLECULAR MARKERS

Natural habitats are shrinking in the world, causing reduction in genetic variability of plants with important economical value. Shift from traditional agriculture of *Pistacia vera* L. (pistachio nut tree, Anacardiaceae) to modern agriculture, ‘disturb’ the genetic pool of the existing natural population of this species by introduction of selected cultivars. The lengthy process of cultivars selection leads on one hand to yield producing crops, but on the other hand to a loss of important traits. Wild relatives of crop species are thus useful as potential genotypes in breeding programmes. Gene banks and live germplasm collections are important in the conservation of the genetic variability, which still exists at a rather limited scale in the wild.

At the Jacob Blaustein Institute for Desert Research (BIDR), Ben-Gurion University of the Negev, Israel, a live germplasm collection of *Pistacia* species was established (Golan-Goldhirsh and Kostiukovsky, 1998). The collection consists of ca. 600 accessions of *P. vera*, *P. atlantica*, *P. khinjuk*, *P. chinensis*, *P. lentiscus*, *P. terebinthus*, and *P. palaestina*. All plants growing in the field collection developed from seeds collected from natural populations of *Pistacia* spp. around the Mediterranean basin, and Asia (Table 1). The BIDR germplasm collection at its current status serves as a small-scale gene bank, representing the genetic variability that occurs in nature. Thus, offering an opportunity to study the genetic relations among and within *Pistacia* species. Young trees (6 to 8 years old) are growing under similar growth conditions and therefore, any phenotypic variability can be related to genetic difference (see Fig. 1). During the last few years we characterized the germplasm by assessing phenotypic traits, following plant growth rate and related these to molecular markers.

Molecular marker techniques, amplified fragment length polymorphism (AFLP) and random amplified polymorphic DNA (RAPD) as well as morphological descriptors and plant growth parameters (following IPGRI descriptors for *P. vera*, 1997) were used to assess the relationships among *Pistacia* species and among accessions of *P. vera* (Barazani et al., 2003; Golan-Goldhirsh et al., 2004).

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Distribution of *P. khinjuk*

Nuts of *P. khinjuk*
Zohary (1952), in his famous monograph on *Pistacia* spp. divided the eleven species of the genus into four different sections (Fig. 2). The three evergreen species of the genus: *P. lentiscus*, *P. weinmannifolia* and *P. saportae* were included in the section *EU Lentiscus*; the two American species were clustered in the section *Lenticeula*; in the section *EU Terebinthus* he included the five species *P. terebinthus*, *P. palaestina*, *P. vera*, *P. khinjuk*, and *P. chinesis*, while *P. atlantica* was separated into a single section *Butmela* (Zohary, 1952). Studies conducted at BIDR germplasm collection on the relationship among *Pistacia* species using genetic marker techniques (Golan-Goldhirsh, 1995), pointing to the significance of the germplasm collection at BIDR and its potential use for development.

The germplasm collection at BIDR includes accessions of *P. vera* that were developed from seeds collected from Baghuz, Turkmenistan. There, natural stands of *P. vera* still exist in two populations, Kepele and Agachli, close to the Iranian and Afghan borders. Plant growth parameters (plant height and trunk diameter) over two years of measurements at the collection site indicated that accessions from Agachli had higher growth rate than those of Kepele. Statistical analysis showed that these differences were significant at 96% and 94% levels for plant height and trunk diameter, respectively (Barazani et al., 2003). Agachli accessions can therefore be considered for future breeding programmes of *P. vera*. Moreover, significant statistical relation was found between plant growth rate and the genetic matrix as was assessed by RAPD (Barazani et al., 2003). Trees in the two populations, Kepele and Agachli, although geographically close, grow in different habitats, which probably led to the genotypical differences.

The pistachio tree is an important nut crop in many countries. However, *P. atlantica*, *P. khinjuk*, *P. palastaena* and *P. terebinthus* are used by local farmers in the Middle East as rootstocks for grafting of *P. vera*. Therefore, wild relatives of *P. vera* still exist in two populations, Kepele and Agachli, developed from seeds collected from Baghuz, Turkmenistan. There, natural stands of *P. vera* still exist in two populations, Kepele and Agachli, close to the Iranian and Afghan borders. Plant growth parameters (plant height and trunk diameter) over two years of measurements at the collection site indicated that accessions from Agachli had higher growth rate than those of Kepele. Statistical analysis showed that these differences were significant at 96% and 94% levels for plant height and trunk diameter, respectively (Barazani et al., 2003). Agachli accessions can therefore be considered for future breeding programmes of *P. vera*. Moreover, significant statistical relation was found between plant growth rate and the genetic matrix as was assessed by RAPD (Barazani et al., 2003). Trees in the two populations, Kepele and Agachli, although geographically close, grow in different habitats, which probably led to the genotypical differences.

The pistachio tree is an important nut crop in many countries. However, *P. atlantica*, *P. khinjuk*, *P. palastaena* and *P. terebinthus* are used by local farmers in the Middle East as rootstocks for grafting of *P. vera*. Therefore, wild relatives of *P. vera* still exist in two populations, Kepele and Agachli, developed from seeds collected from Baghuz, Turkmenistan. There, natural stands of *P. vera* still exist in two populations, Kepele and Agachli, close to the Iranian and Afghan borders. Plant growth parameters (plant height and trunk diameter) over two years of measurements at the collection site indicated that accessions from Agachli had higher growth rate than those of Kepele. Statistical analysis showed that these differences were significant at 96% and 94% levels for plant height and trunk diameter, respectively (Barazani et al., 2003). Agachli accessions can therefore be considered for future breeding programmes of *P. vera*. Moreover, significant statistical relation was found between plant growth rate and the genetic matrix as was assessed by RAPD (Barazani et al., 2003). Trees in the two populations, Kepele and Agachli, although geographically close, grow in different habitats, which probably led to the genotypical differences.

ACKNOWLEDGMENTS

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WHERE IN A PISTACHIO TREE IS \textit{Xanthomonas} AND HOW DID IT GET THERE?

BACKGROUND
\textit{Xanthomonas translucens} has been identified as the probable causal agent of dieback of pistachio (\textit{Pistacia vera}) in Australia. The bacteria have been regularly isolated from twigs with internal staining from diseased trees. The location of \textit{Xanthomonas} in other parts of the tree and the identification of possible entry points are the focus of research in progress at the Sunraysia Horticultural Centre (Vic) and the University of Adelaide (SA).

INVESTIGATION
In spring 2001 we performed various surveys to determine the tissues in which bacteria are most likely to be found. Hundreds of inflorescences and individual male and female flowers, leaves, vegetative buds and current season growth were examined for the presence of the bacteria. Bacteria were present in male inflorescences, leaves and current season growth from highly diseased trees. We also felled diseased male and female trees and healthy male trees at Kyalite (NSW) to locate the bacteria, through laboratory isolations, in different parts of the wood. Samples of wood from the rootstocks up to one-year old twigs, and tissues from young and old sapwood and heartwood were also examined.

\textit{X. translucens} was located mainly in the young, unstained or stained sapwood of the main trunk (Figure 1), primary branches and younger branches. The bacteria were rarely found in discoloured heartwood (dark heartwood is normal in mature trees) (Figure 1), and incidence in leaves was very low. Root and soil samples did not yield \textit{Xanthomonas}. Bacteria or pathogenic fungi were not found in the bark and cortex associated with lesions whereas the stained young xylem beneath the lesions yielded \textit{Xanthomonas} (Figure 2). Scanning electron microscopy is being used to confirm these results. Experiments were initiated in the glasshouse or shade house to determine if pruning wounds and/or scars are possible entry points for the bacteria. We inoculated pruned branches (Figure 3) and leaf scars (Figure 4) on young trees with suspensions of bacteria. Also, attempts are made to introduce the bacteria into the trees by injection (Figure 5) to simulate entry via an insect vector or wound, and to produce symptoms similar to those observed in the field. Results from these experiments will also indicate how fast the bacteria move in the trees.

In the coming months, roots and flowers will be inoculated with the \textit{Xanthomonas} bacteria to determine if those are also possible entry points.

SUMMARY
We have determined where \textit{Xanthomonas translucens} is located in the trees. Results from the ongoing experiments will clarify how the bacteria got into the trees.

More research is needed to determine the ways of dispersion of the bacteria in the orchard and to elucidate the cycle of the disease. Other experiments will be set up to study possible control measures.

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CHESTNUT PRODUCTION IN ANDALUSIA

INTRODUCTION
Last data about Spanish chestnut production estimates 18.259 t in Spain, half of the amount achieved in the seventies. That production corresponds to approximately 50,000 ha out of the 128,537 ha existing in Spain. Though chestnut production is located mainly in North Spain, an interesting area for chestnut production is localised in Andalusia, South Spain (Pereira et al., 2001). Production in Andalusia is considered to be only 2,000 t but it could be underestimated according to marketing data and it could reach 6,000 t in 8,000 ha. There are two main areas: i) Sierra de Huelva in Huelva province (Figure 1), and ii) Serranía de Ronda (Figure 2) and Sierra de Las Nieves, Málaga province. Other chestnut areas are located in Granada, where new orchards are
being established (Figure 3) though traditionally chestnut production came from seedlings. Chestnut is an interesting alternative in Andalusia, mainly in Málaga, because of the precocity of two cultivars, ‘Temprana’ and ‘Pilonga’, harvested at the end of September. Most of the production is commercialised by cooperatives where big quantities of chestnuts are cleaned and classified. Chestnuts are sold in Spain and in the international market. Recently, an important industry for transforming chestnuts has been established in Huelva. Both in Huelva and Málaga, production is based on local cultivars. Growers graft them over seedlings produced in the same area. In Málaga, due to the high prices of the nuts, trees are planted so close as 5 m x 5 m, though it is necessary to prune severely or remove part of the trees later. In Granada, no local cultivars have been found and new orchards are based on the excellent cultivars of Málaga (Figure 3). Weather conditions for chestnut areas in Spain are quite similar (Table 1), with a rainfall around 1,000 mm per year and mild temperature...
res. Chestnut orchards in Tenerife showed lowest rainfall with 700 mm, followed by Castilla-León and Extremadura, around 700 mm. In Andalusia, orchards are located in the most humid areas of South Spain.

In 1995 a study was started to localise and characterise cultivars of South Spain. An inventory was published in 2001 (Pereira et al., 2001) and the results found were published in a guideline book (Pereira and Ramos, 2003) and in a work where cultivars from Andalusia were compared with previous studies (Ramos and Pereira, 2004). The paper is a summary of the main traits of the Andalusian cultivars.

**CULTIVARS**

Up to now 12 cultivars have been studied in Andalusia which are used locally for nut production and propagated by grafting (Figures 4 to 15): 'Capilla', 'Comisaria', 'Corriente', 'Dieguina', 'Helechal', 'Pelón', 'Pilonga', 'Planta Alájar', 'Rubia Tardía', 'Temprana', 'Tomasa' and 'Vázquez'.

Cultivars from Andalusia are different from cultivars from other areas of Spain (Ramos and Pereira, 2004). In comparison with those from Galicia (Pereira and Fernández, 1997) with better characteristics in nut size, but with higher percentage of poly-embryonic and split nuts, and more intrusions of the inner coat in cotyledons what makes it more difficult to peel them. Nuts coming from Andalusian cultivars showed less worms and diseases what could be related with a drier environment.

The best cultivar in Andalusia is 'Pilonga' (Figure 10) due to its early ripening (end of September), big nut size and less percentage of poly-embryonic nuts (Table 2). The worst feature of 'Pilonga' is the high percentage of split nuts, over 8 %. 'Temprana' (Figure 13), cultivated in the same area of 'Pilonga' is a little worse due to a higher percentage of poly-embryonic nuts and intrusions of the inner coat in cotyledons. 'Capilla', 'Corriente', 'Rubia Tardía'
and ‘Tomasa’, (Figures 4, 6, 12 and 14) are three excellent cultivars of Málaga, but they are harvested later than ‘Pilonga’ and ‘Temprana’, at the end of October, when most of the Spanish chestnut production is concentrated and prices are usually lower. Moreover, ‘Capilla’ and ‘Tomasa’ showed the highest percentages of split nuts and ‘Corriente’ the highest percentage of poly-embryonic nuts. In Huelva four main cultivars should be promoted, ‘Comisaría’, ‘Helechal’, ‘Planta Alájar’ and ‘Vázquez’ (Figures 5, 8, 11 and 15) due to their big nut size and low percentage of split nuts. ‘Planta Alájar’ showed a higher percentage of poly-embryonic nuts. In comparison with cultivars of Málaga, all cultivars in Huelva are harvested at the end of October, main period for chestnut harvesting in Spain, when prices are lower. Most of the cultivars from Andalusia produce pollen, since only one accession studied of ‘Helechal’ was sterile. The most frequent type of male catkin found was longunistaminate and only ‘Planta Alájar’ and one accession of ‘Dieguina’ showed mesostaminate catkins. ‘Pelón’ (Figure 9) is a very spread cultivar in Huelva that produces the smallest nuts in Andalusia what makes it less interesting for present market. These cultivars are being collected and introduced in the Universidad de Santiago de Compostela to establish a core collection.

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THE WORLD MACADAMIA INDUSTRY AND RESEARCH ACTIVITIES

INTRODUCTION

Macadamia is one of the world’s finest nuts. The kernel is consumed as salted or unsalted snack food, as chocolate enrobed confectionary, and as an ingredient in products such as biscuits or ice-cream. The kernel has a high oil content (70-80%) and most of the oil is mono-unsaturated lipids with 65.0 and 18.5% oleic and palmitoleic acid respectively (Cavaletto et al., 1966). Oil content has been shown to be an important component of quality; kernels with a specific gravity of 1.0 (oil content of more than 72%) or less were identified as having superior eating and roasting qualities and are classed as first grade kernels or the commercial standard. Total sugar content of raw M. integrifolia kernel ranges from between 3 to 5% (Riperton et al., 1938), the majority of which is sucrose.

The Macadamia genus is a member of the Proteaceae, which is a characteristic Gondwana family (Johnson and Briggs, 1983). Of the nine species, seven are endemic to Australia, with the other two occurring on the islands of Indonesia. Only two of these species, M. integrifolia and M. tetraphylla produce edible kernel. These species occur as a medium sized evergreen tree in the lowland subtropical rainforests of eastern Australia. The fruit consists of a fleshy husk (pericarp) surrounding the hard shell (testa) and the edible kernel (embryo and cotyledons) (Gross 1995).

WORLD PRODUCTION

Macadamias represent less than 2% of the world tree nut market. The market is characterised by undersupply and price fluctuations (Hargreaves 2003).

Australia

Australia is the main macadamia producer with approximately 40% of the world production or 10.000 t of kernel (Table 1). Despite recent surveys indicating that about 1/3 of the industry is new plantings, industry growth that was forecast at 15% yearly has not been reached (Hargreaves 2003) due to poor seasons in 2002 and 2003. The major growing regions are around Alstonville (28° 51’S, 153°21’E) in Northern NSW and Bundaberg (24° 33’ S, 152°00’ E) in South Eastern Queensland with approximately 45 and 35% of the Australian crop produced in these areas respectively. There is renewed interest to identify new growing areas in Australia for macadamia production. The major markets for Australian production are USA, Japan, Germany and China.

USA

Macadamias were first commercialized in Hawaii and most of the USA production continues to originate from these islands. The Hawaiian industry is characterised by mature orchards with new plantings at much smaller levels than for the other producing countries (Vidgen 2003). Domestic sales, including duty-free, are a major market of USA production. Exports are shipped predominately to Japan.

South Africa

Over 45% of the trees in South Africa are less than 5 years of age and there is the potential for significant growth of this industry (Lee 2003). Production of kernel has grown by about 30% between 2000 and 2003 to approximately 3000 t despite poor production seasons in 2002 and 2003. Half its production is exported to USA, with Europe being the next major market (25%).

Others

Macadamias are also produced in Kenya (1500 t), Malawi (1000 t), Brazil (500 t), New Zealand (35 t), Thailand and Costa Rica.

HORTICULTURE

Propagation

Macadamias are generally clonally propagated. Seedling rootstocks are common in Australia using open pollinated seed from the cultivar H2. Seedlings from other cultivars have also been used to a smaller extent. Practical experience suggests that the roots system is not well developed in cuttings of some varieties in Australia. There is little information to guide

<table>
<thead>
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<th>Region</th>
<th>2002 Carry-over</th>
<th>Import</th>
<th>Production Domestic</th>
<th>Export</th>
<th>2003 Carry-over</th>
</tr>
</thead>
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<td>0</td>
<td>9.900</td>
<td>2.000</td>
<td>7.900</td>
</tr>
<tr>
<td>Africa</td>
<td>43</td>
<td>0</td>
<td>6.440</td>
<td>190</td>
<td>6.250</td>
</tr>
<tr>
<td>USA</td>
<td>2.000</td>
<td>7.466</td>
<td>5.500</td>
<td>12.216</td>
<td>770</td>
</tr>
<tr>
<td>Latin America</td>
<td>170</td>
<td>0</td>
<td>3.370</td>
<td>300</td>
<td>3.070</td>
</tr>
<tr>
<td>Total</td>
<td>3.013</td>
<td>7.466</td>
<td>25.210</td>
<td>14.706</td>
<td>17.990</td>
</tr>
</tbody>
</table>

Table 1. Macadamia worldwide kernel production (t) (www.inc.treenuts.org)
rootstock choice, although recently an extensive rootstock trial of own rooted cutting, seedling and clonal rootstocks using 12 cultivars was established in Australia (Hardner and McConchie, 2003). Suitable scion material is selected from the desired cultivar and girdled to increase its carbohydrate content. Scions are then either grafted or budded onto the rootstock. Initial results show that budding success rate is affected by the rootstock and scion combination, which is consistent with anecdotal evidence from macadamia propagators.

Orchard design

Orchards are established at varying densities from 10m x 10m (100 trees per ha) to 7m x 4m (357 trees/ha). Tree size varies among cultivars (Hardner et al. 2002) and may influence planting density. There has been trend in recent years to establish orchards at higher densities to offset high initial capital investments at an earlier age. In addition, there has been some practical experimentation with high density planting (5m x 2m) (Bell and Bell, 2001) that produced high yields of between 8 and 10 t/ha before canopy management, but there is little knowledge of the later age performance of trees to evaluate this system.

Irrigation

Orchards located in Queensland are generally irrigated, especially in the Bundaberg region where there is a significantly lower annual rainfall than in Northern NSW where the majority of orchards are not irrigated. Average annual rainfall for Alstonville in Northern NSW and Bundaberg is 1600 mm and 1140mm respectively. Stephenson et al. (2003) reported that water stress at different phenological stages including floral development, immature nut drop and nut maturation had adverse effect on yield through decrease in nut number and nut size. Adverse effects of irrigation in Northern NSW have also been observed. Trochoulias and Johns (1992) found that NIS yield per unit trunk area decreased with irrigation by up to 10% at excessive rates of irrigation. Variable yield, water use and quality responses between cultivars to irrigation have been reported for macadamias grown in Bundaberg (Searle and Lu, 2003).

Nutrition

An extensive account of macadamia nutrition was undertaken as part of a review of macadamia by Nagao and Hirae (1992). Orchards in Australia have been established on a range of soil types that have differing chemical and physical properties, Stephenson et al. (1986) observed the soil nutrient levels and fertiliser application on three common soil types used to grow macadamias; red podsolic, krasnozem and sandy red earth, and found varied nutrient levels and fertiliser applications. Macronutrients are generally applied as granular fertilizers although in regions where irrigation is used fertigation may also be used. Micronutrients are often recommended as foliar sprays for rapid amendments of nutrient deficiencies. The methods of determining nutrient requirements throughout the industry vary; however they generally involve one or a combination of soil nutrient analysis, leaf nutrient analysis, crop removal replacement or crop logging. Foliar nutrient content varies with leaf age, leaf position, time of year and recent work by Huett et al. (2001) showed that content of several leaf parameters including nitrogen and phosphorus increased with decreased shading and concluded that the current sampling protocols for determination of leaf nitrogen and phosphorus levels were not reliable.

Flowering and fruit development

Initial flowering generally occurs between the 3rd and 5th year after planting. Flowers are hermaphroditic and borne on racemes that contain between 100 to 300 flowers each (Figure 1), between 6 to 35% of these flowers develop into immature fruit (Urata 1954) and only 0.3% will remain at maturity (Ito 1980). It is traditionally accepted that flowers are located on wood that is at least 2 to 3 years of age and there appears to be variation between cultivars. The major pollinator appears to be the European honeybee, although the Australian native species of Trigona has been observed. Flowering in Australian orchards occurs in September, there are significant differences in timing of flowering between cultivars although there is still high potential for cross-pollination between cultivars (Boyton and Hardner, 2002).

Abscission of immature fruit occurs throughout fruit development, however the maximum rates are observed from 3 to 8 weeks after anthesis (Sakai and Nagao 1984). Increases in fruit diameter and fruit fresh weight follow a single sigmoidal pattern in which growth continues until 14 to 15 weeks after anthesis and 15 to 16 weeks after anthesis for fruit diameter and fresh weight respectively. Trueman and Turnbull (1994) found that shell hardening occurred between 12 and 15 weeks after anthesis and effectively ceased increases in fruit diameter although total fruit dry weight per branch increased until 20 weeks post anthesis where monitoring ceased. Increases in dry weight after shell hardening are due to increases in kernel mass, the majority of which is oil accumulation (McConchie, et al. 1996). In Australia, mature fruit drop begins from March to April and can extend until October for some cultivars.

Harvesting

In most Australian orchards, nut-in-husk is mechanically harvested from the ground (Figure 2), although hand harvesting may be used in excessively wet conditions and in very steep areas of the orchard. Nuts are harvested every 4-6 weeks to prevent deterioration of kernel on the ground (Mason and Wells, 1993). Tree shaking and Ethephon have been used both experimentally and commercially to promote nut drop and so reduce the number of harvests, however they have not been widely adopted to date. Ethephon has been shown to be very effective but the response of leaf and nut drop can vary with cultivar, time and method of application and growing region. There are also concerns about the effect of Ethephon application on return and long-term yields as variable responses have been reported (Trueman, 2003, Penter et al., 2003).

![Figure 1. Flowering raceme in M. integrifolia](image1)

![Figure 2. Mechanical harvesting of fallen macadamia nuts in Australia](image2)
Pests and Diseases

The two major insect pests in Australia are the larval macadamia nut-borer (Cryptophlebia viridula) and the fruit-spotting bug (Amblypelta spp.) (Huwer and Maddox, 2003). Nut-borer can cause premature fruit drop or damage to the kernel, damage can be caused throughout nut development (Figure 3). Fruit spotting bug damages the kernel through surface pits and also causes premature nut drop, the majority of damage being done before shell hardening occurs. Research on IPM strategies includes the use of a nut-borer parasite, improved monitoring, trap cropping, and the use of IPM compatible pesticides (Huwer and Maddox, 2003). Further research is also needed to quantify the impact of pest damage on the industry.

Husk spot (pseudo cercospora) is the major pathogen in Australia. Considerable anecdotal evidence suggests that this disease infects the husk of the developing fruit and leads to premature fruit drop. Currently the major defence against husk-spot is prescription application of chemical as infection occurs long before the symptoms are apparent. However, considerably more work is required to document the lifecycle of the fungus, develop robust chemical and genetic defences and estimate the economic impact of the disease.

Canopy management

Macadamia is a vigorous tree and there are concerns about balance between vegetative and reproductive growth and shading on yield. Canopies are very dense, LAI measured in 11 year old macadamia cultivar ‘Haes’ 344 was between 14 and 16, which are among the highest reported for fruit and nut crops (Meyers et al., 1999). Generally trees are trained into a single vertical leader with laterals to carry the crop in the first 3 years after planting to maintain an open canopy (O’Hare et al., 1996). Experience suggests that narrow crotch angles are susceptible to breakage. New trials are being developed for high-density plantings with intensive tree training and external tree support such as trellises (Bell and Bell, 2001), trellis systems that promote irradiance to fruit are used for crops such as apples, however in macadamias yield has been shown to increase with canopy area and light interception, so open systems such as this will need to be tested and compared with the economics of the system.

Long term assessment of mature orchards have found that, although macadamias possess one of the most dense tree-crop canopies, there seems small decline in yield due to crowding (McFadyen et al., 2003) but there was large between year variation. However, hedging of later age trees to maintain may reduce the risk of crop losses due to pest and disease.

Post harvest

The husk is removed on farm as soon as possible after harvesting, as heat of respiration from the husk can be large. The moisture content of wet nut-in-shell harvested from the orchard may range from 10 to 25% depending on environmental conditions before harvesting (Cavaletto 1996) but is generally dried to below 10% moisture content on farm where kernel is considered safe from mould development. However, kernel remains susceptible to both hydrolytic and oxidative rancidity at this level of moisture content.

The nut-in-shell is transported to processing companies where it is slowly dried to approximately 3.5% (1-1.5% kernel moisture content), cracked and then sorted to remove reject kernel (immature, discoloured, germinating, insect damaged or mould) and separate kernel into different styles defined by percentage of whole kernel and kernel size. Kernel is then packaged into foil vacuum-sealed bags and stored in cool stores to reduce the development of oxidative rancidity. Currently post-harvest research in Australia focuses on development of in-line sorting technology for reject kernel, control of after-room-darkening and identification of traits linked to consumer preference.

Genetic improvement

Most cultivars grown for production were developed in Hawaii. Breeding and selection programmes have also been undertaken in Australia, South Africa, California, Brazil and New Zealand. To date there are approximately 700 names representing about 500 genotypes (Hardner and McConchie, 2003). However, there is some evidence that cultivar performance is not stable across countries.

Australian industry is currently investing heavily in macadamia genetic improvement. The major focus of this programme is the development of improved cultivars for the Australian industry however the programme also encompasses conservation of wild macadamia germplasm, selection of elite rootstocks and scion breeding. The native origin of macadamias gives the Australian industry a significant advantage over other countries. Three ex-situ conservation plantations have been established in eastern Australia with cuttings collected from over 300 wild trees across the natural range of M. integrifolia and M. tetraphylla. The industry has also supported in-situ recovery of several degraded wild populations.

The Australian macadamia breeding programme aims to efficiently produce new cultivars for the Australian macadamia industry using a structured quantitative genetic approach. Breeding objectives are developed with the industry and through whole of chain economic modelling to quantitatively assess the impact on profitability of changes in different traits. The current traits used in selection are tree size, cumulative yield, commercial kernel recovery, proportion of whole kernel and kernel size. A breeding population of 5,000 individuals has been established on 16 sites over 3 major growing regions (Bundaberg, Gympie and NNSW). The first selection from these trials of candidates cultivars will be made in 2004 with release to the industry expected from 2012.

ACKNOWLEDGEMENTS

We wish to thank the macadamia industries of the different countries discussed, for their continued support of the research programmes that have developed to information included in this review.

REFERENCES


The project “Introducing of nursery and cultivation techniques of Ceratonia siliqua in China” is funded by the Chinese government. One of the aims of this project is to find a tree species suitable to dry areas of southwestern China that will contribute to the ecological rehabilitation. The project started in 2001 and will be completed by 2005. During the year 2002 the Chinese Academy of Forestry (CAF) contacted IRTA-Mas Bové (Catalonia, Spain) to start a possible collaboration on this species between both institutions. During two years 2002 and 2004, IRTA sent to CAF more than 100,000 seeds, from important carob cultivars: five of Spain (‘Negra’, ‘Duraló’, ‘Roja’, ‘Banya de Cabra’ and ‘Mataifaera’) and two of Portugal (‘Mufala’ and ‘Galhosa’), with the purpose of introducing them in the nursery and, later be planted in the field (Fig 2). In the new plantations two methods of planting...
were used: direct sowing in the field and small plants with containers. The last method would be the most suitable and to be used in the future.

The necessity to know the possibilities of development of the carob tree in China, as an answer to the new expectations generated by this species, fostered the realization of this technical collaboration between China and Spain (Fig. 3).

ECOLOGY

The edaphoclimatic conditions of the Chinese areas where the carob has been introduced, Sichuan, Yunnan and Guangxi provinces placed in the south, are different from those of the Mediterranean Basin to which carob is well adapted. It highlights the great climatic variability, with altitudes of 800-1000 m above sea level, minimum temperatures of 0 or -1ºC and maximum of 40ºC, although there is a big gap of temperature between day and night (about 10 ºC), and rainfall of 700-800 mm in the county of Xichang (Sichuan) and, higher in the other two provinces (Yunnan and Guangxi), about 1000 mm, distributed between June and September. The carob was planted on hilly lands and the soils in overall are not very deep, clay-loam, grey-brown colours, with neutral or slightly acid pH (6-7) and low levels of phosphorus and calcium (Fig. 4).

In the Mediterranean countries (Spain, Italy, Portugal, Greece, Morocco, Tunisia, etc.), the carob grows well in warm temperature and subtropical areas, with altitudes below 600 m above sea level, low rainfall in summer (300-500 mm/year), and tolerates hot and humid coastal zones. It can only withstand light frost; temperatures below –4ºC can damage young trees and flowers of mature trees. Carob can adapt to a wide range of soil types from poor sandy soils and rocky hillsides to deep soils, but they cannot withstand waterlogging. In the Mediterranean Basin carob generally grows in marginal, calcareous and basic soils.

CROP DEVELOPMENT RESTRICTIONS

The areas where the carob tree has been introduced in China, in the case of the Sichuan province, the following remarks can be highlighted:

The areas where the carob seeds have been planted are hilly, long away from the coast, with high altitudes above sea level, high rainfall (800-1000 mm and concentrated on three summer months) and with very poor soils, neutral or slightly acid pH, and these conditions are quite different from the Mediterranean countries. Temperatures of the Yibasan and TongAn areas are warm and more similar to carob original areas of Mediterranean Basin.

Pests: Severe damage is caused in young trees by rabbits and some native ants that gnaw trunks and new shoots.

Diseases: High rainfall, concentrated on summer months, can cause waterlogging problems in young carobs and later promote fungus attacks of *Phytophtora*, in the neck of the tree, and *Oidium* in the leaves of the most sensitive carob seed trees.

Pollination: the carob is a triploecious species with male, female and hermaphrodite flowers borne on different trees. It blooms in summer-autumn and it seems to be mainly pollinated by insects, but also by wind. High rainfall and relative humidity in the rainy summer season, could increase poor fruit set during the pollination time (mainly the period that overlaps with blooming time).

Mechanical harvesting: currently this factor is not very important because there is large manpower and its cost is low.

RESEARCH AND DEVELOPMENT NEEDS

Research and development carob works in the Chinese Academy of Forestry is very limited, outstanding some nursery works (seed germination, planting methods, etc.). Future work would have to assess the performance of the seedlings planted in the three Chinese provinces (about 100,000 seedlings) that adapt better to the new environmental conditions, and select seedlings from more vigorous cultivars, female and hermaphrodite sexes, tolerant to diseases (*Oidium*), early bearing and fruits with good quality. Later it would be necessary to bud the best trees on seedlings and to introduce them in collections and comparative trials to finish their agronomic and commercial evaluation. These works should be carried out within the new agroforestry systems framework in which the carob could solve reforestation problems in degraded areas and its bean production used both for human and animal feeding (sheep, goats, pigs, cows, horses, etc.). A climatic and soil characterization of the possible locations for this species would also be interesting, with the purpose of being able to define its potential expansion area in China, avoiding future problems of lack of crop adaptation.

CONCLUDING REMARKS

There are some favourable aspects on the development of the carob cultivation in China, large surfaces, large manpower for harvesting, potential agroforestry uses, being able to use their production both for human and animal feeding. On the other hand, it is necessary to choose well the growing areas, which should be windy, with little risk of frost, and the cultivars to be recommended should adapt well to Chinese growing conditions because they are different to those of their original areas (Spain, Italy, Portugal, etc.). Based on the previously described, the carob tree in China it can be consider as an alternative crop in dry land areas with warm or subtropical climates for diversification on the agroforestry farms.

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NOTES AND NEWS

IN MEMORIAM: MY PROFESSOR DALE KESTER

A few weeks before Dale’s death the 21st of November 2003 in Davis, California, I was talking to a group of technicians of several growers’ associations and I started my talk recognising that I had been fortunate in my professional life, and one of the reasons was that I had been a student with Dale Kester. His influence has been extremely positive for my work, even if we did not always agree on some subjects, but his personal view of almonds was in any case a clear example of dedication and interest. As most almond researchers, he had a passionate for this species, as well as for his students, and was, as a consequence, able to convey his passion for almond growing to us.

It is now quite difficult to find somebody with this ability to give such a general perspective of almond. Dale, as well as the other great figures of almond research in the past century, Charles Griggs and Antonio Felipe, was an expert both on rootstocks and varieties, and this combined view of the tree complexity was also the way to obtain a complex overview of all problems related to almond growing. Until recently, when we probably find more articles on almond molecular markers than on the almond itself, it was hardly impossible to find any article on almonds without his name cited several times in the bibliography list. As a matter of fact, his most cited article (Kester and Griggs, 1959. Fruit setting in almond: the effect of cross-pollinating various percentages of flowers, Proc. Amer. Soc. Hort. Sci. 74: 214-219) was one of the points about which we sometimes had disagreed.

Just after my arrival in Davis in December 1972, he suggested four points upon which I could start my research work. I only remember one on leafing time and frost resistance, later taken by Mustafa Büyükyilmaz, and the one I selected, on almond self-compatibility. Once I had made my choice, he asked me if I could read Portuguese, because he had an article in that language he was unable to read and that could be important on almond self-compatibility. This was the pioneer work of Almeida (1945), so often referred later after my review. This has been definitive for my future work in almond, because I continue in the same field of work.

Although after my stay in California we only met on a few occasions, we continued to talk on the same subject. I remember a trip to Davis in 1985 where he showed me some pollination results difficult to explain according to the S allele relationships of the different cultivars. We commented several possibilities and finally I suggested a mutation from an S allele to a nul allele. This hypothesis was later confirmed (Kester et al., 1994. A mutation of ‘Nonpareil’ almond conferring unilateral incompatibility. J. Amer. Soc. Hort. Sci. 119: 1289-1292).

During my stay there were other students working under his guidance. They were the mentioned Mustafa Büyükyilmaz from Turkey, Juan Negueroles from Spain and Mustafa Lasram from Tunisia. Also Rachid Hellali from Tunisia was partly working with him. They are all now recognised professionals in fruit growing, research, education and administration, and I guess that I am the only one who continues to work in almond, but I do not regret it. On the contrary, it makes me feel that probably I could boast of being more his heir than the others.

I cannot talk about Dale without mentioning his wife Daphne. They were always together and she was a real support for him. They opened their home to me both when I was a student, as on Thanksgiving day, and when I visited Davis later. Both were friendly and made other people feel at ease with them. They visited Spain several times, and very much enjoyed Spanish cuisine. I remember that on their second visit to Spain, they mentioned that they had attended meetings of the Weight Watchers in order to reduce weight as they knew that in Spain they would eat very well. They were delighted with the croquettes of Pili Royo, Antonio Felipe’s wife.

His work always had the support of another good man that I would also like to bring to mind now, his technician Dick Asay. They formed a real team and Dale recognised it when Dick appeared so often in the scientific publications. This is another example of the traits defining a real researcher: humble, adaptable and open. He was humble, conscious of how much he did not know. Adaptable, in his place both in a scientific meeting and in a growers’ talk. Open, willing to share his knowledge.

I saw him for the last time during the International Horticultural Congress in Toronto in August 2002, and now I would have preferred not to have seen him because he was not the same Dale. He had suffered Daphne’s loss and, although interested as always in his work and all the problems related to almond bud failure, he seemed a little lost to me. However, now I find him more clearly than ever in our daily work.

R. Socias i Company

CONGRESSES AND MEETINGS

XIII GREMPA MEETING ON PISTACHIOS AND ALMONDS

The XIII GREMPA Meeting on Pistachios and Almonds took place in Portugal in Miranda do Douro, the Garden-City of Terra-Quente (Hot land), from 1 to 5 June 2003. Miranda do Douro is located in the North-east of Portugal (Trás-os-Montes region). It has a Roman origin, but it was King D. Dinis who, in the XIV century, named the city as Miranda and ordered the construction of a fortress wall surrounding it, part of which is still visible. The city still has other historical-architectonic structures, like the Roman bridge (“Ponte Velha”) with 20 asymmetrical arches, the ancient palace of the Távoras (the noble family accused of attempting regicide in 1759), the church of “Misericórdia” and several pillories of medieval origin, among other interesting features.

The meeting was organized by the Direcção Regional de Agricultura de Trás-os-Montes (DRAM), the Instituto de Biologia Experimental e Tecnológica (IBET)
and the Universidade de Trás-os-Montes e Alto Douro (UTAD), with the collaboration of the Inter-Regional FAO-CIHEAM Cooperative Research Network on Nuts, and having Vitor Cordeiro and M. Margarida Oliveira as the conveners.

The meeting was attended by more than 80 participants from 14 countries: Algeria (1), Argentina (1), Australia (10), Belgium (1), France (3), Greece (1), Iran (5), Italy (8), Morocco (1), Portugal (22), Spain (17), Tunisia (3), Turkey (3) and USA (6). A Chinese delegation with 7 participants could not attend the meeting because of the severe acute respiratory syndrome (SARS), although China was represented with two abstracts. Also one participant from Macedonia and two other participants from Algeria did not succeed to be present but managed to have their posters presented.

The participants represented several sectors of activity linked to almond and pistachio, including farmers, industrials and researchers. Important scientific advances have been reported and the meeting was a good opportunity to exchange knowledge and strategies among teams from all around the world where almond and pistachio are grown. Besides the scientific sessions, numerous opportunities for discussion and establishment of new collaborations were possible during coffee-breaks, meals or social events.

In total, 75 communications were presented (39 oral communications and 36 posters), unequally distributed by the different sessions, which included: "Cultivars, Rootstocks and Breeding" (10 oral communications and 12 posters), "Flowering, Pollination and Fruit Set" (5 orals, 5 posters), "Pests and Diseases" (3 orals, 3 posters), "Harvesting, Marketing and Industry" (2 orals, 2 posters), "Orchard Management" (4 orals, 4 posters) and finally "Physiology, Biology and Biotechnology" (15 orals, 10 posters). All the abstracts, including those of the participants that finally did not attend the meeting (in total 50 orals and 40 posters were submitted) were included in the Book of Abstracts and distributed by the participants. Before closing the ceremony, a Round table was organized for discussion of common problems and strategies aiming to solve them. The proceedings of this meeting will be edited in a volume of Cahiers Options Méditerranéenes.

In the first working day, the participants were transported to the city Hall Auditorium by the touristic train of Mirandela. In the afternoon of the second working day, a visit was organized to an almond private company "Amendouro", and to the village of Moncorvo where the secular church was visited, as well as a traditional store where almonds are processed in a secret way!!! The day ended with a prosperous meal offered by the Town-hall President of Alfândega da Fé.

On Wednesday, a full day was dedicated to a long tour. The day started with a visit to almond orchards (at the Experimental Centre of Terra Quente), followed by a visit to old wine presses in a Douro farm (Quinta da Pacheca) and a travel by boat, up the Douro river, until Pinhão.

On the last day, after the sessions and closing ceremony, a farewell evening banquet organized at "Estalagem da Senhora das Neves" gathered most of the participants in a happy event where singing and dancing were also included and where the natural abilities of the participants could be demonstrated.

Because of their contribution to this meeting special thanks are due to FAO-CIHEAM, the Director of the Regional Agricultural Services of Trás-os-Montes and IBET, for their encouragement and support during all the organization. Also the Presidents of Câmara Municipal de Mirandela and Alfândega da Fé, as well as Amendouro Company, Mr. António Martins and Mss. Maria de Lurdes Lopes are much acknowledged for their help and granted availability.

Finally, we would like to express our thanks to the Scientific and Organizing Committee of the Meeting and to all participants and contributors of the large almond and pistachio family. We hope this meeting may have contributed for the exchange of scientific knowledge and to strengthen the collaboration of the participants within the network or in connection with it.

M. Margarida Oliveira
Vitor Cordeiro

VI INTERNATIONAL CONGRESS ON HAZELNUT

The 6th International Congress on Hazelnut was held in Tarragona, North-East of Spain, on June 14-18, 2004. The Congress offered an international forum to meet each other and to exchange experiences related to the latest results concerning agronomic, industrial, health benefits and commercial aspects of hazelnut growing. The Congress was organized by the Institut de Recerca i Tecnologia Agroalimentàries (IRTA) – Centre Mas Bové in collaboration with the International Society for Horticultural Science (ISHS) and the FAO-CIHEAM Nut Network. This event was financially supported by several institutions: Diputación de Tarragona, Ministerio de Ciencia y Tecnología, INIA, European Union - project PORTA, Generalitat de Catalunya – Agència de Gestió d’Ajusts Universitaris i de Recerca (AGAUR), Mediterranean Agricultural Institute of Zaragoza (IAMZ - CIHEAM), FAO-CIHEAM Nut Network, Caixa Tarragona, Town council of Tarragona, Reus and Constantí; and the private sponsors: Borges, Morella Nuts, Industries Garriga, Denomination of Origin "Avellana de Reus", Unió Agrària Cooperativa and Coselva.
Several authorities were represented in the opening session: the Councillor of Agriculture (Mr. Antoni Siurana) of the Generalitat of Catalonia, the President of the Diputación of Tarragona (Mr. Joan Aregio), the Director of IRTA Dr. Josep Tarragó, the Chairman of the Nuts Section and Mediterranean Climate Fruits of The International Society of Horticultural Science (ISHS) Prof. Carlo Fideghelli, the representative of The Centre International de Hautes Etudes Agronomiques Méditerranéennes (CIHEAM), Dr. Dunixi Gabiña, and other local authorities.

The meeting was opened with a welcoming of the convenor, Dr. Joan Tous, who referred to the main economic characteristics of the Spanish hazelnut sector, with an average production of 9,000 t of kernel per year and 23,000 ha, 95% of this surface was concentrated in Catalonia and, mainly in Tarragona province (18,000 ha), where the hazelnut is, in diverse districts, an important source of income. In Catalonia region, there are 7,000 small hazelnut farms with an average orchard size of about 1 to 5 ha. In addition, most of these small farms need to be modernized. In this scenario, one of the most important aims is the reduction of the management cost and improve nut quality, to ensure greater returns for growers. The hazelnut sector is grouped in six OPA’s (Nut Growers Associations), all of them located in Catalonia. In Spain, hazelnut commercialization is mainly focused on the chocolate and “snacks” industries.

Dr. J. Tous also explained the history of the hazelnut Congresses in the world and noted that the first Colloquium on Hazelnut in Spain was held in Reus in 1862, organised by the Institut Agrícola of Sant Isidre, and that there was discussed to introduce the hazelnut tree as possible alternative to grapevine in the coastal areas of Tarragona, due to ‘powdery mildew’ fungus problems. Later, in the XXth century, in the year 1976, the 1st International Hazelnut Congress was held in Reus (in this case together with the almond). Since then, different cities all over the world have hosted the following: Avellino, Italy (1983); Alba, Italy (1992); Ordu, Turkey (1996), Corvallis, USA.
Table 1. Main Scientific conclusions of the VI International Congress on Hazelnut.
Tarragona (Spain), 14-18 June, 2004.

<table>
<thead>
<tr>
<th>Session (Nr. of contributions)</th>
<th>Main aspects</th>
<th>Remarks and conclusions</th>
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<tr>
<td>1. Germplasm and Genetic Improvement (30)</td>
<td>• Behaviour and adaptations of hazelnut cultivars to new zones&lt;br&gt;• Behaviour of several breeding obtentions (limited advances until today)&lt;br&gt;• Molecular markers&lt;br&gt;• Many presentations focussed on table varieties</td>
<td>• Current collections should be reviewed with molecular markers.&lt;br&gt;• International data base of molecular markers is useful.</td>
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<td>2.- Biology and Physiology (12) (examples)</td>
<td>• Particular problems vary per country and zone&lt;br&gt;• Nut fall in Australia&lt;br&gt;• Selection of pollinizers in Chile&lt;br&gt;• Studies on root distribution in Portugal&lt;br&gt;• Shedding effects on flowering in Italy</td>
<td>• Phenological data of cultivars differ according sites and climatic conditions.&lt;br&gt;• The knowledge of incompatibility (S) alleles in hazelnut cultivars is required.</td>
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<td>3.- Propagation and Rootstocks (6)</td>
<td>• Achievement of hardwood cuttings’ method</td>
<td>• Rootstocks could be of great interest to solve specific problems, such as:&lt;br&gt;• Improvement of agronomic characteristics of ‘Negret’ cultivar with rootstocks (IRTA, Spain).</td>
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<td>4.- Orchard Management (24)</td>
<td>• Nutrition and pruning&lt;br&gt;• Improvement of harvest facility (machinery, pruning, green covers)&lt;br&gt;• Organic production</td>
<td>• High N fertilizer doses could have a yield depressing effect.&lt;br&gt;• Reference of P in leaves should be revised in some areas.&lt;br&gt;• The irrigation should be adapted to the physiologic phases of the crop.&lt;br&gt;• The Spanish strategy is to develop Organised Technicians Groups (ADV) to help farmers with new EU policy regulations (IPM)*.</td>
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<td>5.- Pest and Diseases (16)</td>
<td>• Solution for specific problems in specific zones&lt;br&gt;• General pest and diseases studies for widespread areas&lt;br&gt;• Increasing problems with traditional pests (bug species) which affect kernel quality&lt;br&gt;• Biological control</td>
<td>• New technologies of Teledetection (GPS or GIS) to study wide growing areas and their problems.&lt;br&gt;• “Eastern Filbert Blight” fungus problem, increases in Oregon hazelnut orchards.&lt;br&gt;• Possibilities for biological control will increase, such as control of “Zeuzera” in Spain.</td>
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<td>6.- Post Harvest and Quality (7)</td>
<td>• Chemical composition (old as well as new cultivars)&lt;br&gt;• Drying to avoid aflatoxin problems, in Turkey</td>
<td>• More research is needed on food security (aflatoxin).</td>
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<td>7.- Health and nuts (2)</td>
<td>• Nut composition and healthy effects&lt;br&gt;• Scientific evidences of disease prevention by the consumption of nuts</td>
<td>• Most marketing efforts use the healthy strategy.&lt;br&gt;• The nut kernels improve health and do not seem to increase body weight.</td>
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<td>8.- Industry, Marketing and Economics (10)</td>
<td>• Crop and international price prediction&lt;br&gt;• Consequences of national policies, mainly for the main producing country (Turkey)&lt;br&gt;• Organic production</td>
<td>• The Turkey policy could reduce surface by 25%.&lt;br&gt;• Market for organic production seems on the increase.&lt;br&gt;• High alternate bearing in the crops of the main producing countries.&lt;br&gt;• Consumer studies can give relevant information to enhance strategies of producers, industries, distribution and research.&lt;br&gt;• Other alternative nut species (Gevuina avellana, in Chile).</td>
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* IPM (Integrated Pest Management)
(2000) and finally Tarragona, Spain (2004), twenty eight years after the first international event.

Then, Prof. Carlo Fideghelli (Chair of the ISHS Section for Nuts and Mediterranean Climate Fruits) gave the “ISHS Medal Award” to the convener to acknowledge his effort for the organisation of the Congress.

The Congress was attended by 125 participants from 20 countries: Turkey, Italy, USA (Oregon), Spain (Catalonia), France, Portugal, Australia, China, New Zealand, Poland, South America (Chile and Argentina), Ukraine, India, Albania, Austria, Georgia, Switzerland, The Netherlands and Slovenia. A total amount of 107 scientific papers were presented in this Congress, 43 as oral communications and 64 as posters. The topics of this Congress were related to the following issues: Plant material (30 papers), Biology and Physiology (12), Propagation and Rootstocks (6), Orchard management (24), Pest and Diseases (16), Post harvest and Quality (7), Health benefits (2) and Industry, Marketing and Economics (10). In Table 1 the main scientific conclusions of this Congress are summarized.

Researchers had the opportunity to visit the experimental fields of IRTA-Mas Bové Research Center (collection of hazelnut germplasm, rootstock and cultivar trials and seedlings collection of *Gevuina avellana* specie), commercial hazelnut orchards, an exhibition of several harvest machines and nut industries (Borges and Coselva). An Open day for the sector was organised the last journey with two workshops: “World hazelnut situation and perspectives in France, USA, Italy, Turkey and Spain” and “Production and commercial aspects on hazelnut”. Also, main scientific conclusions of the Congress were presented to the sector.

After a ‘proposal’ of Italian researchers, the next meeting on the 7th ISHS International Congress on Hazel nut, was decided to be held in Viterbo (Italy), probably in summer 2008.

The five days of the congress were a friendly course of excellent scientific presentations, relaxed discussions and allowed to learn new aspects about our region and local habits. Papers will be published in a volume of *Acta Horticulturae* in the near future.

J. Tous (convener) and M. Rovira (secretariat)
IRTA-Centre Mas Bové. Apartat 415. 43280 Reus (Spain)
E-mails: joan.tous@irta.es; merce.rovira@irta.es

TO BE HELD:

**Almond and Pistachio**

IV ISHS International Symposium on Pistachios and Almonds  
**Date:** May 22-26, 2005  
**Place:** Tehran, Iran
**Convener:** Dr. A. Javanshah  
**Address:** Iranian Pistachio Research Institute  
PO Box 77175 / 435  
Rafsanjan, Islamic Republic of Iran  
Tel: 98 391 422 52 02  
Fax: 98 391 422 52 08  
**E-mail:** javanshah@pri.ir  
**http://www.pri.ir**

**Chestnut**

III ISHS International Symposium on Chestnut  
**Date:** October 20-23, 2004  
**Place:** Chaves (Vila Real), Portugal  
**Convener:** C. Abreu  
**Address:** University of Tras os Montes e Alto Douro  
P.O. Box 202  
5000-911 Vila Real – Portugal  
Tel: 351 259 350 508  
Fax: 351 259 350 400  
**Email:** cagabreu@utad.pt  
**www.utad.pt/eventos/chestnutcongress**

**Walnut**

V ISHS International Symposium on Walnut  
**Date:** November, 7-14, 2004  
**Place:** Sorrento, Naples, Italy  
**Conveners:** D. Avanzato (MiPAF) and M.E. Malvolti (CNR)  
**Addresses:** Istituto Sperimentale per la Frutticoltura di Roma (MiPAF)  
Via di Fioranello, 52, 00134 Roma (Italy)  
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BIBLIOGRAPHY

ALMOND


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CAROB


CHESTNUT


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HAZELNUT


NUTS


static pollen applicator development and tests for almond, kiwi, date, and pistachio


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PECAN


PISTACHIO


STONEPINE


WALNUT


THESIS


MASTERS

## THE FAO-CIHEAM INTER-REGIONAL COOPERATIVE RESEARCH NETWORK ON NUTS

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**Generalitat de Catalunya**  
Departament d’Agricultura Ramadera i Pesca.

**FAO-CIHEAM - Nucis-Newsletter, Number 12 September 2004**