Welcome
Dear readers,

In your hands you have a new issue of NUCIS after 4 years of publishing break. Changes in the editorial staff and reduced funding have been the main causes of this delay. Deepening the collaboration of researchers in Nuts, since their input and information is what keeps the magazine alive, calls for strengthening the involvement of all crop Liaison Officers in the Newsletter, in coordinating the submission of articles for publishing, and also, in collecting information, notes, scientific works, etc. related to their crops. We are grateful to all contributors to this issue: to those, who have written articles and those, who have sent the reports of different symposia that have taken place during these last years. In this issue you will find articles on almond (7), hazelnut (3), and one article on walnut, one on pistachio and one on both almond and hazelnut. Contributions come from Spain (6), Italy (2), and Iran, EUA, Morocco, France and Turkey with one contribution each one. We always endeavor to present the recent scientific development in all nut crops worldwide. However, since the almond is the main nut tree at global level, the research in this field is, naturally, more intense, which reflects in the higher number of submitted articles. The same observation refers to contributors: in each issue of NUCIS we are committed to cover a wide country representation, whenever possible.

Activities 2008-2011
During the years 2008, 2009, 2010 and 2011 a number of activities were supported by the FAO-CIHEAM Interregional cooperative Research Network on Nuts in
The first project is being carried out on the assessment of the agronomic performance of new Spanish almond varieties under different climatic conditions of Tunisia (2009-2011). IRITA, from Spain and l’Institut de l’Olivier, from Tunisia, are the participants of this project. The second project refers to the production techniques and management of pine (Pinus pinea) for early pineapple production: grafting orchards as an alternative for restoration of degraded areas and income generation in rural communities in Tunisia (2008-2011). The institutions involved are Centre Tecnològic i Forestal de Catalunya, IRITA and CIFOR-INIA from Spain; and INRGREF, from Tunisia.

An ENPI-CBC MED, PROMEFO project action involving eight countries (Spain, Tunisia, Lebanon, France, Italy, Syria Greece and Jordan) and nine partners is currently underway.

In recent years, the activities of the Nut Network have been affected as FAO is no longer providing specific regular programme budget for servicing the Network and supporting activities. However, the support given by some FAO services and external funding provided by the Spanish INIA and IRITA, and the co-sponsor and partner CIHEAM allowed that most planned activities could be finally developed like the publication of this Newsletter. In addition, some researchers from developing or transition countries have been and will be supported to participate in different meetings and congresses.

**Genetic resources inventories and descriptors**

Regarding the inventories on germplasm, research and references, four of them have been already published in the REU Technical Series (www.fao.org/regional/Europe/PUB): Almond (1997, RTS 51), Hazelnut (2000, TRS 56), Chestnut (2001, RTS 65) and Walnut (2004, REU 66). These inventories are important compilations of the currently available species genetic resources and information on ongoing research projects and bibliography. It would be interesting to update this information on time, especially that of the oldest Inventories that were published. In addition one more inventory is being compiled and is close to completion. The inventory on Pistachio is being collated by B.E. Ak. It is expected to be ready soon.

The Descriptors for Hazelnut (Corylus avellana L.), were published in 2008, by Bioversity International with the support of FAO and CIHEAM. These descriptors have been achieved after a great effort during some years, led by A.I. Koksal, and having the collaboration of hazelnut Network members. It was distributed during the VIIth ISHS International Congress on Hazelnut, in Viterbo (Italy) (June, 2008).

**Proceedings of meetings and workshops**


During 2007-2009 (prorogued to 2010) AGRI GEN RES Action acronym “SAFE-NUT” was approved by the European Commission. Eleven institutions coming from six different countries, have been working on this project.

A COST (Cooperation in the field of Scientific and Technical Research) action (COST 873) (2007-2011) on bacterial diseases of stone fruits and nuts is being developed. In February 2012, the Final Meeting of the project will be held in Switzerland.

Currently, Spain and Tunisia are developing two AECID projects.
FAO European Regional Office and CIHEAM (IAMZ)
Ms. F. Guerrieri is our Regional representative of FAO Regional Office for Europe and Central Asia (REU) based in Budapest, Hungary. In relation to CIHEAM, Mr. D. Gabiña and Mr. A. López-Francos, placed at IAMZ of Zaragoza, Spain are our representatives.

The Nut Network on the web
Basic information is included in the REU website for ESCORENA (www.fao.org/world/regional/REU/content/escorea/index_en.htm). Additional information about the Nut Network can be found at www.iarmz.ciheam.org/en/pages/paginas/pag_investigación2a.htm.

NUCIS on the web
A full electronic version of each NUCIS (from issue 1 to 15) is now available on the Internet web page of CIHEAM at (www.iarmz.ciheam.org/en/pages/paginas/pag_investigación2a.htm). The contents of this Newsletter can be browsed through and also copied and printed. Readers will be able to find the whole set of NUCIS issues, some of which were already exhausted.

Contributions to NUCIS
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 and since then, the exchange of information between Network members through the pages of this Newsletter is the basis for developing collaboration.

As we asked in the last NUCIS Newsletter, we stress the importance of sending technical descriptions for the new Cultivar Descriptions section. The aim is to make available to readers useful agronomical and commercial information of important traditional cultivars and new varieties. As in past NUCIS, we ask researchers on nuts, their collaboration in this newsletter, with articles, notes, or any other information related to nuts. The pages of this bulletin are open to all readers who would like to suggest ideas or express their opinion about the work developed in the network or to publish short articles and reports on relevant horticultural subjects of general interest. Information should be sent well structured and clearly written in Standard English.

Contributions could be sent through Internet using the Scientific Editor's e-mail. This bulletin is reproduced in black and white only, including pictures. Please send your contributions for the next issue, number 16 by the end of September 2012. We thank all who have contributed to this issue, people publishing a short article, and people who have written reports of symposia conducted recently. To all of them thank you very much for your cooperation.

Finally, we wish all Nut Network members and collaborators a healthy and successful 2012.

The Editor
ALMOND BREEDING IN MOROCCO: A CHRONOLOGICAL PERSPECTIVE

Introduction
Almond tree cultivation was known in Morocco since the cartage era, during the fourth century (El Khatib Boujibar, 1983) or the conquest of Arabs around the sixth century (Kester et al., 1991). Actually, the acreage occupied by almond is around 142 000 ha of which half (5 to 6 millions of trees) is essentially seed propagated (Laghezali, 1985). This way of multiplication has resulted in a large genetic diversity in Morocco. As a consequence, Morrocco is considered as secondary centre of almond propagation (Vavilov). This traditional plant material, resulting from years of adaptation, presents several traits of high importance, particularly drought tolerance and productivity.

The different works on almond that have been undertaken at INRA Morocco were carried out in three major phases: prospections, collection establishment and evaluation of the foreign cultivars and crosses.

1- PROSPECTIONS AND CHARACTERISATION OF PLANT MATERIAL
The prospections, undertaken on local almond populations, started at INRA in 1975, with objectives evolving over time. The first prospections focused on selection for late flowering time and allowed collecting 75 genotypes that currently are planted in different experimental stations of INRA (Errachidia, Marrakech and Meknès). Later, fertility, kernel aspect and late flowering time have been introduced as objectives of the prospection undertaken between 1980 and 1984 (Chahbar and Abir, 1980; Chahbar, 1984; Laghezali, 1985) in the Rif mountains (Imzouren, B’ni Boufrah and Targuist), where 37 genotypes were collected. In 2005 and 2006, surveyed vegetal materials in Imantaout, Azilal, Tafraout and Tiznit, allowed selection of 49 genotypes tolerant to drought stress (Oukabli et al., 2006, 2007). These genotypes were planted in the experimental station of Ain Taaoujdat. Because of their good agronomic traits, they were chosen as parent candidate in the almond breeding programme. Morphological characterization of these genotypes showed a large genetic variability of this heterozygous species. The general trend to early flowering time, production of small fruits with hard shell (RC 25-35%) and double kernel percent, ranged from 2 to 35%. Data on phenological and pomological observations were collected in situ and in the experimental station.

The percent of fruit abortion, considered as a criterion for evaluation, was especially high (5%) in the genotype from the Rif region, and medium in the oasis population (2.4%). In the remaining population, this variable was less than 1%. Genotypes selected in the south of Morocco are suspected to present maximum fruit abortion, but the studied genotypes were selected for their high drought tolerance, explaining the lower fruit abortion of these selected genotypes.

In each population, flowering time depends on each genotype and ranged between the first and last decade of February. In general, the Rif population was earlier than oasis population. The early flowering time of these populations is probably originated by human selection since the fruit setting could benefit from the rainfall, which could allow the production of fruit with high weight. Nevertheless, the flowering time was generally at the early side for all populations, allowing the genotypes to avoid drastic effects of spring frost, considered the origin of the low yield and high production variability. The use of seed produced by selected genotypes in orchard increased cross pollination among closely related parents of local population, leading to increased inbreeding problems. Moreover, wide flowering period range of these genotypes and lack of adequate orchard management, associated with extreme climatic conditions (drought stress) contributed negatively to the reduction of production potential.

At genetic level, no ecotype is known to be specific to Morocco, as opposed to other Mediterranean regions, where several studies showed the presence of traits in some genotypes specific to each region (Italian cultivars from Apuglia, French cultivars of the Alps, Tunisian cultivars of Sfax and Portuguese cultivars of the Alto Douro). The lack of Moroccan ecotype is probably due to the high movement of the plant material in Morocco and to the way of propagation, essentially by seed. The existence of some genotypes at INRA collection, locally named after the farmer or the region where the collection was settled, such as De Safi, Boualouzze or Ksar Essouk does not reflect the presence of local varieties. This shows the low level of farmers when local material is selected, due to the lack of information and training of the farmers. In these conditions, sexual propagation of this species was successful as compared to grafting. The differences in environmental conditions, especially in the south of Morocco and in mountainous regions, where low rainfall, poor soil quality and high evaporation levels exert high stress on the almond. This traditional plant crop, resulting from several years of adaptation, could be basically used to improve drought resistance. This local material is characterized by a small leaf that shuts down early in summer, decreasing water lost and therefore it is considered as a tolerance mechanism to drought stress. Under these conditions, the species could tolerate drought that could induce an hydric potential similar to that of a xerophyte plant (-4MPa) (Oukabli et al., 2007).

The populations of the arid regions were characterized by early maturity with the endocarp adhering to the mesocarp. The early leaf shed in such population is considered as an adaptation aspect to drought conditions.

Natural hybrids of almond x peach were collected from the oasis regions. These hybrids originated from the cross of Missouri peach (local genotype used as rootstock) and some almond genotypes with the same flowering time. The evaluation of this plant material as rootstock for almond and peach is undertaken.

The different prospections realised have allowed the selection of 122 Prunus amygdalus almond genotypes from several traditional crop regions in Morocco. This plant material grown in an experimental station, presents criteria of high importance such as drought stress, and it revealed a high genetic potential for improved agronomic management. It constitutes an essential genetic basis for all breeding research. Its molecular characterization was undertaken to assess the genetic diversity of these populations in order to improve this genetic resource.

2- ESTABLISHMENT OF THE COLLECTION AND PLANT BEHAVIOUR STUDY OF THE INTRODUCED CULTIVARS
The introduction of a collection of foreign cultivars was supported by the French cooperation of C. Grasselly, and continued with the support of GREMPA and ICAR-DA. The introduced plant material originated from different countries of the Mediterranean area and from the USA. The collection was established in one of the important valleys of fruit tree production. The study on the agronomic behaviour of the foreign varieties started in the second half of the past century (Barbeau and El Baooumi, 1979; 1980; Laghezali, 1985; Lansari, 1993; Mamouni et al., 1998), and allowed the identification of good quality cultivars.
Improvement of almond orchards was carried out on the basis of foreign commercial cultivars, with the dominance of two associations ‘Marcona’- ‘Fournat de Breznaud’ and ‘Ferragnès’- ‘Ferraduel’.

The evaluation of the self-compatibility in the Ain Taoujd experimental station (Oukabli et al., 2000; Oukabli, 2001; Oukabli et al., 2003) allowed to point out the performance of some self-compatible varieties such as: ‘Tuono’, ‘Laurane’ and ‘Mandaline’, although under irrigation supply.

The behaviour of this plant material from different geographic provenances under arid conditions (400 mm/year) showed that early flowering genotypes presenting hard shells, such as ‘ATS’, ‘CFS’, ‘Marcona’ and ‘Desmayo’ (Oukabli et al. 2008) were high yielding in comparison with late flowering cultivars. Similar results have been reported in climatic conditions similar to those of the Ain Taoujd experimental station (Godini, 1984). The cultivars that were highly productive in arid conditions presented a kernel percent below 30% and a smaller mesocarp. However, in almond, the yield evaluations in such climatic conditions are difficult to establish, as numerous factors involve the determination of this trait, which generally are beyond genetic control. The analyses of this trait must take into account the variety associations, the influence of the environment and the training system applied.

Some cultivars are more productive than others and the average yield varied between 0,2 kg/tree to 9,6 kg/tree. When the yield potential of this material is compared according its origin (Figure 1), the Mediterranean material is superior. This behaviour is the result of selection according to local adaptation. The American and Syrian genotypes were characterised by low production in our climatic conditions and similar behaviour has been observed in the remaining genotypes.

The flowering time varied from 2 to 3 weeks, depending of genotype and environmental conditions. The observed year to year delay of flowering date might have a drastic effect on the production of self-incompatible genotypes. The observed flowering date delay between ‘Marcona’ and ‘Fournat de Breznaud’ considerably reduced yield (Oukabli et al., 2008). This study allowed the identification of the best adapted cultivars to arid conditions and the possibility to choose the regional cultivars based on the adaptation factors (rainfall, frost...).

3-CROSS BREEDING

The first breeding program started in collaboration with the INRA Bordeaux, crossing different cultivars presenting different performances (‘Archedoise’, ‘IXL’, ‘Texas’, ‘Marcona’, ‘Cristomotor’ and others). The selected hybrids of each family have been grafted on ‘Marcona’ seedlings and planted in an experimental orchard. The evaluation of the selected genotypes showed that some genotypes did not make any remarkable improvement in arid conditions. The previous study showed that the American cultivars were not productive in Morocco’s drought conditions (Oukabli et al., 2007). The selections obtained from crosses involving ‘Archedoise’ cultivars are more productive, except for some genotypes where Marcona is used as parent the yield was low. The yield of the hybrid obtained from ‘Marcona’ was irregular and some of these seedlings were more productive than the parents. Two genotypes presenting the most important traits have been selected to be planted in association with ‘Marcona’ or to be planted alone in orchards. These selections could improve considerably yield, kernel colour and weight. The second breeding program was undertaken in 1997, which objectives are late flowering date and self-compatibility. Twenty genotypes from one thousand hybrids were selected and are under evaluation.

4-SELECTION FOR DROUGHT TOLERANCE

The water efficiency use and isotopic carbon discrimination are some techniques used to select cultivars on drought tolerance. The assessment of these parameters requires time under Mediterranean climate conditions. Other approaches were reported as tools to be used in drought stress evaluation in perennial trees, referring mainly to fruit traits and aerial and root system parts of the plant. Pore density, wax percent and isotopic carbon discrimination have been used in order to identify the best tools for drought stress screening.

4.1 PORE DENSITY

The results using the pore number showed that there is a significant difference between cultivars (Table 1). This trait is genetically controlled and it seems not to be affected by water supply. All cultivars present similar pore numbers on the shell surface, both in dry (rain-fed) or irrigation systems.

![Figure 1. Average shell yield of each genetic pool genotype.](image)

Table 1. Number of shell surface pores / cm² of the tested cultivars under drought and irrigation conditions.

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>Number of pores/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain-fed</td>
<td></td>
</tr>
<tr>
<td>‘Marcona’</td>
<td>17.7 ab 18 a</td>
</tr>
<tr>
<td>‘Fournat de B’</td>
<td>12.7 cd 12 b</td>
</tr>
<tr>
<td>‘Ferragnès’</td>
<td>18.5 a 19 a</td>
</tr>
<tr>
<td>‘Ferraduel’</td>
<td>15.8 bc 13 b</td>
</tr>
</tbody>
</table>

Pore density of the hard shell genotype fruit, prospected in the arid regions of southern Morocco (rainfall <100mm/year) was different (Table 2). The pore number varied from 12 to 25/ cm². No correlation was observed between the pore number on the shell surface and environmental conditions. The genotypes from regions with little rainfall (200 mm/year) present a similar pore number to those from regions with high precipitations (400 to 500 mm).

4.2 Leaf wax content

The wax is extracted by emerging the leaf in a chloroform solution during 20 seconds (Mayeux and Jordan, 1984) and its content is expressed in foliar unit surface. This content depends on the genotype and the ecological crop conditions.
The wax quantity produced on the leaf surface was independent of the genetic nature of the plant material; it was statistically low (P=0.003) in Tafraoute when compared with the amount obtained in Ain Taoujdate. The average leaf content was 0.138 and 0.212 mg/cm², respectively (Table 2).

**b- Wax content evolution in cultivars**
In all studied cultivars the wax content showed an evolution over time. The maximum wax content was observed during the month of August (Figures 2 and 3). During this period, the wax content was three times higher than the level observed after this month. The magnitude of the wax content presents the same evolution pattern as compared with high temperature and drought intensity.

**c- Rootstock effect**
The wax content of the ‘Marcona’ cultivar varied significantly and depends on the rootstock. The values varied from 0.35 mg/leaf to 1.095 mg/leaf when this cultivar was grafted on ‘PG’, ‘G10’ and ‘Garriques’ rootstock, respectively. ‘Marcona’’s leaf wax content varied along with the time of the season and ranged from 0.096 to 0.149 mg/cm² in July and September, respectively (Table 3).

### 4.3 Isotopic carbon
The leaves were collected around the tree during the second week of June. The samples were desiccated, pounded and sent to a foreign laboratory of Isotope Services (Inc. Los Alamos, NM, USA) for the determination of δ¹³C, using the following equation:

\[
\delta^{13}C = \left[ \frac{R_{samples}}{R_{standard}} - 1 \right] \times 1000
\]

The discrimination (Δ) was determined for each sample using the equation:

\[
\Delta = \left( \delta_a - \delta_p \right) / \left( 1 + \delta_p \right)
\]

where \( \delta_a \) is the air isotopic carbon composition and \( \delta_p \) is the leaf isotopic carbon composition.

The ratio \(^{13}C/^{12}C\) of the plant was used as natural indicator of the photosynthesis rate expressed by \( \Delta \) to determine the \(^{13}C/^{12}C\) variation in the plant tissues comparing to those of the atmosphere during growth (Wu et al., 2004).

The values of the \( \Delta \) obtained for ‘Marcona’ cultivars grafted on different rootstocks during 2005-2006, characterised by high precipitation around 600 mm, varied significantly between -25.73 ‰ and -28.07‰ depending on the genotypes. The maximum difference was -2.31‰. These \( \Delta \) leaf values from one year old branches were low, due to drought stress. For all collected genotypes the \( \Delta \) value varied significantly among genotypes and is situated between -28.07 and -25.05. No correlation was observed between these values and altitude and precipitations (Table 3).

### 3.4 Correlation between productivity and different parameters
The yield obtained for ‘Marcona’ during 2006 and the average yield of five years (2002-2006) showed significant differences and depends on the rootstock used. The highest yields were obtained with ‘AT8’, ‘U8’ and ‘O11’ rootstocks and the lowest yields were observed with ‘V3’, and ‘X13’ rootstocks (Table 4). A significant and positive correlation (\( r^2 = 0.54 \)) was observed between vigour (expressed as trunk circumference) and yield. In our experimental conditions, low correlations between yield and delta were observed (\( r^2 = -0.2 \)) (Figure 1). The variation of \( \Delta \) values could be the result of the variation of the stomata conductance or the photosynthesis rate.

The almond is known to be a crop tree with specific physiological traits, allowing drought tolerance. The difference between genotypes is related to the capacity of the plant material to decrease its foliar...
tiation and branch elaboration during the growth season. One part of the stocked carbon was used during leaf initiation and branch elaboration during the winter respiration (Salvador et al., 2006). The carbon stocked in branches and trunk could be used, according to the season and growth conditions.

In comparison with other xyllophetic species such as jujube (Ziziphus jujuba) and argane (Argania spinosa), the almond tree produces an important wax quantity per surface unit (Rao and Raja Reddy, 1980, Bouzoubaa et al., 2005) which contributes to drought stress tolerance in almond trees. The almond triggers several mechanisms in drought stress conditions and its strategy used depends on stress intensity. In extreme conditions (arid conditions), the almond tree drops its leaves as a mechanism to avoid drought stress. The use of the isotopic carbon discrimination is a difficult selection tool for measuring drought stress tolerance in almond (a tedious technique). Important CID variation was observed and the environmental factors could affect the delta values. The use of isotopic carbon was confronted to the annual plant cycle and to the reserve mobilisation during drought years. The δ leaf analyses have provided an idea about the seasonal growth, whereas the leaf age and its position on the tree could be the origin of variation on this aspect. The complexity of the tree structure and the possible interactions between autotrophies (leaf) and heterotrophies (trunk, root) could make these results non useful for this plant material. The stocked carbon in branches and trunks, as reserve, could be considered as carbon source, depending on the growth season. One part of the stocked carbon was used during leaf initiation and branch elaboration during the growing season. One part of the stocked carbon was used during leaf initiation and branch elaboration during the growing season. One part of the stocked carbon was used during leaf initiation and branch elaboration during the growing season.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Trunk section surface (cm²) (ST)</th>
<th>Yield year 2006 (kg/tree)</th>
<th>Poresities</th>
<th>Average Δ C</th>
<th>Average C (‰)</th>
<th>Wax content of the leaf surfaces (mg/cm²)</th>
<th>Leaf surface (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitter almonds</td>
<td>96.7</td>
<td>2.3</td>
<td>10.32</td>
<td>-26.85</td>
<td>43.66</td>
<td>0.067</td>
<td>10.32</td>
</tr>
<tr>
<td>(12 genotypes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet almonds</td>
<td>107.2</td>
<td>3.3</td>
<td>8.7</td>
<td>-27.54</td>
<td>42.95</td>
<td>0.085</td>
<td>8.7</td>
</tr>
<tr>
<td>(4 genotypes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance level</td>
<td>0.0001</td>
<td>0.049</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Variation of the pore number and CID between genotypes originated from different altitudes.

Table 4. Average and accumulated yield registered in ‘Marcona’ on different rootstocks.

REFERENCES


Lansari, A. 1993. Self-incompatibility in Sour Cherry (Prunus cerasus L.), In-breeding and Multivariate relationships among almond [Prunus dulcis (Miller) D. A. Webb] cultivars. Thèse , Michigan State University, USA.


A. Oukabli, INRA.

Research unit: Plant Breeding and Genetic Resources, Regional Agricultural Research Center of Meknes, Morocco oukabli2001@yahoo.fr
THE ALMOND SCION BREEDING PROGRAMME OF IRTA IN CATALONIA (SPAIN)

ABSTRACT
The almond is an important crop in Spain. It covers around 400,000 ha (MARM, 2010), most in rainfed conditions, producing about 10% of the total world production. An almond scion breeding programme by controlled crosses was started at IRTA Mas de Bover in 1975. The main objectives were to obtain new cultivars having late blooming (to avoid spring frost damage), self-fertility (to reduce pollination drawbacks), high producing capacity, nut and kernel quality (hard shell, good kernel appearance, without double kernels, etc.), easy training and pruning, sufficient vigour and tolerance to dryness and diseases. Over the period 1975-2010, 535 different crosses were made, using 199 genitors, which originated 36,651 seedlings. Early selection in the nursery has allowed the handling of large seedling numbers. In 1992, the three first released cultivars were registered, ‘Masbovera’, ‘Glorieta’ and ‘Francollí’, which have been widely planted. Recently, in 2005, four new cultivars, ‘Vairo’, ‘Marina da’, ‘Constanti’ and ‘Tarraco’ were also released and successfully commercialized.

BACKGROUND
R & D Activity
In the mid 1960’s, R. Vidal i Barraquer and J. Vilà started in Mas de Bover, depending then from the “Diputació de Tarra-gona”, the establishment of an extensive collection of Spanish and foreign almond cultivars that would be very useful later for the breeding activity. In 1973, a large research, development and transference programme on almond (plant material and technology) was started (Vargas, 1979).

Sector
At that time, Spain produced about 25% of the world production. Traditional varieties with early blooming time were cultivated, often exposed to spring cold and crop losses. Due to its irregular productions, the almond tree was considered as a supplementary crop, very often located in marginal conditions, in poor soils, unsuitable for other crops.

Scientific environment
In the decade of 1970, the INRA in France developed an important programme to improve almond varieties well suited to the Mediterranean conditions. Worldwide there were also other programmes with different characteristics to scion breeding, in the USA (California) and the former USSR (Ukraine). In those years, programmes were also initiated in other Mediterranean countries: Italy, Tunisia, Greece and Spain (CITA, Zaragoza and later, CEBAS-CSIC, Murcia).

Breeding programme
The IRTA’s programme to obtain new almond varieties from controlled crosses began in 1975 focussed on increasing or modifying characteristics: very late blooming, no excessive branching, medium growth habit, hard or semihard nuts, good kernel aspect, no double almonds, etc. Other characters considered were drought tolerance and two major diseases: Phomopsis amygdali Del. (“fusicoccum”) and Polystigma ochraceum Whale. (“red leaf blotch”) (Martins et al., 2005; Luque et al., 2006; Vargas, 2007, Vargas and Mianzau, 2009).

During cross design, several traits were considered to rise trees with the following characteristics: very late blooming, self fertile, high cropping capacity, vigorous, no excessive branching, medium growth habit, hard or semihard nuts, good kernel aspect, no double almonds, etc. Other characters considered were drought tolerance and two major diseases: Phomopsis amygdali Del. (“fusicoccum”) and Polystigma ochraceum Whale. (“red leaf blotch”) (Martins et al., 2005; Luque et al., 2006; Vargas, 2007, Vargas and Mianzau, 2009).

Early in the programme, local high fruit quality cultivars were used as genitors and also foreign late flowering cultivars and, in some cases, self-fertile cultivars (in those years the choice of interesting self-fertile genitors was very limited). Subsequently, it was possible to add new parents, selections generated mostly by IRTA’s programme.

PROGRAMME DEVELOPMENT
Frame
After the assignment of the center of Mas de Bover to IRTA, in 1986, the breeding programme received a boost and more funding through various projects. Although the programme is commercial, since the priority has always been the development of interesting cultivars for growers, it has also directed to the achievement of scientific breakthroughs. In the framework of various projects, collaborations with several research teams have been maintained: genetics (using markers and elaborating genetic maps), ecophysiology (drought tolerance), pathology (disease tolerance) and food technology (physical characterization, chemical and industrial fitness of almond varieties and advanced selections). These scientific advances were later followed and adopted by some other almond breeding programmes.

CROSSES
Table 1 presents a summary of the size of IRTA’s programme. Over the period 1975-2010 there were made 783 crosses (535 of which were different), having obtained, studied and selected 36,651 trees.

The almond is an important crop in Spain. It covers around 400,000 ha (MARM, 2010), most in rainfed conditions, producing about 10% of the total world production. An almond scion breeding programme by controlled crosses was started at IRTA Mas de Bover in 1975. The main objectives were to obtain new cultivars having late blooming (to avoid spring frost damage), self-fertility (to reduce pollination drawbacks), high producing capacity, nut and kernel quality (hard shell, good kernel appearance, without double kernels, etc.), easy training and pruning, sufficient vigour and tolerance to dryness and diseases. Over the period 1975-2010, 535 different crosses were made, using 199 genitors, which originated 36,651 seedlings. Early selection in the nursery has allowed the handling of large seedling numbers. In 1992, the three first released cultivars were registered, ‘Masbovera’, ‘Glorieta’ and ‘Francollí’, which have been widely planted. Recently, in 2005, four new cultivars, ‘Vairo’, ‘Marina da’, ‘Constanti’ and ‘Tarraco’ were also released and successfully commercialized.

BACKGROUND
R & D Activity
In the mid 1960’s, R. Vidal i Barraquer and J. Vilà started in Mas de Bover, depending then from the “Diputació de Tarra-gona”, the establishment of an extensive collection of Spanish and foreign almond cultivars that would be very useful later for the breeding activity. In 1973, a large research, development and transference programme on almond (plant material and technology) was started (Vargas, 1979).

Sector
At that time, Spain produced about 25% of the world production. Traditional varieties with early blooming time were cultivated, often exposed to spring cold and crop losses. Due to its irregular productions, the almond tree was considered as a supplementary crop, very often located in marginal conditions, in poor soils, unsuitable for other crops.

Scientific environment
In the decade of 1970, the INRA in France developed an important programme to improve almond varieties well suited to the Mediterranean conditions. Worldwide there were also other programmes with different characteristics to scion breeding, in the USA (California) and the former USSR (Ukraine). In those years, programmes were also initiated in other Mediterranean countries: Italy, Tunisia, Greece and Spain (CITA, Zaragoza and later, CEBAS-CSIC, Murcia).

Breeding programme
The IRTA’s programme to obtain new almond varieties from controlled crosses began in 1975 focussed on increasing or modifying characteristics: very late blooming, no excessive branching, medium growth habit, hard or semihard nuts, good kernel aspect, no double almonds, etc. Other characters considered were drought tolerance and two major diseases: Phomopsis amygdali Del. (“fusicoccum”) and Polystigma ochraceum Whale. (“red leaf blotch”) (Martins et al., 2005; Luque et al., 2006; Vargas, 2007, Vargas and Mianzau, 2009).

Early in the programme, local high fruit quality cultivars were used as genitors and also foreign late flowering cultivars and, in some cases, self-fertile cultivars (in those years the choice of interesting self-fertile genitors was very limited). Subsequently, it was possible to add new parents, selections generated mostly by IRTA’s programme.
Table 2 shows information on the types of genitors used in different phases of the programme. In the period 1975-2010, 199 parents were used: 14 Spanish local cultivars, 20 foreign local cultivars, 17 cultivars and selections from various programmes and 148 cultivars and selections of IRTA. The use of the material generated by the breeding programme has increased considerably in recent years, as a logical consequence of the genetic resources obtained.

Usually, when making controlled almond crosses, flowers are emasculated before anthesis and then immediately pollinated artificially, earlier than in natural conditions. It is common to achieve low settings, lower than those produced in the same genitors in normal conditions. Significant differences were observed, which repeated consistently, in the behavior of female cultivars as female parents. In Table 4, 30 genitors are classified according to their average fruit set in the crosses made (Vargas et al., 2002).

Techniques developed
Two useful techniques were developed from the 1990’s for increasing the efficiency of the breeding process: a) early selection b) electrophoresis of stylar ribonucleases.

Early selection made handling of a large number of seedlings possible with limited resources (Vargas et al., 2005). The seeds obtained from the crosses are planted at a close spacing (about 4 m x 0.3 m) and seedlings are submitted to an early selection process in the nursery, without their transplant to orchards, eliminating uninteresting seedlings quickly. Thus, it makes handling of a large number of almonds possible in a small area (8,000 trees/ha).

Table 1. Controlled crosses. IRTA, Mas de Bover. Number of crosses made, flowers pollinated, seeds obtained and trees studied in different periods.

<table>
<thead>
<tr>
<th>Years</th>
<th>Crosses</th>
<th>Flowers</th>
<th>Seeds</th>
<th>Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975/1979</td>
<td>60</td>
<td>20,990</td>
<td>4,589</td>
<td>1,846</td>
</tr>
<tr>
<td>1980/1984</td>
<td>31</td>
<td>13,034</td>
<td>2,787</td>
<td>1,359</td>
</tr>
<tr>
<td>1985/1989</td>
<td>11</td>
<td>2,516</td>
<td>288</td>
<td>146</td>
</tr>
<tr>
<td>1990/1994</td>
<td>110</td>
<td>63,949</td>
<td>21,390</td>
<td>7,775</td>
</tr>
<tr>
<td>1995/1999</td>
<td>170</td>
<td>101,017</td>
<td>16,460</td>
<td>9,597</td>
</tr>
<tr>
<td>2000/2004</td>
<td>305</td>
<td>140,864</td>
<td>22,526</td>
<td>12,177</td>
</tr>
<tr>
<td>2005-2010</td>
<td>96</td>
<td>45,389</td>
<td>5,579</td>
<td>3,751</td>
</tr>
<tr>
<td>Total 1975/2010</td>
<td>783</td>
<td>387,761</td>
<td>73,619</td>
<td>36,651</td>
</tr>
</tbody>
</table>

Table 2. Genitors used in crosses in different periods. Genetic resources (GR) of domestic origin (generated in the programme) and external (local Spanish and foreign cultivars, also cultivars and selections from other breeding programmes).

<table>
<thead>
<tr>
<th>Years</th>
<th>Native GR</th>
<th>Foreign GR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cultivars and selections of IRTA’s programme</td>
<td>Local Spanish cultivars</td>
</tr>
<tr>
<td>1975/1979</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>1980/1984</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>1985/1989</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>1990/1994</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>1995/1999</td>
<td>44</td>
<td>2</td>
</tr>
<tr>
<td>2000/2004</td>
<td>90</td>
<td>5</td>
</tr>
<tr>
<td>2005/2010</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td>Summary 1975/2010 (different)</td>
<td>148</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 3. Some progenitors widely used: Spanish local cultivars and foreign cultivars and selections originated in breeding programmes.

<table>
<thead>
<tr>
<th>Local cultivars</th>
<th>Cultivars and selections originated in breeding programmes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDC</td>
<td>NT</td>
</tr>
<tr>
<td>Spanish:</td>
<td></td>
</tr>
<tr>
<td>‘Marcona’</td>
<td>20</td>
</tr>
<tr>
<td>‘Desmayo Largueta’</td>
<td>14</td>
</tr>
<tr>
<td>‘Ramillete’</td>
<td>6</td>
</tr>
<tr>
<td>‘Mena d’en Musté’</td>
<td>5</td>
</tr>
<tr>
<td>‘Constantí’</td>
<td></td>
</tr>
<tr>
<td>Foreign:</td>
<td></td>
</tr>
<tr>
<td>‘Belle d’Aurons’</td>
<td>7</td>
</tr>
<tr>
<td>‘Cristomorto’</td>
<td>17</td>
</tr>
<tr>
<td>‘Genco’</td>
<td>9</td>
</tr>
<tr>
<td>‘Tuono’</td>
<td>8</td>
</tr>
<tr>
<td>‘Falsa Barese’</td>
<td>5</td>
</tr>
</tbody>
</table>

NDC = Number of different crosses that have been used. NT = Number of trees obtained.

High production in ‘Vairo’ cultivar.
and susceptibility to some diseases can be observed when trees are very young, facilitating the elimination of plants without interest. In a short period a large number of seedlings can be removed. Table 6 shows a summary of the selection process undertaken in the period 1991-2004 (482 families). The selection speed is fast: the average percentage of kept trees at the end of the second year was 56%, reducing to 16% in the third, to 4.5% in the fourth and only to 0.6% after the fifth year. Due to such selection intensity, it was only necessary to observe fruit characters in 9.8% of the seedlings raised and assess self-fertility in 9.16% (Table 7).

Electrophoresis of stylar ribonucleases (RNase) has allowed to identify the S alleles which regulate pollen-style compatibility relations. Information about the self-incompatibility genotypes of the parents is very useful for a breeding programme because it allows the planning of crosses that generate progenies with all individuals being self-compatible (Batlle et al., 2001, Boskovic et al., 2003; Mnejja et al., 2002). For example, in the case of a cross between two parents, one self-compatible and the other self-incompatible, sharing one common allele, the use as male parental of the self-compatible genitor will provide 100% descendants of self-compatible trees, while if its reciprocal cross is made (using the self-compatible genitor as female genitor) the expected proportion of self-compatible trees would reduce to 50% (Table 8). With the information provided by electrophoresis of RNases and based in the crossed S-genotypes, 63 exclusively self-compatible progenies were obtained.

### Table 4. Average fruit set obtained in cultivars used frequently as female genitors in controlled crosses (%). Flowers emasculated before anthesis and pollinated artificially.*

<table>
<thead>
<tr>
<th>Female genitor</th>
<th>Fruit Set</th>
<th>Female genitor</th>
<th>Fruit Set</th>
<th>Female genitor</th>
<th>Fruit Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Wawona'</td>
<td>6.25</td>
<td>'Tarraco'</td>
<td>17.94</td>
<td>'Belle d'Aurons'</td>
<td>31.97</td>
</tr>
<tr>
<td>'Anxaneta'</td>
<td>6.51</td>
<td>'10-98'</td>
<td>18.24</td>
<td>'Falsa Baresse'</td>
<td>33.76</td>
</tr>
<tr>
<td>'8-1'</td>
<td>7.50</td>
<td>'Cristomorto'</td>
<td>20.00</td>
<td>'Ferragenses'</td>
<td>34.21</td>
</tr>
<tr>
<td>'FGFP092'</td>
<td>8.46</td>
<td>'Glorieta'</td>
<td>20.11</td>
<td>'21-22'</td>
<td>36.81</td>
</tr>
<tr>
<td>'10-57'</td>
<td>9.89</td>
<td>'Tardive Verdière'</td>
<td>20.70</td>
<td>'Stelliette'</td>
<td>38.55</td>
</tr>
<tr>
<td>'4-665'</td>
<td>10.12</td>
<td>'Garbi'</td>
<td>21.93</td>
<td>'FGTR30'</td>
<td>40.13</td>
</tr>
<tr>
<td>'8-33'</td>
<td>10.60</td>
<td>'Masbovera'</td>
<td>22.74</td>
<td>'Primorsky'</td>
<td>45.50</td>
</tr>
<tr>
<td>'8-47'</td>
<td>13.73</td>
<td>'Geno'</td>
<td>24.50</td>
<td>'Lauranne'</td>
<td>45.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'FLTU18'</td>
<td>25.27</td>
<td></td>
<td>48.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'TUAI6'</td>
<td>26.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Rana'</td>
<td>28.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Tarragonés'</td>
<td>28.37</td>
<td>'Francolí'</td>
<td>29.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* In all cases: N° flowers >1000; N° years ≥ 2; N° crosses ≥ 4; N° male parents ≥3. Adapted from Vargas et al., 2002.

### Table 5. Early selection. Main steps in the process.

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Activity / Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Winter</td>
<td>Making crosses</td>
</tr>
<tr>
<td>0</td>
<td>Autumn - winter</td>
<td>Sowing seeds</td>
</tr>
<tr>
<td>1</td>
<td>Spring - autumn</td>
<td>Seedlings growing in the nursery</td>
</tr>
<tr>
<td>2</td>
<td>Winter</td>
<td>Foliation date</td>
</tr>
<tr>
<td>2</td>
<td>Fall - winter</td>
<td>Vigour, growth habit and branching habit</td>
</tr>
<tr>
<td>3</td>
<td>Winter - spring</td>
<td>Blooming date, bearing precocity</td>
</tr>
<tr>
<td>3</td>
<td>Summer - winter</td>
<td>Fruit characteristics, general tree appearance</td>
</tr>
<tr>
<td>4</td>
<td>Winter - spring</td>
<td>Self-fertility, blooming time, yield potential</td>
</tr>
<tr>
<td>4</td>
<td>Summer - winter</td>
<td>Fruit, general seedling appearance, sensitivity to drought and diseases</td>
</tr>
<tr>
<td>5</td>
<td>Winter - spring</td>
<td>Self-fertility, blooming time, yield potential</td>
</tr>
<tr>
<td>5</td>
<td>Summer - winter</td>
<td>Fruit, general seedling appearance, sensitivity to drought and diseases</td>
</tr>
</tbody>
</table>

### Table 6. Early selection. Selection intensity. Kept seedlings at the end of different years and seasons*. Mean data from crosses made in the period 1991-2004 (482 families).

<table>
<thead>
<tr>
<th>Year</th>
<th>Study on fruit character</th>
<th>Study on autofertility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trees Start</td>
<td>P2</td>
</tr>
<tr>
<td>1991-2004</td>
<td>26,977</td>
<td>19,077</td>
</tr>
<tr>
<td>1991-2004</td>
<td>100</td>
<td>71</td>
</tr>
</tbody>
</table>

*P2, P3, P4 and P5: seedlings kept after selection in spring in years 2, 3, 4, and 5.
*O2, O3, O4 and O5: seedlings kept after selection in autumn-winter of the years 2, 3, 4 and 5.

### Table 7. Early selection. Selection intensity at the time of fruit characterisation (3rd -4th year) and self-fertility (4th -5th year) observations.

<table>
<thead>
<tr>
<th>Crossing years</th>
<th>N° of seedlings start</th>
<th>Study on fruit character</th>
<th>Study on autofertility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-2004</td>
<td>26,977</td>
<td>2,644</td>
<td>9.80</td>
</tr>
</tbody>
</table>

**RESULTS**

**Advances in variety breeding**

Among others, the following may be included:

- **Obtention of useful information on breeding cultivars:**
  - Early seedlings selection (Vargas et al., 2005).
  - Use of electrophoresis of stylar ribonucleases for determining incompatibility of S alleles (Batlle et al., 1997; Batlle et al., 2001, Boskovic et al., 1997, 1999 and 2003, Lopez 2004, Lopez et al., 2004 and 2006; Mnejja et al., 2002; Martins et al., 2005).
- Use of molecular markers in breeding (Arús et al., 1994; Ballester et al., 1998, López et al., 2004, 2005a and 2005b, Martins et al., 2005; Viruel et al., 1995).
- Transmission of characters: self-compatibility (López et al., 2006), autogamy (Vargas et al., 1998), blooming date (Vargas et al., 1984, Vargas and Romero 2001), almond taste / flavor (Vargas et al., 2001) and tolerance to “Fusicoccum” (Luque, 2006, Vargas and Miarnau, 2009, Vargas et al., 2009b).
- Fruit set in controlled crosses (Vargas et al., 2002).
- Tolerance to diseases (Vargas and Miarnau, 2009, Vargas et al., 2009b) and drought (Batlle et al., 1998; Miarnau, 2009, Vargas et al., 2009b).
- Effect of pollination type in self-fertile varieties (Martin and Rovira, 2008, Martin et al., 2009).

Table 8. Example of the use of stylar ribonucleases in crossing design. Progenies obtained in the case of crossing two parents, one self-compatible (SF) and another self-incompatible (INC) with one common allele, depending on the crossing sense. In the example: $S_i$ with alleles $S_i S_i$ and INC with alleles $S_i S_j$.

<table>
<thead>
<tr>
<th>Crossing type (female x male)</th>
<th>Alleles Descendants</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INC x SF</td>
<td>$S_i S_i x S_j S_j$</td>
<td>$S_i S_i$ or $S_j S_j$ *</td>
<td></td>
</tr>
<tr>
<td>SF x INC</td>
<td>$S_i S_i x S_j S_j$</td>
<td>$S_i S_i$ (self-incompatible) o $S_j S_j$ (self-compatible)</td>
<td>50% self-compatible seedlings</td>
</tr>
</tbody>
</table>

* In this crossing, only the pollen grains with the $S_i$ allele will fertilize the flowers of the female parent. The $S_j$ allele pollen cannot fertilize flowers having the same allele (in this case $S_j S_j$).

- Introduction of new almond genetic resources, very useful for the breeding programme.

Achievement of new varieties
In 1992 three cultivars were registered: ‘Masbovera’, ‘Glorieta’ and ‘Francoli’. They achieved a wide distribution (reported sales of about 600,000 trees).

In 2005, the IRTA requested the Plant Material Rights for four new cultivars, “Vairo”, “Constanti”, “Masbovera” and “Francoli”, which have been very well received in the sector and they have been spread very quickly (reported sales more than 500,000 trees).

Table 9 gathers the origin of the cultivars. Tables 10-15 summarize their main agromonic and commercial characteristics. The tables include well-known reference cultivars for comparative purposes.

Table 9. Origin of the cultivars.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Parentage</th>
<th>Crossing year</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRTA, new cvs.:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vairo’</td>
<td>‘4-665’ x ‘Lauranne’</td>
<td>1991</td>
</tr>
<tr>
<td>‘Constanti’</td>
<td>‘FGFD2’ x Polinización libre</td>
<td>1993</td>
</tr>
<tr>
<td>‘Marinada’</td>
<td>‘Lauranne’ x ‘Glorieta’</td>
<td>1994</td>
</tr>
<tr>
<td>‘Tarraco’</td>
<td>‘FLTU18’ x ‘Anxaneta’</td>
<td>1991</td>
</tr>
<tr>
<td>IRTA, first cvs.:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Masbovera’</td>
<td>‘Primorskij’ x ‘Cristomorto’</td>
<td>1975</td>
</tr>
<tr>
<td>‘Glorieta’</td>
<td>‘Primorskij’ x ‘Cristomorto’</td>
<td>1975</td>
</tr>
<tr>
<td>‘Francoli’</td>
<td>‘Cristomorto’ x ‘Tuono’</td>
<td>1976</td>
</tr>
</tbody>
</table>

Table 10. Blooming, pollination and ripening period. Flowering time, mean full blooming date of 14 years (1998-2011) at Mas de Bover as number of days from ‘Desmayo Largueta’ (’DL’) full bloom, self-compatibility, $S$ genotypes and harvesting season.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Blooming period</th>
<th>N days after ‘DL’</th>
<th>Self-compatibility</th>
<th>Genotype $S$</th>
<th>Ripening period</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRTA, new cvs.:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vairo’</td>
<td>Late</td>
<td>25</td>
<td>Yes</td>
<td>$S_i S_i$</td>
<td>Early</td>
</tr>
<tr>
<td>‘Constanti’</td>
<td>Late</td>
<td>25</td>
<td>Yes</td>
<td>$S_i S_i$</td>
<td>Early-Medium</td>
</tr>
<tr>
<td>‘Marinada’</td>
<td>Very late</td>
<td>32</td>
<td>Yes</td>
<td>$S_i S_i$</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Tarraco’</td>
<td>Very late</td>
<td>34</td>
<td>No</td>
<td>$S_j S_j$</td>
<td>Medium-late</td>
</tr>
<tr>
<td>IRTA, first cvs.:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Masbovera’</td>
<td>Late</td>
<td>27</td>
<td>No</td>
<td>$S_i S_i$</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Glorieta’</td>
<td>Late</td>
<td>24</td>
<td>No</td>
<td>$S_i S_i$</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Francoli’</td>
<td>Late</td>
<td>24</td>
<td>Yes</td>
<td>$S_j S_j$</td>
<td>Early</td>
</tr>
<tr>
<td>Reference cvs.:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘D. Largueta’</td>
<td>Early</td>
<td>0</td>
<td>No</td>
<td>$S_i S_i$</td>
<td>Late</td>
</tr>
<tr>
<td>‘Marcona’</td>
<td>Medium</td>
<td>13</td>
<td>No</td>
<td>$S_j S_j$</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Ferragnés’</td>
<td>Late</td>
<td>28</td>
<td>No</td>
<td>$S_i S_i$</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Guara’</td>
<td>Late</td>
<td>25</td>
<td>Yes</td>
<td>$S_j S_j$</td>
<td>Early</td>
</tr>
</tbody>
</table>

All cultivars have shown a high bearing capacity and are easily trained and pruned (Table 12). Several of them have a remarkable tolerance level to two major diseases: “Fusicoccum” (P. amygdali Del.) and “red leaf blotch” (P. ochraceum Whal.) (Table 13).

IRTAs’s varieties have good fruit characteristics. They are hard-shelled, producing a good kernel appearance and having no doubles. The kernel
Table 11. Self-fertility and autogamy in self-compatible cultivars. Mean fruit setting in bagged branches before blooming (%).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Years of observations</th>
<th>Mean fruit set</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRTA, new cvs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vairo’</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>‘Constanti’</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>‘Marinada’</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>IRTA, first cvs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Francoli’</td>
<td>6</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 12. Production (yield potential and bearing precocity), tree vigour, growth habit and training and pruning ease.

<table>
<thead>
<tr>
<th>Cultivar potential</th>
<th>Yield potential</th>
<th>Bearing vigour</th>
<th>Tree habit</th>
<th>Growth</th>
<th>Training and pruning</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRTA, new cvs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vairo’</td>
<td>Very high</td>
<td>Early</td>
<td>Very strong</td>
<td>Medium</td>
<td>Very easy</td>
</tr>
<tr>
<td>‘Constanti’</td>
<td>High-very high</td>
<td>Early</td>
<td>Strong</td>
<td>Medium-upright</td>
<td>Very easy</td>
</tr>
<tr>
<td>‘Marinada’</td>
<td>Very high</td>
<td>Very early</td>
<td>Mid-low</td>
<td>Medium-upright</td>
<td>Very easy</td>
</tr>
<tr>
<td>‘Tarraco’</td>
<td>Very high</td>
<td>Very early</td>
<td>Mid-low</td>
<td>Medium-upright</td>
<td>Very easy</td>
</tr>
<tr>
<td>IRTA, first cvs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Masbovera’</td>
<td>High-very high</td>
<td>Medium</td>
<td>Very strong</td>
<td>Medium-upright</td>
<td>Very easy</td>
</tr>
<tr>
<td>‘Glorieta’</td>
<td>High-very high</td>
<td>Early</td>
<td>Very strong</td>
<td>Medium-upright</td>
<td>Very easy</td>
</tr>
<tr>
<td>‘Francoli’</td>
<td>High-very high</td>
<td>Early</td>
<td>Strong</td>
<td>Medium</td>
<td>Very easy</td>
</tr>
<tr>
<td>Reference cvs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘D. Largueta’</td>
<td>High</td>
<td>Mid-late</td>
<td>Mid-high</td>
<td>Spreading</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Marcona’</td>
<td>High</td>
<td>Early</td>
<td>Mid</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Ferragnès’</td>
<td>High-very high</td>
<td>Mid</td>
<td>Strong</td>
<td>Medium-upright</td>
<td>Very easy</td>
</tr>
<tr>
<td>‘Guara’</td>
<td>High-very high</td>
<td>Early</td>
<td>Mid-low</td>
<td>Drooping</td>
<td>Difficult</td>
</tr>
</tbody>
</table>

Table 13. Estimation of tolerance or sensitivity degree to “Fusicoccum” (P. amygdales Del.) and “red leaf blotch” (P. ochraceum Whal.).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>“Fusicoccum”</th>
<th>“Mancha ocre”</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRTA, new cvs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vairo’</td>
<td>Tolerant</td>
<td>Very tolerant</td>
</tr>
<tr>
<td>‘Constanti’</td>
<td>Sensitive</td>
<td>Tolerant</td>
</tr>
<tr>
<td>‘Marinada’</td>
<td>Tolerant</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Tarraco’</td>
<td>Tolerant</td>
<td>Sensitive</td>
</tr>
<tr>
<td>IRTA, first cvs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Masbovera’</td>
<td>Very tolerant</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Glorieta’</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>‘Francoli’</td>
<td>Sensitive</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Reference cvs.:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘D. Largueta’</td>
<td>Very sensitive</td>
<td>Tolerant</td>
</tr>
<tr>
<td>‘Marcona’</td>
<td>Very sensitive</td>
<td>Tolerant</td>
</tr>
<tr>
<td>‘Ferragnès’</td>
<td>Very sensitive</td>
<td>Tolerant</td>
</tr>
<tr>
<td>‘Guara’</td>
<td>Sensitive</td>
<td>Very sensitive</td>
</tr>
</tbody>
</table>

size of the cultivar ‘Tarraco’ should be highlighted and also the oil content of several of them (Tables 14 and 15).

PROSPECTS

Sector

The almond is an important crop in Spain (about 400,000 ha, producing 10% of the world production). Often, orchards are located in marginal land, giving very low yields, but in recent years a slow but steady trend resulted in higher crop yield (drip irrigation, better soils, productive cultivars, etc.). To become competitive, the current Spanish production systems need a deep change. In many Spanish regions, the almond crop is the only, or one of the few alternatives for sustainable farming production.

Cultivars

The plant material is a basic producing factor in the orchards. The traditional Spanish cultivars have important cropping limitations. The range of cultivars has undergone a remarkable renewal over the last 25 years due to the use of varieties generated by breeding programmes, first in France (INRA) and then in Spain (CITA, CEBAS and IRTA). The new varieties made significant crop ad-

vances. In the future the reconversion process of varieties will have to be continued.

Breeding programmes

Considerable progress has been made, but there are still plenty of aspects to be further improved. The aims of the crosses should be basically the same, as it is clear that a good variety should meet a number of outstanding characters, with particular emphasis on: a) kernel quality, b) tolerance to diseases and c) very late blooming. Referring to these three, with the currently available genetic resources, it is expected to achieve significant progress in the coming years.

Regarding support, to carry on IRTA’s breeding programme in the future, approaches to the industry are being made to seek sources of additional funding.

Kernel quality

In the crosses made in recent years, particular attention has been focussed on kernel size and aspect. Trees with big sized kernels were obtained and with excellent appearance, with high interest as genitors. With the information currently available, also crosses can be made aimed at specific features related to the industrial kernel properties (oil content, oleic acid, stability, etc.).

Diseases

There are considerable differences among varieties in their level of sensitivity or tolerance to two important diseases: “Fusicoccum” and “red leaf blotch”. Therefore it is possible to select trees with a good tolerance level to these diseases (eg. ‘Vairo’). Tolerance to diseases (especially “Fusicoccum”) has been considered from the start of the programme; in future programmes, it will be a priority.

Extremely late blooming

Some of the new cultivars have already a late or very late blooming period (‘Marina da’ and ‘Tarraco’). It is relatively easy to delay blooming even more, crossing two very late blooming selections (the programme has generated outstanding genetic resources for this character) or by using the American genitor ‘Tardy Nonpa rel’ or any of its offsprings. However, it is not easy that outstanding individuals for their extreme blooming delay also carry a range of good features. It will probably be necessary to rise F3 or even several generations to produce extremely late blooming interesting cultivars.

We acknowledge funding from Spanish INIA and the EU to IRTA’ almond breeding programme Projects SC1997-049, RTA2001-081, RTA2004-030, RTA2007-057, RTA2011-0130 and TRT2066-00021-00-00).
REFERENCES

Arús, P.; Olarte, C.; Romero, M.A.; Var- 
isozyme genes in F1 segregating pro- 

Ballester, J.; Boskovic, R.; Batlle, I.; 
Arús, P.; Vargas, F.J.; De Vicente, M.C., 1998. Location of the self-incompati- 
bility gene in the almond linkage map. Plant 

Ballester, I.; Ballester, J.; Boskovic, R.; 
almond breeding to design crosses and 
select self-compatible seedlings. FAO­ 
CIHEAM Network on Nuts, Nucis-News- 
letter 6: 12-14.

Batlle, I.; Tanriver, E.; Lakhal, H.; Rome- 
ro, M.A.; Vargas, F.J., 2001. Use of stil- 
lar ribonucleases in almond breeding. XI 
GREMPA Seminar on pistachios and al-
monds, Sanliurfa (Turkey), 1999. Cahiers 
Options méditerranéennes, 56: 111-115.

Batlle, I.; Sanz, G.; Romero, M.A.; Var-
gas, F.J.; Savé, R.; de Herralde, F.; 
Cohen, M.; Biel, C.; Campanals, A.; 
Messegueur, R.; Pagès, J.M.; De Vicente, 
for drought resistance. Acta Horticultu-
rae, 470: 72-73.

Boskovic, R.; Tobutt, K.R.; Batlle, I.; 
Du-
val, H., 1997. Correlation of ribonuclea- 
zymograms and incompatibility geno-
types in almond. Euphytica, 97: 167-
176.

Boskovic, R.; Tobutt, K.R.; Batlle, I.; 
Du-
val, H.; Martínez Gómez, P.; GRADZIEL, 
T.M., 2003. Stylar ribonucleases in al-
mond: correlation with and prediction of 
incompatibility genotypes. Plant Breeding, 122: 70-76.

López, M.; Mneija, M.; Rovira, M.; Coll-
ins, G.; Vargas, F.J.; Arús, P.; Batlle, I., 
2004. Self-incompatibility genotypes in 
almond re-evaluated by PCR, stylar ri-
bonucleases, sequencing analysis and 
controlled pollinations. Theor. Appl. Ge-
et., 109: 954-964.

López, M.; Romero, M.A.; Vargas, F.J.; 
Bat-
lle, I., 2005b. ‘Francolí’, a late flowering 
cultivar re-classified as self-compat-


Table 14. Nut characteristics. 
Physical traits. Weight of unshelled nuts (g), kernel weight (g), 
kernel yield (shelling percentage) (%) and double kernels (%). 
Mean values of samples analyzed during 10-35 years.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Number of analyzed samples</th>
<th>Nut weight</th>
<th>Kernel weight</th>
<th>Shelling percentage</th>
<th>Double kernels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IRTA, new cvs.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vairo’</td>
<td>62</td>
<td>4.19</td>
<td>1.20</td>
<td>28.75</td>
<td>0.06</td>
</tr>
<tr>
<td>‘Constanti’</td>
<td>69</td>
<td>4.31</td>
<td>1.18</td>
<td>27.64</td>
<td>1.48</td>
</tr>
<tr>
<td>‘Marinada’</td>
<td>57</td>
<td>4.14</td>
<td>1.31</td>
<td>31.86</td>
<td>0.32</td>
</tr>
<tr>
<td>‘Tarraco’</td>
<td>54</td>
<td>5.20</td>
<td>1.60</td>
<td>31.09</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>IRTA, first cvs.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Masbovera’</td>
<td>190</td>
<td>4.88</td>
<td>1.36</td>
<td>27.94</td>
<td>0.38</td>
</tr>
<tr>
<td>‘Glorieta’</td>
<td>159</td>
<td>5.03</td>
<td>1.43</td>
<td>28.55</td>
<td>1.86</td>
</tr>
<tr>
<td>‘Francoli’</td>
<td>146</td>
<td>4.08</td>
<td>1.22</td>
<td>30.33</td>
<td>3.77</td>
</tr>
</tbody>
</table>

Table 15. Fruit characteristics. 
Chemical composition of blanched kernels. 
Oil (%), protein (%), soluble sugars (%), total fiber (%) and water (%). 
Average values (2005-2009 crops, 1-3 locations, 3 trees per cultivar and location).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Oil</th>
<th>Protein</th>
<th>Soluble sugars</th>
<th>Total fiber</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IRTA, new cvs.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Vairo’</td>
<td>55.0</td>
<td>25.2</td>
<td>2.88</td>
<td>8.01</td>
<td>4.03</td>
</tr>
<tr>
<td>‘Constanti’</td>
<td>54.2</td>
<td>25.5</td>
<td>2.82</td>
<td>8.32</td>
<td>3.99</td>
</tr>
<tr>
<td>‘Marinada’</td>
<td>54.0</td>
<td>24.3</td>
<td>3.44</td>
<td>8.61</td>
<td>4.08</td>
</tr>
<tr>
<td>‘Tarraco’</td>
<td>55.0</td>
<td>25.5</td>
<td>2.82</td>
<td>8.22</td>
<td>4.08</td>
</tr>
<tr>
<td><strong>IRTA, first cvs.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Masbovera’</td>
<td>57.0</td>
<td>23.3</td>
<td>2.53</td>
<td>8.02</td>
<td>3.79</td>
</tr>
<tr>
<td>‘Glorieta’</td>
<td>55.8</td>
<td>24.9</td>
<td>2.57</td>
<td>8.32</td>
<td>3.86</td>
</tr>
<tr>
<td>‘Francoli’</td>
<td>54.9</td>
<td>26.1</td>
<td>2.92</td>
<td>7.71</td>
<td>4.13</td>
</tr>
<tr>
<td><strong>Reference cvs.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Marcona’</td>
<td>53.7</td>
<td>25.9</td>
<td>2.62</td>
<td>8.89</td>
<td>4.11</td>
</tr>
<tr>
<td>‘Nonpareil’</td>
<td>46.3</td>
<td>24.9</td>
<td>2.18</td>
<td>9.77</td>
<td>4.80</td>
</tr>
</tbody>
</table>

López, M.; Mneija, M.; Rovira, M.; Col-
lins, G.; Vargas, F.J.; Arús, P.; Batlle, I., 
2004. Self-incompatibility genotypes in 
almond re-evaluated by PCR, stylar ri-
bonucleases, sequencing analysis and 
controlled pollinations. Theor. Appl. Ge-
et., 109: 954-964.

López, M.; Romero, M.A.; Vargas, F.J.; 
Bat-
lle, I., 2005b. ‘Francolí’, a late flowering 
cultivar re-classified as self-compat-


Luque, J.; Martos, S.; Batlle, I.; Clavé, J.; 
Romero, M.; Vargas, F., 2006. Suscep-
tibility a Phomopsis amygdali en al-
mdenos descendientes del cruzamiento 
‘Primorskiy’ x ‘Lauranne’. Actas del XIII 
Congreso de la Sociedad Española de 
Fitopatología (SEF), Murcia (Spain), 251.

MARM - http://www.marm.es/
**THE INTRODUCTION OF NEW ALMOND CULTIVARS IN SPANISH ALMOND GROWING**

**INTRODUCTION**

Spain is the second world’s almond producer (Table 1). Although the United States of America, basically by the Californian production, is the leading producer ahead of all the others, the almond breeding programs of Spain are the most active in the world and those releasing the largest number of new cultivars (Socias i Company et al., 2011). This work has produced a clear penetration of the new plant materials, both cultivars and rootstocks, in the Spanish almond growing regions (Socias i Company et al., 2009).

<table>
<thead>
<tr>
<th>Country</th>
<th>Average production 2000-09 (tm in shell)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>884,914</td>
</tr>
<tr>
<td>Spain</td>
<td>223,431</td>
</tr>
<tr>
<td>Syria</td>
<td>110,595</td>
</tr>
<tr>
<td>Italy</td>
<td>106,648</td>
</tr>
<tr>
<td>Iran</td>
<td>99,582</td>
</tr>
<tr>
<td>Morocco</td>
<td>78,636</td>
</tr>
<tr>
<td>Tunisia</td>
<td>46,300</td>
</tr>
<tr>
<td>Turkey</td>
<td>45,466</td>
</tr>
<tr>
<td>Greece</td>
<td>45,219</td>
</tr>
<tr>
<td>Algeria</td>
<td>37,526</td>
</tr>
<tr>
<td>Lebanon</td>
<td>27,210</td>
</tr>
<tr>
<td>Pakistan</td>
<td>26,247</td>
</tr>
<tr>
<td>China</td>
<td>25,600</td>
</tr>
<tr>
<td>Libya</td>
<td>25,400</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>22,299</td>
</tr>
<tr>
<td>Portugal</td>
<td>17,099</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>17,016</td>
</tr>
<tr>
<td>Chile</td>
<td>10,364</td>
</tr>
<tr>
<td>Israel</td>
<td>7,091</td>
</tr>
<tr>
<td>France</td>
<td>3,712</td>
</tr>
<tr>
<td>Rest</td>
<td>25,708</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,901,041</td>
</tr>
</tbody>
</table>

The Spanish market only distinguishes two cultivars as such, ‘Marcona’ and ‘Desmayo Largueta’, whilst the rest of cultivars are grouped under the undefined name of ‘Comunas’. Even such important cultivars as ‘Guara’ and ‘Ferragèns’, representing and important share of the Spanish production, are not marketed as individual cultivars. Similarly, some new releases with an excellent kernel quality are also marketed in a mixture of kernels. As a consequence, the Spanish production statistics do not reflect the level of production attributable to the new cultivars. In addition, the statistics on the surface planted with each cultivar are not

---

**Table 1. Average almond world production for the period 2000-2009**

(web page of FAO)
fully reliable and do not give a trustworthy picture of the presence of the new cultivars in the Spanish orchards. The long life of the almond orchards renders updating these figures quite difficult, thus not reflecting the dynamics of cultivar change produced in the Spanish orchards during the last four decades.

Probably the best figure to show the changes produced in the Spanish almond orchards is the production of almond plants by the Spanish nurseries. Therefore, in order to obtain a real figure of the introduction of the new cultivars in the Spanish orchards, we have revised the statistics of the plants marketed by the Spanish nurseries as collected by the Spanish Office of Plant Varieties.

**MATERIALS AND METHODS**

The Spanish Office of Plant Varieties at the Ministry of the Environment and Rural Affairs collects the data from the different Autonomous Regions on the production of fruit plants by the Spanish nurseries. The years studied were from the 1995/96 to the 2009/10 seasons. The data collected had to be carefully revised in order to avoid inaccuracies, such as synonyms and incorrect wording. Some clones were identified with acronyms or abbreviations not corresponding to any known selection or breeding clone. The most notable case of synonymy was that of 'Desmayo Largueta', also referred to as 'Largueta', 'Desmayo blanco', 'Desmayo común' or 'Desmayo verde'. The same cultivar could also be identified in different lists by the cultivar name or the trade mark, such as 'Avijor' or 'Lauranne'.

Once the data were refined from any detected inaccuracies, the cultivars were grouped according to their origin (Table 2). These figures allowed obtaining the total

\[
\begin{array}{ll}
\text{CITA cultivars} & 7,370,178 \\
\text{Masbovera} & 322,234 \\
\text{Francoli} & 80,613 \\
\text{Glorieta} & 240,360 \\
\text{Tardor} & 2,500 \\
\text{Constantí} & 95,020 \\
\text{Marinada} & 183,253 \\
\text{Tarraco} & 53,416 \\
\text{Vairo} & 132,790 \\
\text{IRTA cultivars} & 1,110,186 \\
\text{Almudena} & 1,560 \\
\text{Antoñeta} & 85,778 \\
\text{Marta} & 119,309 \\
\text{Penta} & 4,304 \\
\text{Tardona} & 647 \\
\text{CEBAS cultivars} & 211,598 \\
\text{Marcona} & 1,659,200 \\
\text{Desmayo Largueta} & 1,560,723 \\
\text{Garriguès} & 344,906 \\
\text{Ramillete} & 269,016 \\
\text{Atocha} & 104,561 \\
\text{Desmayo Rojo} & 108,124 \\
\text{Carreró} & 103,436 \\
\text{Soft-shell} & 7,920 \\
\text{Other Spanish} & 435,007 \\
\text{Traditional Spanish cultivars} & 4,593,943 \\
\text{Ferragnès} & 2,408,780 \\
\text{Ferraduel} & 1,866,750 \\
\text{Lauranne} & 47,985 \\
\text{Other French} & 22,101 \\
\text{French cultivars} & 4,345,616 \\
\text{Tuono} & 497,816 \\
\text{Cristomorto} & 61,832 \\
\text{Fragiulio} & 4,320 \\
\text{Italian cultivars} & 563,966 \\
\text{Nonpareil} & 1,100 \\
\text{Texas} & 8,365 \\
\text{Californian cultivars} & 9,465 \\
\text{Others} & 37,910 \\
\text{Total} & 18,095,625 \\
\end{array}
\]
values of each cultivar or group of cultivars and the percentages of each, in order to draw the graphs showing their evolution trends during the period examined.

RESULTS AND DISCUSSION

The first observation from the data is the undeniable prevalence of the CITA cultivars during the 14 seasons over the total amount of more than 18 million plants produced by the Spanish nurseries. Over this period, the CITA cultivars amounted to 40.73%, with ‘Guara’ as the leading cultivar, with 38.68%, which represents 94.97% of the CITA cultivars. Although in 2009/10 the percentage of these cultivars slightly decreased (Fig.1), during this period the trend has been towards a constant increase. The new cultivars ‘Belona’ and ‘Soleta’ appeared in the season 2006/07 and ‘Mardia’ in 2009/10. Therefore, for the moment the data do not allow establishing the real level of penetration of these new cultivars in spite of the references of their introduction in the new orchards.

The second Spanish breeding program is that of IRTA developed at the Centre of Mas de Bover. The incidence of the cultivars released by this program amounts to 6.14% of total, although their evolution can be clearly differentiated. Thus, their percentage ranged from 0.15 to 6.64% (Fig. 2) until 2007/08, but the following season there was a sharp increase up to 23.36%, mainly due to the introduction of the last releases from this program and the sound recommendations by the main growers’ associations. Probably the data of the coming years will show if this upturn is seasonal (in 2009/10 this percentage was 12.86%) or is maintained.

The cultivars released by CEBAS-CSIC of Murcia do not appear in the statistics until the season 2001/02 because this program started later than the previous ones (Fig. 3). From that season their incidence has ranged from 0.2 to 5%, with a global average of 1.17%, showing a lower incidence than the older programs.

The traditional Spanish cultivars still represent nearly a quarter of the total, with 24.57%, with significant variations along the period, although any trend can be noticed (Fig. 4). Among these cultivars, ‘Marcona’ with 9.17% and ‘Desmayo Larga’ with 8.62% are the most important, both with a stable presence along these seasons. The other traditional Spanish cultivars are much less present, including ‘Garrigues’, ‘Ramilette’, ‘Desmayo Rojo’, ‘Atocha’, ‘Carrero’, ‘Pajarera’, ‘Aspirilla’, ‘Cartagenera’, ‘Peraleja’, ‘Planeta’ and many others less important. The presence of soft-shell cultivars, as opposed to the Californian production, is extremely low, with 0.04%.

The French cultivars developed by INRA also represent another quarter of the nursery production, with 24.01%. ‘Ferragnes’ with 13.31% and ‘Ferraduel’ with 10.32% are undoubtedly the most important cultivars, although their share is continuously decreasing along this period (Fig. 5), as their presence lowered from 39.69% in the season 1995/96 to 12.85% in the last one. Nearly insignificant is the presence of the self-compatible cultivar ‘Lauranne’, as well as that of other cultivars, either releases from the breeding program (‘Ferralise’ and ‘Ferrastar’) or traditional French cultivars (‘Al’, ‘Bartre’ and ‘Princesse’).

The presence of Italian cultivars, mainly ‘Tuono’ and ‘Cristomorto’, was very important in the 1970s, but during the period under study only amounted to 3.12%, most of them of ‘Tuono’, with a few plants of ‘Cristomorto’ and ‘Frugialio’, following a decreasing trend. The presence of Californian cultivars is fully testi- monial (0.05%), being most of the plants of ‘Texas’ and a few of ‘Nonpareil’. Finally, 0.21% of the plants could not be identified.

Taking into account that most French cultivars produced by the Spanish nurseries are releases from the INRA breeding program carried out by C. Grasselly, as well as the incidence of the releases from the different Spanish programs, it is evident that the Spanish production is every time more dependent on improved cultivars. The share of new bred cultivars amounts to 24.57%, divided into 48.03% of Spanish programs and 23.89% of the French program. Although the total remains quite
The share of self-compatible cultivars is really significant, with 47.52% of total. The weight of the self-compatible cultivars is mainly due to the new Spanish cultivars because the presence of the traditional Italian cultivars such as ‘Tuono’ and ‘Fra­giulio’ is very low, and that of the French ‘Lauranne’ only testimonial. The trend during this period has been the increase of the presence of self-compatible cul­tivars (Fig. 7), confirming that the Span­ish orchards really represent a success of these cultivars (Socias i Company, 2002).

The productive success of these new cul­tivars is being fully recognized not only by the growers, but also the market and the industry have valued the physical and orga­noleptic quality of the kernels of some of these cultivars. It must be emphasized that some CITA releases such as ‘Belona’ and ‘Soleta’ may exceed the quality rating of the best evaluated traditional cultivars ‘Marcona’ and ‘Desmayo Largueta’.

ACKNOWLEDGEMENTS
This research was supported by the Spa­nish grant AGL2010-22197-C02-01 and the Research Group A12 of Aragón. Technical assistance by O. Frontera is highly recognized.

REFERENCES

R. Socias i Company1, O. Kodad1, J. M. Alonso1, J. L. Espada2, P. Chomé3, A. Martínez­Treceño3
1 Unidad de Fruticultura,
Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA),
Av. Montañana 930,
50059 Zaragoza - Spain
2 Unidad de Cultivos Leñosos,
Centro de Técnicas Agrarias, DGA,
Av. Montañana 930,
50059 Zaragoza - Spain
3 Oficina Española de Variedades Vegetales,
C. Alfonso XII 62,
28014 Madrid - Spain
E-mail: rsocias@aragon.es

stable along the period studied, there is a clear increase of the presence of the Spanish releases in detriment of the French releases (Fig. 6). Considering that self-compatibility has been the main objective of most breeding programs to solve the problems of almond pollination (Socias i Company, 1990), the
ALMOND COMPOSITION AND QUALITY: ASSUMPTIONS AND FACTS

INTRODUCTION
The quality of any product is a concept of very difficult definition. This difficulty is usually increased in all agricultural products because their composition is often very complex and, most of times, unknown. As a consequence, not only the quality concept is difficult to establish, but also ephemeral (Janick, 2005), because of the continuous changes in the market preferences. In a species very close to almond such as peach, these continuous changes in the market demands is clearly evident giving rise to constant changes in many qualitative aspects, such as skin and flesh color, shape, skin hairiness, etc.

Almond is the most important tree nut crop in terms of commercial production. This production is limited to areas characterized by a Mediterranean climate (Kester and Asay, 1975), including regions in the Mediterranean countries, the Central Valley of California, the Middle East, and some equivalent areas in the Southern Hemisphere. Traditional almond culture utilized open-pollinated seedlings (Gras-sely, 1972; Rikhter, 1972) which, together with self-incompatibility, produced a very high heterozygosity in this species (Kester et al., 1990; Socias i Company and Felipe, 1992). This large variability has provided a useful genetic pool for almond evolution, allowing in each growing region the selection of almond cultivars well adapted to this area (Kester et al., 1990). Some cultivars, however, have shown high plasticity, being adapted to different growing conditions (Felipe, 2000).

Traditional almond production was centered in the Mediterranean countries, but in the 20th century it shifted to new growing regions. At present there is a clear dominance of the Californian production and an increasing importance of the Australian production, with a clear possibility of displacing the Spanish production from the second to the third place. From the commercial point of view, the Spanish almond imports from California represent an important volume of the exports from the United States, giving rise to continuous controversies on the possible differential quality of both productions. These discussions, however, lack of a sound scientific basis to establish clear criteria on quality differentiation. Some parameters can be clearly measured and used to characterize each cultivar. This information is crucial not only in order to increase the knowledge of the almond diversity, but also the nutritional and healthy value of the kernels, and the possibility of selecting the most adequate cultivars for the industry (Socias i Company et al., 2008). The modern almond industry requires commercial cultivars characterized by kernels with high quality attributes, because the best end-use for each cultivar is a function of its chemical composition (Berger, 1969) and of the consumers’ trend for foods without synthetic additives (Kring and Berger, 2001). Kernels with a high percentage of oil could be used to produce nougat or to extract oil, which is used in the cosmetic and pharmaceutical industries (Socias i Company et al., 2008). In addition, high oil content is desirable because higher oil contents result in less water absorption by the almond paste (Alessandroni, 1980). On the contrary, high oil contents are not desirable in the production of almond flour or almond milk. In the case of individual fatty acids, low content of linoleic acid is correlated with high oil stability (Zacheo et al., 2000), whereas high content of oleic acid is considered a positive trait from the nutritional point of view (Socias i Company et al., 2008).

The information available at present on the chemical composition of the almond kernels is restricted to a reduced number of cultivars, mostly from the country where these cultivars originated or are grown. As a consequence, comparisons among cultivars from different countries are affected by possible differences related to the climatic conditions of each country and to the different management of the almond orchards. Therefore, the study of the chemical composition of a set of cultivars from different origin but grown in the same conditions was considered interesting, taking the opportunity of the almond collection belonging to the Spanish National Germplasm Network maintained at the CITA of Aragón (Espiau et al., 2002). This collection was initially assembled by A. J. Felipe and shows a very large genetic diversity as related to all traits taken into account for almond description (Gülcän, 1985), including not only the morphological traits of the tree, the vegetative organs and the fruit, but also the physiological traits, such as blooming time and susceptibility to pests, diseases, and frosts (Socias i Company and Felipe, 1992), as well as their molecular characterization (Fernández i Martí et al., 2009).

The knowledge of the chemical composition of the almond kernels would allow establishing not only quality criteria, but also consumption criteria, due to the incidence of some compositional parameters on the nutritional and healthy values of almond kernels (Socias i Company et al., 2011). Some recent studies point out that almond consumption in the Mediterranean region represents a complementary source of vitamin E (Gimeno, 2000). Almond consumption has also been related to a decrease of the problems of colon cancer and of high blood pressure (Davis et al., 2003), as well as a decrease in the risk of heart diseases (Chen et al., 2006).

The high nutritive value of almond kernels arises mainly from their high lipid content, which constitutes an important caloric source but does not contribute to cholesterol formation in humans. This is due to their high level of unsaturated fatty acids, mainly monounsaturated fatty acids (MUFA), since MUFAs are inversely correlated with serum cholesterol levels (Sabate and Hook, 1996). Kernel tendency to rancidity during storage and transport is a quality loss and is related to oxidation of the kernel fatty acids (Senessi et al., 1996). Thus, oil stability and fatty acid composition, essentially the O/L ratio (Kester et al., 1993), are considered an important criterion to evaluate kernel quality. The presence of natural anti-oxidants in
Thus, our main objective was the study of the genetic diversity present at the Spanish National Almond Collection present at the CITA of Aragon in relation to their kernel oil content, as well as for oil composition in the main fatty acids. This knowledge would be essential for establishing the value of the different cultivars from the quality point of view.

**MATERIALS AND METHODS**

The kernels of 73 almond cultivars coming from 10 different countries were analyzed for this study (Kodad et al., 2011). The trees are maintained as living plants grafted on the almond x peach hybrid clonal rootstock INRA GF-677, using standard management practices (Espiau et al., 2002). Nuts from open pollination were harvested in 2008 and 2009 at maturity stage, when fruit mesocarp was fully dried and split along the fruit suture and peduncle abscission was complete (Felipe, 1977). Two samples of 20 fruits were collected for each treatment.

Fruits were left to dry and then shelled to obtain the kernels. The kernels were blanched in hot water. After drying, the kernels were ground in an electrical grinder to obtain almond flour. Oil was obtained from the flour in a commercial fat-extractor. The kernel oil content was expressed as the difference in weight of the dried kernel sample before and after extraction. The oil sample was utilized to determine the different fatty acids according to the official method UNE-EN ISO 5509:2000 (ISO, 2000). The ratio O/L (relation between the concentrations of oleic acid and linoleic acid) was also obtained.

The results of the two years of analysis were averaged for all the cultivars of each country. The means were compared by LSD at 5%.

**RESULTS AND DISCUSSION**

When considering the average values of each cultivar (data not shown), the first notion to be deduced was the large variability for the oil content and the concentration of the different fatty acids among the different almond cultivars, independently of their country of origin. The average value of oil content, on a dry matter basis, ranged from 51.39% in ‘Siria-3’ and 66.80% in ‘Filippo Ceo’. When this range of variability was examined for the cultivars of each country, the widest range was observed among the cultivars from Spain (from 54.75% to 66.40%), followed by a medium range of variability for the cultivars of France (from 54.75% to 64.73%) and Italy (from 56.23% to 66.80%), being low for the cultivars of Portugal (from 58.33% to 63.66%) and the USA (from 57.36% to 63.60%). It is worth noting that nearly all cultivars from France, Italy and the USA showed a mean value of oil content higher than 60%. This range of variability for the cultivars of Argentina, India, Ukraine and Syria, present in a much lower number than those from the other countries, was found to be between the limits observed for the cultivars of the other countries. These results showed the inconsistency of the opinion often manifested that the Californian cultivars have lower oil contents than the European cultivars.

The range of variability for the main fatty acids was also wide. For oleic acid it was from 62.86% in ‘Ne Plus Ultra’ to 77.35% in ‘Yosemite’, being both cultivars from the USA. For linoleic acid it was from 14.04% in ‘Yosemite’ to 26.85% in ‘Spi-lo’. For palmitic acid it was from 4.88% in ‘Tardive de la Verdière’ to 7.01% in ‘Des Mayorgo Largeta’. For stearic acid it was from 1.47% in ‘Nonpareil’ to 3.41% in ‘Filippo Ceo’. Finally, for palmitoleic acid it was from 0.31% in ‘Siria-3’ to 0.61% in ‘LeGrand’.

Considering oleic acid, the fatty acid with the highest content in almond oil, the widest range of variability was observed among the cultivars from the USA (from 62.86% to 77.35%), followed by those from France (from 65.31% to 76.99%), Greece (from 64.00% to 74.97%), Spain (from 67.42% to 74.92%) and Portugal (from 67.66% to 74.10%). The highest mean value for the content in oleic acid (Table 1) was found for the cultivars from Italy (72.93%), followed by those of France (72.42%), Spain (72.20%), Portugal (70.99%), the USA (70.26%) and Greece (69.39%), although the differences between these countries were not significant. Only for the cultivars from India (present only with three accessions), the content of oleic acid was significantly lower than the content of the cultivars from the other countries.

For linoleic acid, the widest ranges of variability were observed for the cultivars of the USA (from 14.04% to 26.63%) and France (from 14.29% to 24.71%), and the shortest for those of Portugal (from 17.03% to 23.22%) and Spain (from 15.37% to 22.44%). The lowest values for the content of linoleic acid were found among the cultivars from Italy, France and Spain, with values significantly lower than those for the cultivars of some countries. In relation to the O/L ratio, the highest values were found among the cultivars from Italy, France and Spain, whereas the values from India were significantly lower (Table 1). It must be taken into account that a high O/L ratio implies higher oil stability and, therefore, an index of almond quality and of resistance to rancidity must be considered.

The three other main fatty acids are present in much lower amounts, and the differences observed between cultivars from different countries are not important (Table1).

As a whole, thus, the lipid composition of the almond kernels is a characteristic trait of each cultivar, independently of its

<table>
<thead>
<tr>
<th>Country</th>
<th>Oil</th>
<th>Oleic</th>
<th>Linoleic</th>
<th>O/L</th>
<th>Palmitic</th>
<th>Palmitoleic</th>
<th>Stearic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>65.19</td>
<td>70.60</td>
<td>20.91</td>
<td>3.40</td>
<td>5.86</td>
<td>0.40</td>
<td>1.65</td>
</tr>
<tr>
<td>Spain</td>
<td>60.40</td>
<td>72.20</td>
<td>18.46</td>
<td>4.02</td>
<td>6.15</td>
<td>0.45</td>
<td>2.05</td>
</tr>
<tr>
<td>USA</td>
<td>60.90</td>
<td>70.26</td>
<td>20.56</td>
<td>3.59</td>
<td>6.03</td>
<td>0.46</td>
<td>1.94</td>
</tr>
<tr>
<td>France</td>
<td>60.51</td>
<td>72.42</td>
<td>18.22</td>
<td>4.13</td>
<td>5.83</td>
<td>0.44</td>
<td>2.17</td>
</tr>
<tr>
<td>Greece</td>
<td>58.68</td>
<td>69.39</td>
<td>21.09</td>
<td>3.42</td>
<td>6.19</td>
<td>0.48</td>
<td>2.30</td>
</tr>
<tr>
<td>India</td>
<td>64.08</td>
<td>66.25</td>
<td>23.85</td>
<td>2.83</td>
<td>6.22</td>
<td>0.42</td>
<td>2.41</td>
</tr>
<tr>
<td>Italy</td>
<td>61.30</td>
<td>72.93</td>
<td>18.06</td>
<td>4.22</td>
<td>5.81</td>
<td>0.45</td>
<td>2.07</td>
</tr>
<tr>
<td>Portugal</td>
<td>60.57</td>
<td>70.39</td>
<td>20.11</td>
<td>3.63</td>
<td>6.02</td>
<td>0.45</td>
<td>2.31</td>
</tr>
<tr>
<td>Syria</td>
<td>55.63</td>
<td>71.75</td>
<td>19.76</td>
<td>3.66</td>
<td>6.56</td>
<td>0.35</td>
<td>1.83</td>
</tr>
<tr>
<td>Ukraine</td>
<td>60.44</td>
<td>71.85</td>
<td>19.02</td>
<td>3.92</td>
<td>5.98</td>
<td>0.39</td>
<td>1.96</td>
</tr>
</tbody>
</table>

Table 1. Average oil content and composition in the main fatty acids of almond cultivars from different countries.

Blanched almond kernels with rugous surface, a trait decreasing quality.
country of origin. Therefore, the nutritive value and the quality stability of the kernel depend on the genotype and not on the geographic origin. These results show that the valorization of the almond quality must not take into account the geographical origin of the cultivar, but other aspects of its composition, not only the lipid fraction. The oil content and the percentages of the different fatty acids do not directly affect the subjective appreciation of the kernel quality, but the different possibilities of its industrial utilization, showing again that the definition of quality is extremely difficult.

The present industrial trend for specific requirements in relation to the kernel quality for the different confectioneries made with almond implies a better knowledge of the kernel composition in order to establish selection criteria for the best adequate cultivars for each product. These criteria have been incorporated into the almond breeding program of the CITA of Aragón and have been an important point for the commercial qualitative kernel valorization of the new releases such as ‘Belona’, ‘Soleta’, and ‘Mardía’, with low content of linoleic acid, because this low content is correlated with a high oil stability.

The results of this study show the wide variability present in the lipid fraction of the almond kernels, independently of their country of origin, as cultivars of 10 countries were included, not only from the Mediterranean area, but also an important group of cultivars from the USA, as well as some representatives from Argentina and India. However, it was impossible to establish a compositional pattern of any region because in each region there are cultivars with very different values for each component. In addition, it has been also impossible to establish valorization criteria based only on the lipid composition. However, these results are extremely important for the industry in order to choose the adequate cultivar for each confectionery. Thus, as already mentioned, kernels with high oil content are the best for making “Jijona” turrón (soft nougat) or for extracting oil, as required by the pharmaceutical industry. Thus, as already mentioned, kernels with high oil content are the best for making “Jijona” turrón (soft nougat) or for extracting oil, as required by the pharmaceutical industry.

However, it is note worthy to stress the high O/L ratio of the cultivars from Italy, France and Spain. This fact may allow increasing the storage ability not only of the kernels of these cultivars, but also of their derivative products, such as nougat, marzipan, etc. This implies all the intermediate steps, from the field, at harvesting, to consumption of each of these products. From this point of view the Spanish cultivars can be distinguished from the Californian ones, thus showing a distinctive quality trait, not only interesting from the consumers’ point of view, but also in any breeding program, taking into account the breeding objective of increasing the organoleptic and nutritive quality of the almond kernels.

ACKNOWLEDGEMENTS
Review funded by the Spanish projects CICYT AGL2010-22197-C02-01 and INIA RF2008-00027-00-00, the European project AGRI GEN RES 870/2004 068 (SAFE-NUT) and the activity of the Research Group A12 of Aragón. We appreciate the technical assistance of J. Bübal and O. Frontera.

REFERENCES

O. Kodad and R. Socias i Company
Unidad de Fruticultura, CITA de Aragón,
Av. Montañara 930, 50059 Zaragoza, Spain
E-mail: rsocias@aragon.es
THE ALMOND Sf ALLELE: AN ALLELE IN QUESTION

INTRODUCTION

Once self-compatibility in almond was re-discovered in the 1970s, its importance in almond growing was clearly stressed and its relevance in almond breeding was fully understood (Socias i Company, 1978). The horticultural importance of almond self-compatibility is obtaining commercial yields after an acceptable fruit set (Socias i Company et al., 2009). Therefore, one of the major challenges in the breeding process has been the evaluation of self-compatibility (Socias i Company et al., 2010). The first approaches included fruit set (Almeida, 1945) and pollen tube growth (Socias i Company et al., 1976), but this evaluation was focused on the expression of self-compatibility, not in its genetic identification. These approaches involved both field and laboratory tests, usually laborious and time-consuming, subject to several external contingencies, such as climatic conditions handling procedures, because working with fruit trees implies more work, more space and more time than in annual species (Socias i Company, 1998).

The first results suggested that, as in other Rosaceous species, almond showed a mono-allelic gametophytic self-incompatibility system (Socias i Company et al., 1976). As a consequence, self-compatibility could be due to the presence of an Sf allele, as it happened in other close species. First of all, transmission to the offspring was quickly confirmed (Socias i Company et al., 1976), but this evaluation was focused on the expression of self-compatibility, not in its genetic identification. These approaches involved both field and laboratory tests, usually laborious and time-consuming, subject to several external contingencies, such as climatic conditions handling procedures, because working with fruit trees implies more work, more space and more time than in annual species (Socias i Company, 1998).

The more recent advances in genetic analysis at the gene level have allowed a closer approach to the Sf allele in almond. First, S alleles, including Sf, were identified by PCR analysis using conserved and allele-specific primers (Channuntapipat et al., 2001; Ma and Oliveira, 2001). Various consensus primer sets have been designed to discriminate S-genes in almond. They were designed from conserved regions of S-genomes to amplify across the second intron (Channuntapipat et al., 2003; Tamura et al., 2000), or both (Sutherland et al., 2004). However, PCR primers designed from conserved regions do not always distinguish between alleles with a similar number of nucleotides (López et al., 2004). In addition, the detection of some alleles is masked by the presence of another allele, thus giving a wrong single band. This confusion was first detected by Channuntapipat et al. (2003) when the presence of either Sf or S8 masked the amplification of Sf by PCR when using conserved primers. The same masking has also been observed with other alleles (Alonso and Socias i Company, 2005b; Fernández i Martí et al., 2009).

As a consequence, other primer sets have been specifically designed to amplify Sf (Channuntapipat et al., 2001; Ma and Oliveira, 2001). Screening efficiency and flexibility have been greatly increased with the development of successful multiplex PCR techniques by Sánchez Pérez et al. (2004). This technique avoids the problem of the masked presence of an allele by the expression of another. Once the S allele could be identified, the amino acid sequence of its RNase could be determined. However, since the beginning, several amino acid sequences for the Sf, RNase have been deposited in the databases by different authors.

ALLELE SEQUENCING

When the different sequences of the Sf RNases deposited in the databases were compared, several differences could be observed between them. This diversity was closely examined by Hanada et al. (2009) in order to solve previous confusions on their identity. As a result of this examination, the sequences could be contrasted because most of them had been determined in ‘Tuono’ and genotypes derived from it, consequently for the same Sf-RNase. This identity allowed different sources of self-compatibility for the genotypes studied to be discarded. The first sequences by Channuntapipat et al. (2001) and Ma and Oliveira (2001) were already different. Further sequencings suggest that the sequence by Channuntapipat et al. (2001) was the correct and must be taken as the consensus sequence.

Figure 1. Multiple alignment of the deduced amino acid sequence of different S almond alleles. Accession numbers are referred in Table 1.
Table 1. Similarity of different almond S-RNases with the consensus S₅-RNase.

<table>
<thead>
<tr>
<th>Allele</th>
<th>Genotype</th>
<th>Database code</th>
<th>Coincidence with the S₅ consensus allele (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₅ consensus</td>
<td>'Lauranne' selection IRTA12-2</td>
<td>AY291117</td>
<td>100</td>
<td>Channuntapipat et al. (2001)</td>
</tr>
<tr>
<td>S₅</td>
<td>'Tuono'</td>
<td>AF157009</td>
<td>98</td>
<td>Ma and Oliveira (2001)</td>
</tr>
<tr>
<td>S₅</td>
<td>'Tuono'</td>
<td>DQ156217</td>
<td>64</td>
<td>Barckley et al. (2006)</td>
</tr>
<tr>
<td>S₅</td>
<td>'Tuono'</td>
<td>AM690356</td>
<td>99.3</td>
<td>Bošković et al. (2007)</td>
</tr>
<tr>
<td>S₅</td>
<td>'Cambra'</td>
<td>EU684318</td>
<td>100</td>
<td>Kodad et al. (2009a)</td>
</tr>
<tr>
<td>S₆</td>
<td>'Ponç'</td>
<td>EU293146</td>
<td>100</td>
<td>Kodad et al. (2009a)</td>
</tr>
<tr>
<td>S₆</td>
<td>'Alzina'</td>
<td>FJ887784</td>
<td>100</td>
<td>Kodad et al. (2010)</td>
</tr>
<tr>
<td>S₆</td>
<td>'Gardonès'</td>
<td>FJ887783</td>
<td>100</td>
<td>Kodad et al. (2010)</td>
</tr>
<tr>
<td>S₆</td>
<td>'Vivot'</td>
<td>AB467370.1</td>
<td>100</td>
<td>Fernández i Martí et al. (2010a)</td>
</tr>
<tr>
<td>S₆</td>
<td>'Fra Giulio Grande'</td>
<td>AM690361</td>
<td>100</td>
<td>Bošković et al. (2007)</td>
</tr>
</tbody>
</table>

The identity of the S₅ sequences from both self-compatible and self-incompatible genotypes gave rise to another question: the double expression of this allele (Kodad et al., 2009; Socias i Company et al., 2011). These two forms of the S₅ allele are equally identified by specific primers and show an identical allele sequence (Fernández i Martí et al., 2009; Kodad et al., 2009). This double expression suggests that the coding region of the S₅ gene may not be the exclusive origin of self-compatibility in almond (Kodad et al., 2009a) and that some genetic modification outside this coding region must be affecting that expression (Fernández i Martí et al., 2009), taking into account that this identity is not only restricted to the coding region (C1 to C5), as deduced from their sequences (Fig. 1), but also to the alignment of their 5'-flanking regions as shown by the construction of a fosmid library (Fernández i Martí et al., 2010).

All the almond self-compatible genotypes so far identified have shown the same S₅ allele (Table 1), thus suggesting a monophyletic origin of self-compatibility in almond. Work in process (Fernández i Martí et al., in preparation) is proposing a point change in the S₅ allele producing this expression change from self-incompatibility to self-compatibility.

ALLELE TERMINOLOGY

The mistakes in allele sequences observed by Bošković et al. (2007) led them to incorrectly name a new allele, S₉, which they wrongly considered different from S₅, although it is identical to S₅, but showing a different activity (Kodad et al., 2009a). This new name may create new confusions in almond S allele research because the identity of any allele must be preserved, once correctly defined by its sequence, in spite of showing a different phenotypic expression. As a consequence, the denomination S₉ was suggested for the active S₅ allele showing a self-incompatible expression (Kodad et al, 2009a), whereas the denomination S₅ was suggested for the inactive S₅ allele showing a self-compatible expression (Fernández i Martí et al., 2009). As already mentioned, these two forms of the S₅ allele are equally identified by specific primers and show an identical allele sequence (Fernández i Martí et al., 2009; Kodad et al., 2009). Thus, the only difference between them is their expression, not their genetic identity.

As the priority sequence was the sequence published by Channuntapipat et al. (2001), and being considered the consensus sequence, any change in allele terminology must take into account this priority and cannot be based in erroneous results.

ACKNOWLEDGEMENTS

This research was supported by the Spanish grant AGL2010-22197-C02-01 and Research Group A12 of Aragón.

REFERENCES


Ma and Oliveira (2001) showed valine instead of isoleucine and histidine instead of arginine in the C2 region, probably as a result of a mistake in sequencing (Fig. 1). Fig. 1 shows the alignment of the published sequences for the S₅-RNase as well as some other S-RNases for comparison and mostly agrees with the results of Hannona et al. (2009) and Fernández i Martí et al. (2010). The consensus sequence of Channuntapipat et al. (2001) was amplified in 'Lauranne' and selection IRTA12-2, two self-compatible genotypes deriving from 'Tuono', the cultivar utilized in several determinations as shown in Table 1, although not always correctly.

Barckley et al. (2006) gave an amino acid sequence for 'Tuono' S₅ identical to S₅, probably due to missampling. Consequently, they incorrectly suggested that the 'Tuono' genotype present in California, although self-compatible, showed a different S₅ allele and could be a different clone than the 'Tuono' genotype studied in the other reports. As a consequence of this missampling, all the conclusions of this paper must be discarded.

A similar confusion was produced by the paper of Bošković et al. (2007), who had to recognize a missequencing in a note added in proof, thus invalidating most of the reasoning of their conclusions. Their 'Tuono' S₅ did not really show the supposed histidine substitution instead of arginine in its sequence, thus confirming that the consensus sequence of Channuntapipat et al. (2001) must be maintained for all the S₅ alleles so far sequenced. This consensus sequence is identical to the S₅ sequence of 'Cambra', another cultivar derived from 'Tuono', to the S₅ sequence of 'Blanquerna', a cultivar derived from 'Genco', not from 'Tuono', and to five S₅ alleles reportedly concerning self-incompatibility in almond (Table 1).


Fernández i Company, R., Kodad, O., Alonso, J.M., 2005; Alonso and Socias i Company, 2007). Characterized by their high kernel quality and considered possible commercial substitutes for the two preferred cultivars in the Spanish market, ‘Marcona’ and ‘Desmayo Largaeta’. The last release from this breeding program is ‘Mardía’, recently registered because of its good horticultural and commercial traits.

ORIGIN
 ‘Mardía’ (selection G-2-25, clone 541) comes from the cross of ‘Felisia’, a self-compatible and late-blooming release of the Zaragoza breeding program of small kernel size (Socias i Company and Felipe, 1999), and ‘Bertina’, a late-blooming local selection of large kernel size (Felipe, 2000). This cross was made with the aim of utilizing two late blooming almond cultivars, one of them carrying the late-bloom allele Lb (Socias i Company and Felipe et al., 1999), of very different kernel size and genetically very distant, in order to avoid the problems related to inbreeding depression (Alonso and Socias i Company, 2007).

BLOOMING TIME
Blooming time has been a very important evaluation trait. As an average, its blooming time is 25 days later than “Nonpareil”, 20 days after ‘Guara’ and 13 days after ‘Felisia’, the latest blooming cultivar released so far (Fig. 1). The consistent late blooming time is due to very high chilling and heat requirements (Alonso et al., 2005; Alonso and Socias i Company, 2009), much higher than in any other almond genotype (Table 1). Flowers are of small size, white, with epistigmatic pistil, both on spurs and on one-year shoots. Bloom density is regular and high (Kodad and Socias i Company, 2008b),

R. Socías i Company, O. Kodad, À. Fernández i Marti and J.M. Alonso Unidad de Fruticultura, CITa de Aragón, Av. Montañana 930, 50059 Zaragoza, Spain E-mail: rsocias@aragon.es

‘MARDÍA’, AN EXTRA-LATE BLOOMING ALMOND CULTIVAR

INTRODUCTION
The almond (Prunus amygdalus Batsch) breeding program of the CITa of Aragón aims to develop new self-compatible and late-blooming cultivars to solve the main problem detected in Spanish almond growing, its low productivity, due to the occurrence of frosts at blooming time or later and to a deficient pollination (Felipe, 2000). The first three cultivars released from this breeding program were ‘Aylés’, ‘Guara’ and ‘Moncayo’ (Felipe and Socias i Company, 1987), ‘Guara’ having represented more than 50% of the new almond orchards in the last years (MAPA, 2002). Later three more cultivars were registered in 1998, ‘Blanquerna’, ‘Cambra’ and ‘Felisia’ (Socias i Company and Felipe, 1999), ‘Blanquerna’ being of very good productivity and kernel quality, and ‘Felisia’ of very late blooming time (Fig. 1). Two more cultivars ‘Belona’ and ‘Soleta’ were registered in 2005 (Socias i Company and Felipe, 2007), characterized by their high kernel quality and considered possible commercial substitutes for the two preferred cultivars in the Spanish market, ‘Marcona’ and ‘Desmayo Largaeta’. The last release from this breeding program is ‘Mardía’, recently registered because of its good horticultural and commercial traits.

ORIGIN
 ‘Mardía’ (selection G-2-25, clone 541) comes from the cross of ‘Felisia’, a self-compatible and late-blooming release of the Zaragoza breeding program of small kernel size (Socias i Company and Felipe, 1999), and ‘Bertina’, a late-blooming local selection of large kernel size (Felipe, 2000). This cross was made with the aim of utilizing two late blooming almond cultivars, one of them carrying the late-bloom allele Lb (Socias i Company and Felipe et al., 1999), of very different kernel size and genetically very distant, in order to avoid the problems related to inbreeding depression (Alonso and Socias i Company, 2007).

BLOOMING TIME
Blooming time has been a very important evaluation trait. As an average, its blooming time is 25 days later than “Nonpareil”, 20 days after ‘Guara’ and 13 days after ‘Felisia’, the latest blooming cultivar released so far (Fig. 1). The consistent late blooming time is due to very high chilling and heat requirements (Alonso et al., 2005; Alonso and Socias i Company, 2009), much higher than in any other almond genotype (Table 1). Flowers are of small size, white, with epistigmatic pistil, both on spurs and on one-year shoots. Bloom density is regular and high (Kodad and Socias i Company, 2008b),
**AUTOGAMY**

Self-compatibility was tested as soon as the original seedlings produced the first flowers by examining the arrival or not of pollen tubes at the ovary after self-pollination (data not shown). Sets after self-pollination and autogamy were studied on three grafted trees of each selection during several years due to the large variability found between years in field trials for fruit set (Socias i Company et al., 2005). Average set after artificial self-pollination was 17.9%, higher than after cross-pollination, 15.7%, showing a good self-compatible behavior, although this difference was not statistically significant. Average set in bagged branches was 9.8%, higher than the threshold of 6% indicated by Grasselly et al. (1981) for autogamy, and 23.7% for open pollination. These sets (Kodad and Socias i Company, 2008a) are lower than those considered for a commercial crop in Californian cultivars (Kester and Griggs, 1959), but ensure a good crop level because of the high bloom density of this selection, resulting in a high productivity (Kodad and Socias i Company, 2006). Its S-allele genotype has been determined as S6Sf (Kodad and Socias i Company, 2008a).

**PERFORMANCE**

Field behavior has been evaluated with three grafted trees in an experimental plot and in three external trials. One of the most important points considered was the behavior in relation to spring frost injury. Especially important were the observations in 2003 and 2004, with severe frosts in most almond growing regions of Spain. Whereas cultivars considered as resistant to frosts such as ‘Guara’ (Felipe, 1988) suffered important yield reductions, ‘Mardía’, due to its extremely late blooming season, did not suffer any damage (Kodad and Socias i Company, 2005).

Tree training has been easy because of its slightly upright growth habit (Kodad and Socias i Company, 2008b), without the problem of bending branches of ‘Guara’. Thus, induction of lateral branching is recommended during the first years. Adult trees show an intermediate vigor and branching intensity, as well as a good equilibrium between vegetative growth and production, thus allowing reduction of pruning. Field observations in the different locations showed its tolerance to *Polystigma* and other fungal diseases.

Ripening time is early, although later than in ‘Guara’, which allows the succession of harvest. Nut fall before harvest has been very low, but nuts fell easily when shaken. Yield rating has been slightly lower than for ‘Guara’ (7 vs. 8 in a 0-9 scale).

---

**Table 1 - Chilling and heat requirements of ‘Mardía’ as related to other cultivars**

(Alonso et al., 2005; Alonso and Socias i Company, 2009).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Chilling requirements (CU)</th>
<th>Heat requirements (GDH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desmayo Largueta</td>
<td>428</td>
<td>5458</td>
</tr>
<tr>
<td>Marcona</td>
<td>428</td>
<td>6603</td>
</tr>
<tr>
<td>Nonpareil</td>
<td>403</td>
<td>7758</td>
</tr>
<tr>
<td>Belona</td>
<td>353</td>
<td>7741</td>
</tr>
<tr>
<td>Soleta</td>
<td>340</td>
<td>7872</td>
</tr>
<tr>
<td>Ferragnès</td>
<td>444</td>
<td>8051</td>
</tr>
<tr>
<td>Guara</td>
<td>340</td>
<td>8159</td>
</tr>
<tr>
<td>Felisia</td>
<td>329</td>
<td>9465</td>
</tr>
<tr>
<td>Mardía</td>
<td>503</td>
<td>10233</td>
</tr>
</tbody>
</table>

Chilling units - Growing Degree Hours in °Celsius.

---

**Table 2 - Chemical composition of ‘Mardía’ as compared to other cultivars.**

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Protein (% DWz)</th>
<th>Oil (% DWz)</th>
<th>Oleic acid (% oil)</th>
<th>Linoleic acid (% oil)</th>
<th>Oleic/linoleic acid ratio</th>
<th>α-tocopherol (mg·kg⁻¹ oil)</th>
<th>γ-tocopherol (mg·kg⁻¹ oil)</th>
<th>δ-tocopherol (mg·kg⁻¹ oil)</th>
<th>Total tocopherol (mg·kg⁻¹ oil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. Largueta</td>
<td>24.5</td>
<td>57.35</td>
<td>70.65</td>
<td>20.55</td>
<td>3.44</td>
<td>304.3</td>
<td>15.3</td>
<td>1.66</td>
<td>321.3</td>
</tr>
<tr>
<td>Marcona</td>
<td>23.8</td>
<td>59.10</td>
<td>71.75</td>
<td>19.40</td>
<td>3.70</td>
<td>463.3</td>
<td>18.5</td>
<td>1.87</td>
<td>483.7</td>
</tr>
<tr>
<td>Nonpareil</td>
<td>13.0</td>
<td>60.47</td>
<td>67.72</td>
<td>23.28</td>
<td>2.91</td>
<td>400.0</td>
<td>27.8</td>
<td>1.57</td>
<td>429.4</td>
</tr>
<tr>
<td>Belona</td>
<td>16.4</td>
<td>65.40</td>
<td>75.60</td>
<td>12.73</td>
<td>5.94</td>
<td>418.4</td>
<td>15.4</td>
<td>2.18</td>
<td>436.0</td>
</tr>
<tr>
<td>Soleta</td>
<td>20.0</td>
<td>61.80</td>
<td>69.20</td>
<td>19.70</td>
<td>3.51</td>
<td>214.0</td>
<td>13.3</td>
<td>1.51</td>
<td>228.8</td>
</tr>
<tr>
<td>Ferragnès</td>
<td>25.4</td>
<td>57.53</td>
<td>70.20</td>
<td>20.10</td>
<td>3.49</td>
<td>377.5</td>
<td>18.7</td>
<td>1.84</td>
<td>398.0</td>
</tr>
<tr>
<td>Guara</td>
<td>29.3</td>
<td>54.33</td>
<td>63.10</td>
<td>25.70</td>
<td>2.46</td>
<td>385.4</td>
<td>15.7</td>
<td>1.76</td>
<td>402.9</td>
</tr>
<tr>
<td>Felisia</td>
<td>27.0</td>
<td>56.32</td>
<td>68.05</td>
<td>22.10</td>
<td>3.08</td>
<td>250.6</td>
<td>18.2</td>
<td>1.73</td>
<td>270.6</td>
</tr>
<tr>
<td>Mardía</td>
<td>19.8</td>
<td>59.10</td>
<td>74.95</td>
<td>16.55</td>
<td>4.53</td>
<td>201.5</td>
<td>12.1</td>
<td>1.23</td>
<td>214.8</td>
</tr>
</tbody>
</table>

Dry weight.

---

**Fig. 1. Mean flowering time of ‘Mardía’ as related to other cultivars (7-years average). Percentages refer to the amount of flowers opened.**
The external trials have shown their good adaptation to different growing and weather conditions, maintaining a high level of bud density in all locations (Kodad and Socias i Company, 2008b). A trial in Aniñón (Zaragoza) at 730 m above sea level and of very cold climate has had good production even in years with late frosts. A trial in El Pinós (Alacant), at 575 m above sea level but with a milder climate, has shown their very good production as well as vegetation (G. Valdés, unpublished). Blooming and ripening dates observed in these locations have been, as expected, earlier in El Pinós than in Zaragoza, but later in Aniñón.

INDUSTRIAL QUALITY AND COMPOSITION

Nut and fruit evaluation has been done through seven years according to the IPGRI and UPOV descriptors. Nuts show a very good aspect and good size (4.9±0.5g). Shell is hard (shelling percentage of 24%), adapted to the Spanish industry. Kernels also show a very good aspect and good size (1.2±0.2g), heart-shaped, without double kernels (Fig. 2). Industrial cracking has been carried out by the Cooperative “Frutos Secos Alcañiz” and has shown very good results, without presence of double layers in the shell. Kernel breakage at cracking has been low, with 86.2% of whole kernels.

The chemical composition of the kernels has been determined in order to establish their best utilization opportunities. The content in protein is medium and that of oil is high, similar to that of ‘Marcona’ (Table 2), a very interesting trait for “turrón” (nougat) production. The percentage of oleic acid, that of higher quality for fat stability and nutritive value in the lipid fraction, is especially high (Kodad and Socias i Company, 2008c), close to 75% (Table 2). The content in linoleic acid, of lower quality than the oleic acid, is low, showing a very high ratio of oleic/linoleic acids (4.5), as another index of high oil quality. The amount of tocopherol is lower than in other cultivars (Kodad et al., 2006), indicating the need for a rapid processing of kernels after cracking.

Roasting has been tested by the industry “Almendras Castillo de Loarre” for appetizer use. Behaviour has been good, although less than in the favorite one in the Spanish market, ‘Desmayo Largueta’. The latest blooming almond cultivar so far released. Flower morphology allows self-pollination. Easy tree formation. Pruning requires some rejuvenation. Interesting for the quality and composition of the kernel. The intermediate ripening time may allow a progressive harvesting with other cultivars.

REFERENCES


THE EFFECT OF SOME ECOLOGICAL FACTORS ON ALMOND (PRUNUS AMYGDALUS L.) HULLS BIO-AANTIOXIDANT CONTENT AND ANTIRADICAL ACTIVITY FROM DIFFERENT GENOTYPES AND SPECIES

ABSTRACT

The effect of four ecological factors including precipitation, annual water cycle, soil texture and sun light were investigated in this study. Therefore, 20 genotypes of Amygdalus communis L. and 4 species of wild Azerbaijani almonds present in Azerbaijan region of Iran were selected from Esfahan, Khosroshahr, Shabestar, Mamanag, Sofian and Shahindezh. The fruits of these almonds were collected; their hulls were separated, dried, ground and then a methanolic extract was prepared from powdered hulls. Total phenolic content, antioxidants reducing power and scavenging capacity were evaluated. Significant differences were found in phenolic content, reducing power and radical scavenging capacity of hulls among almond genotypes and species of different regions. The values of almond hull’s total phenolic content showed that collected almond fruits from Esfahan and Shahindezh had a high total phenolic hull content. Results of this investigation showed that among the ecological factors studied, sun light in relation to tree spacing among different almond orchards and annual water cycle can affect almond hull’s total phenolic content.

INTRODUCTION

Nuts are traditionally food associated with the Mediterranean-type diet. Their regular consumption, in moderate doses, is related to a lower risk of cardiovascular diseases. The anticancer activity of nuts has also been demonstrated in experiments with animals. These beneficial effects are mainly attributed to their lipid profile, arginine, fiber, and vitamin E contents as well as to other compounds with antioxidant properties, such as polyphenols (Monagas et al., 2007).

Almonds (Prunus amygdalus Batsch) are one of the most popular tree nuts on a worldwide basis and rank number one in tree nut production. They belong to the Rosaceae family that also includes apples, pears, prunes, and raspberries (Sang et al., 2002a; Wijeratne et al., 2006; Jahanban Esfahan et al., 2009). The United States is the largest almond producer in the world and most of the US almonds are grown in California in an area that stretches over 400 miles from Bakersfield to Red Bluff (Sang et al., 2002b).

Almond fruit consists of an outer hull with an intermediate shell that contains a kernel or edible seed covered by a brown skin. The hull splits open when maturity is reached and is then separated from the shelled almond (whole natural almond). During some industrial processing of almonds, the skin (seed coat) is removed from the kernel by blanching and then discarded. For roasted almonds and other appetizers, skins are not removed. The skin, which has very low economic value, represents 4% of the total almond weight but contains 70–100% of total phenols present in the nut. By products derived from almond industrial processing (skins, shells, and hulls) are normally used for livestock feed and as raw material for energy production (Monagas et al., 2007). However, over the past few years, research has been conducted to evaluate the possible use of these byproducts as sources of compounds/fractions with antioxidant properties that could be used to control the oxidative process in the food industry or as functional ingredients for the elaboration of nutritional supplements (Siriwardhana et al., 2006). Extracts of whole almond seed, brown skin, shell and green shell cover (hull) possess potent free radical scavenging capacities (Siriwardhana and Shahr-
Table 1. Ecological characterization of collected almond fruits regions.

<table>
<thead>
<tr>
<th>Regions</th>
<th>precipitation (mm)</th>
<th>annual water cycle (irrigation, day)</th>
<th>soil texture</th>
<th>Tree spacing in relation to sun light (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esfahan</td>
<td>400</td>
<td>60</td>
<td>Clay</td>
<td>10</td>
</tr>
<tr>
<td>Khosroshahr</td>
<td>410</td>
<td>10</td>
<td>Clay-Sandy</td>
<td>4</td>
</tr>
<tr>
<td>Shabestar</td>
<td>460</td>
<td>10</td>
<td>Sandy</td>
<td>4</td>
</tr>
<tr>
<td>Mamagan</td>
<td>420</td>
<td>20</td>
<td>Clay</td>
<td>4</td>
</tr>
<tr>
<td>Sofian</td>
<td>450</td>
<td>20</td>
<td>Clay-Sandy</td>
<td>3</td>
</tr>
<tr>
<td>Shahindezh</td>
<td>433</td>
<td>–</td>
<td>not irrigated</td>
<td>20</td>
</tr>
</tbody>
</table>

Almond blooming in Esfahan

The content of total phenolics was determined colorimetrically using Folin-Ciocalteu’s phenol reagent, as described by Singleton and Rossi (1965). Briefly, 2.5 ml of ten-fold diluted Folin-Ciocalteu reagent, 2 ml of 7.5% sodium carbonate, and 0.5 ml phenolic extract (1mg/ml) were mixed well. The absorbance was measured at 765 nm after 15 min heating at 45 °C. A mixture of water and reagents was used as a blank. The phenolic content was expressed as mg gallic acid equivalents per g of extract.

Reducing power

The reducing power of almond hulls phenolic extracts was determined according to the method of Oyaizu (1986). Almond hulls phenolic extract (1 mg/ml), phosphate buffer (1 ml, 0.2 M, pH 6.6) and potassium ferrycyanide (1.0 ml, 10 mg/ml) were mixed together and incubated at 50 °C for 20 min. Trichloroacetic acid (1.0 ml, 100 mg/ml) was added to the mixture and centrifuged at 13,400 g for 5 min. The supernatant (1 ml) was mixed with distilled water (1 ml) and ferric chloride (0.1 ml, 1.0 mg/ml), and then the absorbance was measured at 700 nm.

DPPH radical scavenging activity

The DPPH radical scavenging activity of almond hulls was estimated according to the method of Blois (1958). After mixing 0.1 mL (1mg/ml) of almond hulls with 0.9 ml of 0.041 mM DPPH in ethanol for 10 min, the absorbance of the sample was measured at 517 nm. Radical scavenging activity was expressed as percentage according to the following formula:

\[
\% \text{DPPH radical scavenging activity} = \left(1 - \frac{\text{sample OD}}{\text{control OD}}\right) \times 100
\]

Statistical analysis

All the assays were carried out in triplicate. The results are expressed as mean values and standard error (SE) of the mean or standard deviation (SD) of the mean. The differences between the almond genotypes and species were analyzed using one-way analysis of variance (ANOVA). This treatment was carried out using SPSS v.15 program.

RESULTS AND DISCUSSION

Almond is an important tree nut with high resistance to arid or semiarid climates. In addition, almond trees can adapt themselves easily to these waterless conditions (Sathe et al., 2002). In regions used for collecting almond fruit samples, annual precipitation was approximately constant for all regions and the mean value of rainfall was 429 mm (Table 1). Therefore, this shows that annual precipitation can not affect almond hull total phenolics content.

In studied regions, most of the precipitation was seen in spring, autumn and winter seasons within the year. But in summers there was little or low precipitation. Therefore, farmers irrigate almond trees to increase kernel yields. Annual water cycles of almond gardens in different studied regions in this investigation are shown in Table 1. These results show that almond tree plots with low irrigation (Esfahan) or no irrigation (Shahindezh) have a high concentration of almond hull total phenolics content. In other words, it indicates that almond tree irrigation regime can affect almond hull total phenolics content.

Soil samples for each studied region are shown in Table 1. Soil texture of almond orchards in different regions was almost clay-sandy. On the other hand, almond genotypes and species with high total phenolics content in their hulls extract had been grown in clay or clay-sandy soils and
genotypes or species with low total phenolics content had also been cultivated in clay-sandy or sandy soils. These results show that the soil texture of an almond growing region can not have an effect on almond hull total phenolics content.

The almond mesocarp becomes dry, leathery, and astringent to the taste, reflecting the fact that the mature almond mesocarp has an unusually high concentration of flavonoids compared to its botanical relatives, as well as to other fruits. This is thought to be a consequence of the length of time that the mesocarp is subjected to intense heat, ultraviolet radiation, and pest infestation, as the flavonoids play protective roles against all these stress factors (Rabinowitz, 1991; 2002; 2004). The effect of sunlight radiation on almond hulls total phenolics content is shown in Table 2. The results obtained in this study show that almond genotypes and species from Esfahlan and Shahindezh regions suffered much heat and ultraviolet radiation from sunlight, due to the considerable tree spacing in these regions. Therefore, the almond trees present in these regions have increased the synthesis of flavonoids and other phenolics compounds in their hulls to protect their inner materials content, specifically seed or kernel, against harmful effects of ultraviolet radiation. Effects of infrared, heat and gamma irradiation have been studied in vitro conditions. Lee et al. (2006) reported that far-infrared radiation and heat treatment enhanced total phenolics content, radical scavenging activity and reducing power of water extracts in peanut (Arachis hypogaea L.) hulls. In another study, Harrison and Were (2007) recorded that gamma irradiation increases the total phenolics content yield and antioxidant activity of almond skins. Finally, it was concluded that among four ecological factors studied, sunlight radiation and irrigation regime affected almond hulls total phenolics content.

Contents of total phenolics in almond hulls differed statistically ($P < 0.05$) (Table 2). The mean value of total phenolics content in 24 almond hull phenolic extracts was 65.8±1.67 mg gallic acid equivalents/g extract. Maximum total phenolics content in hulls extract was 134.7±2.74 mg/g for A. fenzliana (Fritsch) Lipsky from Shahindezh region and minimum total phenolics content was 30.2±0.98 mg/g for A5-118 from Sofian region. The content of total phenolics in almond hull extract reported by Siriwadhana and Shahidi (2002), Wejeratne et al. (2006), Siriwadhana et al. (2006) and Jahanban Esfahlan et al. (2009) were 71.1±1.74 mg catechin equivalents/g extract, 71±2 mg quercetin equivalents/g extract and 78.2±3.41 mg gallic acid equivalents/g extract respectively. In this study, although the mean value of total phenolics content in 24 almond hull phenolic extracts showed similar findings to related references with respect to total phenolics content, some genotypes and species contained higher total phenolics than the identified almonds. For the measurements of the reductive ability, the Fe$^{2+}$ to Fe$^{3+}$ transformation was investigated, in the presence of methanolic extract, using the method of Oyaizu (1986). The reducing power increased along with a higher phenolic extract content and it was positively correlated with phenolic content. The results of correlation analyses between the total phenolics content, reducing power and antiradical activities are depicted in Figure 1. Statistically significant ($P < 0.05$) correlation was found between total phenolics versus antiradical activity and reducing power. Using a 24-point correlation between total phenolics and antioxidant activity, the data were significant at $P < 0.05$. In the case of leguminous seeds extracts, a statistically significant ($P ≤ 0.01$) correlation was also determined for total phenolics versus total antioxidant activity (Amarowicz et al., 2004a). The strong correlation between the content of total phenolics and the reducing power was found in the extracts of selected plant species from the Canadian prairies as reported by Amarowicz et al. (2004b), Velioglu et al. (1998) examined 28 plant products and found a significant relationship between the total antioxidant activity and total phenolics in flaxseed and cereal products.

The extended maturation period of the almond fruit mesocarp, flowing into remarkably stable senescence period, allows for biosynthesis of lignans in the mesocarp, compared to the nearly absence of these compounds in other fruits. The mesocarp in senescence, after harvesting the nut meats, remains remarkably stable as it retains its high sugars, flavonoids, and ligand.
Table 2. Phenol content, reducing power and antiradical activity of collected almond genotypes and species hulls phenolics extracts from different locations of Azarbaijan region

<table>
<thead>
<tr>
<th>Regions</th>
<th>Sample number</th>
<th>Phenol content (mg/g GAE g extract)</th>
<th>Reducing power (Absorbance at 700nm)</th>
<th>Antiradical (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esfahan</td>
<td>1</td>
<td>82.9±2.51</td>
<td>0.759</td>
<td>80.3±2.23</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>92.8±1.91</td>
<td>0.804</td>
<td>86.5±1.56</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>101.1±2.31</td>
<td>0.809</td>
<td>90.3±0.39</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>80.6±2.35</td>
<td>0.738</td>
<td>80.1±0.58</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>89.3±2.27</td>
<td>0.777</td>
<td>84.3±1.23</td>
</tr>
<tr>
<td>Khosroshah</td>
<td>5</td>
<td>35.9±1.25</td>
<td>0.366</td>
<td>49.2±0.39</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>59.6±1.33</td>
<td>0.591</td>
<td>64.7±2.25</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>66.2±1.11</td>
<td>0.614</td>
<td>70.5±2.36</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>41.4±1.05</td>
<td>0.517</td>
<td>50.1±0.84</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>50.7±1.18</td>
<td>0.521</td>
<td>58.6±1.46</td>
</tr>
<tr>
<td>Shabestar</td>
<td>9</td>
<td>48.4±1.51</td>
<td>0.547</td>
<td>56.5±0.47</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>62.7±0.57</td>
<td>0.601</td>
<td>69.2±1.32</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>39.0±1.91</td>
<td>0.489</td>
<td>51.5±1.11</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>36.8±1.72</td>
<td>0.398</td>
<td>49.6±1.47</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>46.7±1.42</td>
<td>0.508</td>
<td>56.7±1.09</td>
</tr>
<tr>
<td>Mamagan</td>
<td>13</td>
<td>48.1±1.42</td>
<td>0.555</td>
<td>55.3±1.44</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>73.2±2.35</td>
<td>0.658</td>
<td>76.4±1.44</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>43.9±1.79</td>
<td>0.503</td>
<td>52.3±2.33</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>48.9±1.48</td>
<td>0.526</td>
<td>58.2±0.65</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>53.5±1.76</td>
<td>0.560</td>
<td>60.5±1.46</td>
</tr>
<tr>
<td>Sofian</td>
<td>17</td>
<td>38.2±1.24</td>
<td>0.475</td>
<td>52.1±0.33</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>30.2±0.98</td>
<td>0.398</td>
<td>46.3±2.11</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>49.3±1.32</td>
<td>0.568</td>
<td>58.6±1.26</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>43.2±2.22</td>
<td>0.489</td>
<td>52.5±0.65</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>40.2±1.44</td>
<td>0.482</td>
<td>51.8±1.08</td>
</tr>
<tr>
<td>Shahindezh</td>
<td>21</td>
<td>134.7±2.74</td>
<td>0.929</td>
<td>95.2±1.39</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>94.5±1.11</td>
<td>0.845</td>
<td>85.4±2.36</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>104.8±2.53</td>
<td>0.856</td>
<td>92.3±0.14</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>123.9±1.54</td>
<td>0.911</td>
<td>95.1±0.68</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>114.4±1.98</td>
<td>0.885</td>
<td>92.0±1.14</td>
</tr>
<tr>
<td>Total mean</td>
<td>-</td>
<td>65.8±1.67</td>
<td>0.662</td>
<td>67.3±1.24</td>
</tr>
</tbody>
</table>

The values are means of three replicates with standard errors (mean ± S.E, n =3), p<0.05.

CONCLUSIONS

Polyphenols and other antioxidant constituents may contribute to the health promoting effect of fruits, vegetables, whole grains, and nuts. Agricultural by-products of almond such as hull and shell are important resources for extraction of polyphenols and dietary fiber. Almond polyphenols include simple phenols, flavonoids, tannins, condensed or polymerised flavonoids or phenols, and proanthocyanidins. Results of this study showed that practices such as low or no irrigation and tree spacing can enhance almond hull total phenolics content. Moreover, it should be considered that the concentration and composition of phenolic compounds in plants is influenced by a large number of factors such as climate and agricultural conditions. Therefore, more investigations are needed on the extent of cultivar-environment interactions that affect almond polyphenol content.

ACKNOWLEDGMENTS

We would like to thank H. J. Esfahlan and Dr. Y. Shiri for proofreading the manuscript.

REFERENCES


THE AGRI GEN RES “SAFENUT” ACTION: A EUROPEAN STRATEGY FOR THE PRESERVATION AND UTILIZATION OF HAZELNUT AND ALMOND GENETIC RESOURCES

ABSTRACT
The SAFENUT project aims at enhancing the characterization, preservation and utilization of the European hazelnut and almond germplasm (Corylus avellana and Prunus dulcis) through the recovery and valorisation of local cultivars in the traditional productive areas of the Mediterranean basin. The project, financed by the European Commission - Directorate General for Agriculture and Rural Development - benefits from the participation of eleven partners from six European Countries (Italy, France, Greece, Portugal, Slovenia, Spain).

The general interest for genetic resources is based on the opportunities offered by their utilization (Berthaud, 1997). Genetic resources not only provide the required raw material for sustainable genetic improvement of crops, but offer a unique gene combination to ensure adaptability and productivity. This is reflected in the objectives of the Convention on Biological Biodiversity (CBD) and in the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA).

The concept of conservation of genetic resources has recently evolved to integrate also the process that leads to the creation and conservation of varieties as well as to the maintenance of genes of these varieties. Furthermore, the problem of continuously expanding the number of accessions in gene banks introduces the concept of “core collections” as selected and smaller collections, representative of species’ diversity (Brown 1989), where the sampling is made in a basic collection with the purpose to conserve most of the genetic variability. The result is a smaller collection representative of the existing diversity which is easier to manage, evaluate and utilise. In fact, it has been noted that one of the reasons why plant breeders are using less basic germplasm in research is the lack of information on traits of economic importance which often shows high genotypes for environmental interaction and requires replicated multi-location evaluations. As information builds up, the utilisation of genetic resources becomes more active.

Therefore, from a methodological point of view, the SAFENUT action implements and fosters the application of the core collection concept together with the development of an interactive web-system in the Mediterranean bio-region for dissemination and exchange of all the gathered data and information on hazelnut and almond genetic resources in sustainable agricultural systems. This paper describes the general objectives and the final output of the Action.

INTRODUCTION
Plant genetic resources (PGR), which are the backbone of agriculture, play a positive and unique role in the enhancement of crop productivity and adaptability in sustainable systems. As for nuts, their cultivation is also an agro-ecosystem of good environmental and landscape quality. Exploration, exchange and conservation of PGR is one of the main objectives to achieve sustainable food security for future generations and poverty reduction in developing countries. This concept arises from the objectives of the Convention on Biological Biodiversity (CBD) and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA).

Although germplasm exchange and plant introduction have sporadically occurred for centuries, aimed efforts started only in 1920s. During the seventies, taking into account the concept of genetic erosion, the efforts have been focused on the limited availability of genetic resources. Surveys have been carried out and collections have been established. According to the FAO, today there are about 6 million accessions in 1400 gene banks (Glazmann et al., 2010).

The current issue on genetic resources is how to manage them. So far the management of genetic resources considered the three steps linear model: conservation­utilization. Moreover, the biotechnologies support the management of genetic resources offering different techniques for the safeguard of genetic resources, from in vitro culture to DNA storage.

The difficulties in the management and utilization of the continuously expanding number of conserved accessions can be limited by the identification of ‘core collections’: a selected and smaller collection representative of species’ genetic diversity (Brown, 1989). Designing core collections involves an appropriate use of diversity, offering to the breeders an opportunity to work with a quite manageable number of accessions evaluated on traits of economic importance. In fact, one of the reasons why plant breeders are using less basic germplasm in research is the lack of information on quantitative traits which often show high genotypes versus environmental interaction and require
replicated multi-location evaluations (Upadhyaya et al, 2006). As a complement, the conservation is also organized in situ systems where the current diversity has been maintained. Evaluation of genetic material in situ allows preserving the relationship between species and environment, taking into account the continual interaction among physical, human factors and crops. In this contest, the farmer becomes one of the main actors of the creation and maintenance of the present diversity. At the farm level, conservation involves the maintenance of traditional crop varieties within the traditional agricultural system.

On these premises, the European SAFE-NUT Project, elaborated within the Council Regulation (EC) N. 870/2004 AGRI GEN RES, represents a resourceful strategy for re-organizing and sharing, in a more efficient manner, the hazelnut and almond genetic resources by upgrading the knowledge on their value as well as the precious cultural meaning related to their traditional and historical uses. The two Mediterranean species, commodities of relevant European economic importance, represent two interesting case studies, since their utilization is strongly intertwined with human civilization (Bacchetta et al, 2009). More than 5000 years before Christ, a Chinese manuscript highlighted the medical properties of Corylus avellana, while Catone (234-149 BC), the most ancient Latin writer, spurred the cultivation of this crop indicated as ‘...nuces, calvas, avellanas, praeestinas et grecaes’. Almonds date back in print to the Bible. Romans referred to almond as ‘Nouces Grecae’ since this crop was cultivated firstly by Greek people.

In addition to the above mentioned considerations, the present work describes the main objectives of the SAFENUT Action and the general results that focus on the characteristics of the final outcome of the activities.

THE SAFENUT Objectives
The Action benefits from the participation of 11 Research Institutions in 6 European Countries (Italy, Spain, Portugal, France, Slovenia, Greece) and from the involvement of some of the most important hazelnut and almond producers, directly engaged in breeding activities and conservation of genetic resources.

The management of the Action has been organized in the following activities:

Survey of local, National and European Corylus avellana collections and on farm recovery of ‘ecotypes’
Leading partner: IRTA (Spain), with the involvement of ENEA, UNITO (Italy), Slovenia, NAGREF (Greece) and UTAD (Portugal).

With the aim to safeguard the European hazelnut genetic resources, the first activity aimed at increasing the knowledge of the hazelnut material in ex situ and in situ collections among Partner Countries. An exhaustive list of all the accessions conserved in the European collections is useful to check the misnaming of different accessions and to centralize and share the germplasm. The second step, for a suitable and complete evaluation, is the harmonization of morphological descriptors. Most of the hazelnut genetic resources that are not present in collections are ‘on farm’ preserved. With the aim to recover and safeguard - to the maximum possible extent - useful genetic diversity, a survey has been carried out in Spain, Slovenia, Greece and Italy.

Recovery of old endangered almond varieties and in situ characterization of germplasm.
Leading partner: INRA (France), with the involvement of CRA-ISF (Italy), NAGREF (Greece) and CIT (Spain).

The aim of this activity is twofold: the centralization and harmonization of almond germplasm among Country partners and the data acquisition on morphological characterization with reference to the previous work carried out by the Prunus Working Group. Despite local almond genetic resources maintained in national collections, many traditional cultivars are endangered. The recovery of this material, often conserved “on farm”, represents an important goal to achieve in order to preserve the agro-biodiversity heritage. Moreover, some local hand-made products, realized using imported almonds, lost their typical taste. Consumers’ interest in components with beneficial properties on human health requires almonds’ chemical and molecular analysis to identify the nutritional and nutraceutical value, as well as the germplasm’s origin and identity.

Evaluation of Corylus avellana plant material.
Leading partner: UNITO (Italy), with the involvement of ENEA and CRAB (Italy), IRTA (Spain), Slovenia, and NAGREF (Greece).

Traditional methods of identifying hazelnut cultivars are mostly based on morphological and phenological traits. The primary characterisation using harmonised descriptors of cultivars and new survived ecotypes, was the first step of this objective. The characterization of selected accessions, with particular attention to nutritional and nutraceutical aspects, meets the consumers’ demand for high food quality, favouring new agro-industrial opportunities. Nuts are the best source of fibre, micronutrients, antioxidant and polyunsaturated fats. Many researchers showed that eating a handful of nuts per day is a good nutritional advice in the contest of a healthful and balanced diet. Furthermore, potential benefit of nuts were shown on cardiovascular pathologies and also some effects were found on diabetes and some forms of cancer. The positive trend on ‘functional food’ makes this crop particularly interesting. The definition of nutritional value of hazelnut cultivars focused on oil quantity and quality, mineral, and phenolic content. Moreover, the characteristics of nuts are of interest to define quality and potential uses of the product.

The availability of reliable data on biochemical and molecular traits of the germplasm allowed to define the suitable use of the nut products, as required by industries, row consumers, etc. This informa-
tion is also very useful for breeding programs. Results in DNA analysis can show the true-to-type identification as well as problems of germplasm’s misnaming or homonymous and synonymous present in the collection. The aim of this objective was to apply SSR technique to a first set of traditional cultivars and selected ecotypes in order to verify their origin. This will allow the establishment of a database with genetic cultivar profiles.

Ecological, economic and socio-cultural aspects related to sustainable production and traditional knowledge

Leading partner: CRA-ISF (Italy), all Partners with the involvement of ONG and farmer’s Associations.

This objective aims at highlighting the importance of typical products in a global agricultural system. The survey and dissemination of the existing fruit exhibitions in Europe (exposing nuts and/or their products; celebrating almond or hazelnut as trees) valorise the traditional products and increase knowledge of local uses. One of the main goals was the “cultural target”, namely the safeguard of the historical memory of old varieties’ local and traditional uses. This memory, usually belonging to the old farmers, needs to be preserved and transferred to the young generations or it will be lost forever. On the basis of this consideration, a first step was to develop a questionnaire to gather information and data on this topic. As a second step, a survey of almond and hazelnut traditional uses was promoted involving students and stakeholders. The knowledge and the safeguard of the traditional agricultural practices, land uses, orchard structures and organizations can be potentially useful for new sustainable agro-industrial applications. Therefore, the activities have also been focused on the development of a tool to gather information and data on this topic.

Designing an almond core collection

Leading partner: CITA (Spain)

This objective aimed at identifying the unregistered almond varieties present in the Partner Countries for their selection and introduction in the European almond reference collection in Spain. Chemical analyses were performed on the promising material and the nursery for grafting plant materials was established. In the light of defining the almond core collection, the traits for accession and characterization have been reviewed to obtain a wide spectrum of almond genetic variability. Another activity has been the establishment of a DNA bank, which is a valuable tool to enhance the utilisation of germplasm.

SAFENUT website and database

Leading partner: ENEA (Italy)- All Partners

A Mediterranean widely accessible web-based system (the SAFENUT database) has been established in order to develop a European virtual collection of the characterised hazelnut and almond genetic resources. This is a precious tool to widespread the knowledge on the accessions, to monitor the management of Corylus avellana and Prunus dulcis genetic resources and their localisation, including traditional and ecological information.

RESULTS

One of the first outputs is on germplasm’s centralization: 13 hazelnut collections have been recognized and a list of about 222 clones and selections was completed to verify synonyms and misnaming. A widespread survey was carried out in Spain, Greece, Italy and Portugal in order to recover the ‘on farm’ conserved ecotypes at risk of genetic erosion: about 121 accessions have been pre-selected, more than 30% of which are already identified as new genotypes by SSR markers. A fruitful survey was carried out in Abruzzo (Italy) and in France to recuperate and restore numerous old endangered almond clones.

With the aim to harmonise the morphological evaluations, specific descriptors were elaborated for the genetic materials’ characterization both in the permanent collection and in new selections. More than 150 almond and 305 hazelnut accessions were analyzed at 10 SSR loci over 3 years in order to verify the genetic authenticity. One hundred ten accessions of the two species were evaluated for fat acids, tocopherols, phenolic compounds, mineral and protein contents during the three years of the Action. Seven reference hazelnut cultivars were identified and monitored each year to investigate the environmental effect on the biochemical nut properties. On these concerns, the multivariate analysis of the entire data allowed the individuation of the core collections.

The recovery of traditional knowledge was undertaken by different activities: 2097 questionnaires were elaborated following the interviews of students and their parents in all Partner Countries; a survey on the festivals related to the two Mediterranean species was carried out and a publication was released. Furthermore, questionnaires addressed to farmers offer the opportunity to compare problems, technical practices and biodiversity at European level.

Documentation of information on Plant Genetic Resources (PGR) is imperative for planning and implementing activities related to their conservation, sustainable utilisation and benefit sharing accrued from their use.

The SAFENUT Database (DB) has been implemented on the basis of the framework of the Scrigno Database which is a National virtual Atlas, related to the traditional Italian Food Crops. The SAFENUT DB tools are the following: DB management system is MDB Access, the application programming interface is Asp 3.0, web server program: IIS. Currently, the host of the DB is Aruba (AR-Italy), subsequently ENEA Casaccia (Italy). The core of the DB includes four sections: the data, the policy of access, the administrative tools and the outputs.

The SAFENUT DB, web interface available at the address: http://www.safenut.net, has been organised in order to provide users driven on-line interrogation of search-queries, across multi-trait data based on germplasm evaluation data. The virtual inventory is coherent with other in-
REFERENCES


Coordinator Team
1 ENEA, UTAGRI - Agenzia Nazionale per le Nuove Tecnologie, l' Energia e lo Sviluppo Economico Sostenibile
2 All Partners
4 Istituto Sperimentale per la Frutticoltura (CRA), Italy;
5 Universidade degli Studi di Torino (UNITO), Italy; National Agricultural Research Foundation Pomology Institute (NAGREF), Greece;
6 National Agricultural Research Foundation-Institute of Olive Trees and Subtropical Plants (NAGREF - ISPOT), Greece;
7 Instituto de Recerca i Tecnologia Agroalimentaries (IRTA), Spain;
8 Universidade de Trás-os-Montes and Alto Douro (UTAD), Portugal;
9 Universa v Ljubljani, Biotehniska Fakulteta, Slovenia;
10 Consorzio di Ricerca Applicate alla Biotecnologia (CRAB), Italy.
11 Spazio Verde s.r.l.;
12 Association Nationale des Producteurs de Noisette (APN), France.

EXPANSION OF HAZELNUT RESEARCH IN NORTH AMERICA

The United States typically produces 2-4% of the world hazelnut ( Corylus avellana) crop, with 70-80% produced in Turkey, 15-16% in Italy, and the remainder produced in Spain, Azerbaijan, France, the Republic of Georgia, and several other countries with Mediterranean-like climates (FAOStat, 2010). In recent years, interest in growing hazelnuts has been expanding in North America outside of the traditional area of the Willamette Valley of Oregon where 99% of the USA crop is currently produced. For decades, the only university-based hazelnut research was centered at Oregon State Univ. (OSU), in Corvallis, Oregon. Today, work is also underway at Rutgers Univ. in New Jersey, the Univ. of Nebraska, Lincoln, the Univ. of Minnesota, the Univ. of Wisconsin, and the Univ. of Guelph, Ontario, Canada. Hazelnut research is also being done by the National Arbor Day Foundation, a not-for-profit educational organization also in Nebraska, as well as several private nurseries. This increase in interest in hazelnut production is likely due to their low-input, sustainable nature and the high value and rising popularity of the crop.

OREGON STATE UNIVERSITY

The world’s largest hazelnut research and genetics program is located at OSU where comprehensive work supports the commercial hazelnut industry in the region. With research starting in the mid-1900s and breeding since 1969, significant advances have been made at OSU in many aspects of hazelnut production, research, and genetic improvement, much of which has been summarized in a number of review publications (Mehlenbacher, 1991; Thompson et al., 1996; Mehlenbacher, 1994; Mehlenbacher, 2005; Mehlenbacher, 2007; Mehlenbacher, 2009). While this backlog of information provides support for the current expansion of hazelnut research at other institutions, the most notable advances come from research on the fungal pathogen Anisogramma anomala, which causes eastern filbert blight disease (EFB). EFB has been long considered the primary limiting factor to hazelnut culture in the eastern United States (Thompson et al., 1996). This disease, which is harbored by the tolerant wild American hazelnut Corylus americana, causes severe cankers and die-back on the European hazelnut (Johnson and Pinkerton, 2002). Nearly all cultivars of C. avellana are highly susceptible to this disease (Coyne et al., 1998; Lunde et al., 2000). The EFB pathogen, native to the eastern USA, was not present in the Pacific Northwest at the initiation of its hazelnut industry in the late 1800s. As
such, the industry thrived in its absence for nearly 100 years, and, being of modest economic importance, the EFB fungus remained unstudied and poorly understood. Unfortunately, the disease was introduced into southwest Washington in the late 1960s causing significant loss in the Washington hazelnut industry. Since that time, it subsequently spread throughout the entire hazelnut producing region in Washington and Oregon. Fortunately, the prevailing weather patterns in the region slowed its southward spread, providing time for researchers at OSU to study A. anomala. They were able to successfully discern its reproductive and infective behavior, while also developing fungicide regiments and cultural controls to keep the existing orchards alive, although not without added expense and challenge. (Johnson and Pinkerton, 2002). The major breakthrough came with the identification of genetic resistance to the pathogen in the C. avellana pollinator ‘Gasaway’ (Mehlenbacher et al., 1991). Finally, after more than 30 years, the release of the new EFB-resistant cultivars ‘Jefferson’ for the in-shell market and ‘Yamhill’ for the kernel market have revitalized the Oregon industry (Mehlenbacher et al., 2009, 2010). Today, research and breeding is ongoing at OSU, with a focus on developing superior cultivars expressing resistance to EFB from other genetic backgrounds (Sathuvalli and Mehlenbacher, 2009a & b; Sathuvalli et al., 2010), in addition to developing a greater understanding of the genetic diversity and genomic makeup of C. avellana (Mehlenbacher, 2009; Gürcan et al., 2010). This work further supports the development of hazelnut production in other regions of North America and worldwide.

RUTGERS UNIVERSITY

The Rutgers University (New Brunswick, NJ) hazelnut research program was initiated in 1996. Early on, the Rutgers program developed close ties with OSU, which generously provided access to Corylus germplasm not previously tested in the eastern USA, including a number of sources of resistance to EFB. Since Rutgers is located within the native range of A. anomala and there is no hazelnut industry in NJ, it was possible to screen plants there under very high disease pressure. To investigate prospective sources of resistance, breeding selections and cultivars shown resistant in Oregon, where it is believed a limited diversity of the fungus is present, were grown at Rutgers and inoculated using isolates collected across the pathogen’s native range. Through this work, pathogenic variation was observed in A. anomala, in terms of several isolates being able to cause cankers on known sources of resistance in Oregon (Molnar et al., 2010a). This finding supported a need to identify and utilize a diversity of resistance genes in breeding, including pyramiding genes, to develop cultivars more likely to maintain resistance for long periods of time. Fortunately, this work also led to the identification of several plants that held up against a wide diversity of isolates (Molnar et al., 2010a). To better understand the pathogen, a draft genome sequence of A. anomala was completed in December 2010 (Cai et al., 2011a), along with a much more extensive collection of A. anomala isolates gathered from over 40 locations across the eastern USA and southern Canada. The immediate goal of the research now underway is to mine the genome of A. anomala for simple sequence repeats (SSRs) that can be used to examine the genetic diversity and population structure of isolates in our collection (Cai et al., 2011b). This information, when coupled with pathogenicity tests, may provide a much better understanding of the fungus and may also allow for selection of isolates for improved resistance breeding. It will also allow opportunities to investigate the breakdown of resistance genes, if and when they occur, such as that observed on ‘Gasaway’ in New Jersey (Molnar et al. 2010b). To broaden the genetic base for breeding, collections of C. avellana were made in Eastern Europe and the former Soviet Union for subsequent evaluation at Rutgers. These collections were made from a number of research institutes and botanical gardens, as well as local markets, bazaars, and road side stands in western and southern Russia, Poland, Moldova, Estonia, Latvia, Lithuania, the Republic of Georgia, Uzbekistan, and Kyrgyzstan. Additional ma-
material was provided from OSU from collections made in Turkey, increasing the total number of *C. avellana* seedlings from foreign collections evaluated at Rutgers to over 5,000 plants. The goal of the germplasm collection work is to search for novel sources of heritable resistance with hopes that some would also produce nuts of improved quality (Molnar et al., 2007).

The first controlled hybridizations of hazelnuts began at Rutgers in 2001 and have continued yearly. Breeding priorities include selecting for resistance to EFB, the production of medium to large-size round nuts with high-quality kernels, cold hardness of male flowers, resistance to bud mite (*Phytopus avellanae* Nal.), nuts that drop free of the husks, and high, consistent yields (kg/ha). Two different approaches are being taken to obtain progeny that meet these objectives. One is to identify and utilize EFB-resistant *C. avellana* in an intra-specific hybridization program similar to that underway at OSU (Mehlenbacher, 1994), but selecting for plants adapted to New Jersey and similar eastern regions. However, limitations may present themselves in this scenario when trying to enhance adaptation to colder, more stressful environments, based on the current production range of cultivated *C. avellana*. The other method being employed is to use a wide variety of EFB-resistant, cold-hardy selections of *C. americana* as parents in an interspecific hybridization program with *C. avellana*, with unrelated *C. avellana* with excellent nut and kernel qualities used as the recurrent parents. It is expected that this approach will take several additional generations of breeding due to the small nut size and other negative attributes of *C. americana*, such as nuts that remain in the husks upon maturity. All seedlings are exposed to EFB through greenhouse and/or field inoculations starting in their first year, and only those that remain free of disease in year five are retained for evaluation of nuts and kernels. Currently, there are over 25,000 hazelnut seedlings resulting from controlled crosses under evaluation at Rutgers. From the earliest crosses, 14 improved EFB-resistant plants have been selected and are now being planted in replicated yield trials across the northeastern USA, as well as in Nebraska and southern Ontario.

**NATIONAL ARBOR DAY FOUNDATION**

The National Arbor Day Foundation is a not-for-profit educational organization devoted to inspiring people to plant trees. They currently have over one-million members. Hazelnut research was initiated there in 1996 with the planting of a nine-acre field at Arbor Day Farms in Nebraska. Over 5,000 seedlings, purchased from Badgersett Research Corporation in Canton, Minnesota, were planted and provided minimal inputs. The plants were derived from open-pollinated seed of plants of hybrid origin (*Corylus americana × C. avellana*), which provided a diverse body of germplasm to grow and evaluate. Over time, most of the plants proved to be well-adapted to the harsh Nebraska climate even under the very low maintenance conditions. Based on the early success of the planting, a hazelnut “charter members” project was initiated in 2000, which had members growing and evaluating hazelnut plants at their homes or farms derived from hybrid seed collected at the Arbor Day Farm. Members were asked to respond to a survey to report attributes of survival, plant size, nut yield, and nut size. In 2010, the membership totaled 100,000 people who were shipped more than 500,000 hazelnut seedlings.

**UNIVERSITY OF NEBRASKA, LINCOLN**

To more systematically evaluate the planting at Arbor Day Farm, the University of Nebraska, Lincoln became involved with the project, which ultimately leads to the identification of several consistently high-yielding selections (Hammond, 2006). Based on single-plant estimates, the four-year average of the highest yielding selection was four tons per hectare of dried, in-shell nuts. Although single-plant estimates can be unreliable, the fact that the plants yielded a significant amount while grown on a marginal site with little inputs is compelling. This work bolstered support for the potential of growing hazelnuts for production in the Midwest, leading to further research, including characterizing nut and kernel aspects of the best performers from the Arbor Day collection in terms of their feedstock potential for biodiesel and other oleochemicals (Xu et al., 2007; Xu and Hanna, 2009; Xu and Hanna, 2010).

**HYBRID HAZELNUT CONSORTIUM**

Recognizing a need to leverage existing research and germplasm holdings at several institutions around the USA to enhance the development of hazelnuts as a new widely adapted, sustainable crop, the Arbor Day Foundation initiated the development of the Hybrid Hazelnut Consortium in 2008. Partners in the consortium now include OSU, Rutgers, the University of Nebraska, Lincoln, the Nebraska Forest Service, and the Arbor Day Foundation. This partnership provides a unique opportunity to combine the strengths of research programs located on both coasts and in the Midwest USA. By utilizing the breadth of breeding knowledge and genetic resources developed at OSU, the

*Corylus americana* used as parent in breeding cold hardy disease resistant plants.
FAO-CIHEAM - Nucis-Newsletter, Number 15  December 2011

EFB resistance research and breeding at Rutgers, and the extreme climate and land resources of Nebraska, developing and commercializing hazelnuts over a much wider growing region, a goal of substantial proportions, comes into reach. The potential of this partnership was recognized and bolstered by the USA Department of Agriculture, which awarded a $1.39 Million Specialty Crops Research Initiative grant to the group in 2009.

THE UNIVERSITY OF MINNESOTA AND UNIVERSITY OF WISCONSIN

In 2006, hazelnut research was initiated at the Univ. of Minnesota (St. Paul, MN) in collaboration with the University of Wisconsin (Washburn and Ashland, WI) operating under the name the Upper Midwest Hazelnut Development Initiative (UMHDI). Much of the work underway at these locations is in response to numerous small farmers planting hybrid hazelnut seedlings in Minnesota, Wisconsin, Iowa, and Illinois. The UMHDI was largely organized to provide production information, and eventually improved clonal plant material for growers to further develop the fledgling industry. Hazelnut production is a new endeavor in this part of the country and information on growing needs, harvesting, drying, cracking, and marketing nuts is still in development (Fischbach, 2010). Topics of study include propagation, planting date, orchard spacing, weed management, nitrogen fertilization, and irrigation, as well as harvesting and processing technology. One primary initiative of the program is to work with the growers to identify superior performing seedlings from their thousands of plants. The best plants will be propagated and entered into regional replicated evaluation trials. Once superior plants are identified, based on total yield potential, they will be propagated through tissue culture to develop opportunities for large-scale clonal commercial plantings, which will in turn provide more uniform and consistent yields. To support future breeding efforts, wild C. americana seedlings, which are abundant in Wisconsin and Minnesota, are also being identified and collected for evaluation.

UNIVERSITY OF GUELPH

Hazelnut research began in 2008 at the University of Guelph in southern Ontario, Canada. This research includes field evaluation of available cultivars at the Simcoe Research Station, micropropagation research of hybrid hazelnuts, rapid liner production, and efforts to develop the infrastructure, knowledge, and partnerships necessary to build a hazelnut industry in southern Ontario. The impetus for this work is largely due to the Ferrero candy company, the makers of Ferrero Roche chocolates and Nutella, building a large processing facility in Brantford, Ontario. Researchers at Guelph, in collaboration with private individuals and the local nut growing group the Society for Ontario Nut Growers, hope to have 100 acres of clonal hazelnut trials in place by 2012 (A. Dale, pers. commun., 2010).

SUMMARY

The increasing worldwide demand for nut crops and the sustainable, low-input nature of hazelnuts has brought a lot of recent attention to their production. Hazelnut research is now ongoing at six universities and one not-for-profit institute in North America, which is a significant increase from only one university fifteen years ago. Two of these, OSU and Rutgers, are also undergoing substantial hazelnut genetic improvement work with rapid progress being demonstrated. With a much deeper understanding of the
Four-year-old replicated hazelnut yield trial at the Rutgers Horticultural Research Farm 1, located in North Brunswick, New Jersey, USA.

References


Hammond, B., 2006. Identifying superior hybrid hazelnut plants in southeast Nebraska. MS Thesis, Univ of Nebraska-Lincoln, USA.


T. J. Molnar.
Plant Biology and Pathology Department. Rutgers University. 59 Dudley Road. New Brunswick, NJ 08901 USA.
Email: molnar@aesop.rutgers.edu.


FAO-CIHEAM - Nucis-Newsletter, Number 15 December 2011
HAZELNUT IN ASTURIAS (NORTHERN SPAIN)

INTRODUCTION

In Spain hazelnut (Corylus avellana L.) cultivation is concentrated in Catalonia (northeastern Spain), where 85% of the cultivated hazelnut area is located. Nevertheless, this species is traditionally grown in the north of Spain: Asturias, Navarra and Basque Country, where climate is more adequate to the requirements of this crop. In Asturias hazelnut cultivation has a long tradition; in the XVIIth Century this species was already mentioned in different manuscripts and it is described as an important resource for the local farmers with part of the crop exported to England. Nuts from this region were very appreciated, due to their good fruit characteristics. Mid XX century the situation changed as growers began to abandon orchards in most of the areas where hazelnut was very well cultivated. Thus they turned into marginal areas and hazelnut production decreased considerably, causing a possible loss of the local genetic diversity. Today, hazelnut in Asturias can be found growing spontaneously or planted in land boundaries and on river banks (Figure 1). However, regular plantations disappeared. In spite of this situation, the tradition of hazelnut cultivation is maintained and in some areas hazelnut harvesting is still an event, covering the family consumption and the sale in local markets. Hazelnut Festivals are still alive in some areas.

In order to recover hazelnut material and preserve the genetic diversity of this species in Asturias, during a period of three years (2003-2005) a hazelnut germplasm prospection was carried out by IRTA (Institut de Recerca i Tecnologia Agroalimentàries) from Catalonia and SERIDA (Servicio Regional de Investigación y Desarrollo Agroalimentario) from Asturias. The main objectives of the prospection were: 1) to describe the variation in the hazelnut material found, using morphological descriptors and molecular markers, 2) to investigate the genetic relationships between this local germplasm and reference cultivars from other regions and countries producing hazelnut, 3) to study the genetic relationships between cultivated germplasm and wild hazelnuts collected in Asturias and, 4) to preserve de most interesting material prospected in two hazelnut collections (one in Asturias and another in Catalonia), where this material will be studied and maintained. The study of this material in collection will allow selecting the most interesting material according their agronomic and commercial fruit characteristics. This selection would be the base for future hazelnut orchards in Asturias.

Figure 1. Hazelnuts growing in Asturias, planted in land boundaries.

Figure 2. Easy pellicle removal after lightly roasting.

VARIATION IN HAZELNUT MATERIAL USING MORPHOLOGICAL DESCRIPTORS

At the end of August of the three years of the study, some hazelnuts from prospection were pre-selected. At the end of the exploration a total of 90 materials had been collected in 48 different localities that were considered to be cultivated forms. This first selection was done considering information from different farmers, and also observing morphological tree characteristics (vigor, habit), and fruits. Trees pre-selected were marked and a sample of 20-50 nuts / tree were collected in situ to be more accurately characterized in the laboratory, using 19 qualitative standard descriptors (involutecres, nut and kernel characters), following the UPOV guidelines specific for this species. The test on pellicle removal after lightly roasting has also been evaluated.

Morphological characterization revealed a great phenotypic diversity in the evaluated fruit traits. The Shannon-Weaver diversity index of the 19 considered descriptors averaged 0.82, with values ranging from 0.07 to 1.08. The highest values of the diversity index was for the following traits: “thickness of callus at base” and “serration of indentations” for the involucres traits (1.03 and 1.04, respectively), “shape” and “number of stripes on shell” in the nut traits (1.046 and 1.082, respectively) and “appearance of skin” for the kernel traits (1.087). The local selections were phenotypically diverse and many had characteristics appreciated by the market, as the easy pellicle removal after lightly roasting (Figure 2). A high proportion of these materials showed morphological characters similar to well-known Spanish cultivars as ‘Casina’ (from Asturias) and / or ‘Negret’ (from Catalonia).

POLYMORPHISM LEVELS DETECTED BY ISSR MARKERS

The expression of these morphological characters could have an environmental component, thus a genetic study using ISSR molecular markers (inter simple sequences repeat) has been carried out to investigate the genetic structure of the local Asturian hazelnut genetic diversity and the relationships with other materials.

Fifty trees from the 90 pre-selected materials, and four local accessions derived from a previous exploration in Asturias (‘Casina’, ‘Grande’, ‘Espinaredo’ and ‘Quirós’) were included in this study. In addition seventeen cultivars from different producing countries: ‘Camponica’, ‘Mortarella’, ‘Tonda di Giffoni’, ‘Tonda Romana’ and ‘Santa Maria del Gesu’, from Italy; ‘Gironell’, ‘Grifoll’, ‘Morell’, ‘Negret’, ‘Pauetet’, ‘Ribet’ and ‘Segorbe’, from northeastern Spain; ‘Tombui’, from Turkey and ‘Butler’, ‘Ennis’, ‘Royal’ and ‘Vilamette’, from the USA, were used as reference cultivars for this analysis. Eleven ISSR primers, which generated 66 polymorphic bands, were selected to carry out this study: GAG(CAA)5, (ACTG)4, (AG)BCG, (AGAC)4535, (AGAA)4AG406 and (CAGA)4190.
A considerable diversity. A total of 91 different alleles were identified with a mean of 7 per locus, and polymorphic information content values ranged from 0.43 to 0.83, with a mean of 0.69. A total of 91 different alleles were identified with a mean of 7 per locus, and polymorphic information content values ranged from 0.43 to 0.83, with a mean of 0.69. The plot obtained from principal coordinate analysis, the unrooted neighbour-joining tree constructed, and the population structure analysis showed a differentiation among the three populations included in this study: local cultivated hazelnuts, local wild hazelnuts and the set of reference cultivars (Figure 3). However, some introgressions in the three populations and several putative intermediate forms between them were identified. The local cultivated germplasm contains: (1) a group of accessions clearly differentiated within the Spanish-Italian gene pool, (2) a group with intermediate forms probably derived from hybridization and in any case probably associated with new domestication from hybridization and in any case probably associated with new domestication events, and (3) accessions probably derived from exchange with other geographic origin (mainly from Catalonia). The differentiation of these groups within the local material cultivated is of great interest for the preservation and use of the local genetic diversity of this species.

LOCAL GENETIC DIVERSITY CONSERVATION

To preserve the prospected material, two ex situ hazelnut collections were installed in two field collections with different weather conditions (Atlantic and Mediterranean), one in SERIDA (Villavicencio, Asturias; Northern Spain) orchards and another in IRTA (Constanti, Catalonia; Northeastern Spain) orchards. Wood from the material having the best characteristics (38 materials) has been collected in situ in winter. This material was sent to IRTA and was grafted, applying the “hot callusing pipe” method. Material grafted was in nursery for one year, and then it was earthed up to obtain its own rooting system. The following year, the material gathered the conditions to be planted in the collections. In 2010, the first fruits of some of the materials have been gathered from the collections, and the complete characterisation of the tree (production, suckering, behaviour in different climatic conditions, etc.) and the fruit (commercial characteristics) will be carried out in the following years.

The study and conservation of all this genetic hazelnut diversity from Asturias, could provide new cultivars or genitors to be used in future breeding programmes.

ACKNOWLEDGEMENTS

This research has been supported by grants RF01-030 and RF01-036 from the Ministerio de Ciencia y Tecnologia, and by RF01-036, RF01-030) INIA projects, Spain.

REFERENCES


M. Rovira 1 and J.J. Ferreira 2

1 IRTA-Mas de Bover, Ctra. Reus –El Morell, km. 3.8, 43120 Constanti, Tarragona (Spain).

2 Área de cultivos Hortofrutícolas y forestales SERIDA, 33300, Villavicencio, Asturias (Spain).
AN INEXPENSIVE MODE TO RECOVER UNSOLD ROOTED HAZELNUT SUCKERS

SUMMARY

At the end of 2007, due to a really scarce hazelnut plants demand, a nurseryman took the decision of not digging out a lot of coppices prepared in July, the same year. At the ringing time, some experimental theses such as IBAK, Hydroretenteur and both, were applied to these coppices. After one vegetative season, i.e., from July to December 2007, the rooted suckers were not dug out and they remained untouched in the same place of the nursery. In November 2008, after 2 vegetative seasons, the rooted suckers were dug out and before selling them, some quality parameters were measured. As expected, the quality was better than the quality obtained (as usual) from similar coppices after only one vegetative season. In fact, the rooted suckers obtained from coppices after 2 vegetative seasons show collar diameters over 25 mm and heights over 200 cm. This kind of strong plants is highly appreciated by the local growers.

INTRODUCTION

In the Langhe district, the hazelnut plants demand is variable depending on years and sometimes it is very poor or nil. Therefore, sometimes it may happen that the nurseryman has a lot of unsold rooted suckers. In this case the nurseryman takes the extreme solution to dig out the rooted suckers and destroy them by fire. Another solution is to dig out the rooted suckers, transplant them and wait another vegetative season before selling the plants. There is a third opportunity, presented hereby: leave the untouched coppices with their rooted suckers in the same place and dig them out after 2 vegetative seasons. At the end of the 2008-vegetative season, the quality of rooted suckers obtained from the coppice left for 2 vegetative seasons in the same place in the nursery was detected. In the meanwhile, the effect of IBAK, Hydroretenteur (Roversi, Armengolli, Mozzone, 2008; Malvicini, Roversi, Marino, 2008; Roversi, Malvicini, 2009) in which the rooted suckers were dug out from the coppices after just 1 vegetative season. In this case, the rooted suckers were dug out from the coppices after 2 years. In November 2008, after 2 vegetative seasons, the rooted suckers were dug out, and ratings of commercial marketability were made, as nurserymen usually do. Then, some quality parameters were measured and recorded for all 5 commercial categories.

RESULTS

A) At the beginning of the trials

As shown in table 1, at the ringing time (June 2007), the average sucker number of coppices was above 34, with some significant differences between coppices expected for the different theses applied.

The suckers height was about 65 cm and not significantly different among the coppices.

The percentage of suckers suitable for ringing was between 87% (Hydroretenteur) and 92.1% (IBAK).

were applied to these coppices for 5 replicates:

• test (not ringed);
• IBAK at 3000 ppm;
• Hydroretenteur (Hyd) added to the mounded soil;
• IBAK + Hyd

Before applying these experimental theses, some sucker parameters (number, height and suitable ringing rate for each coppice) were recorded. The theses here applied are similar to those of previous works done (Roversi, Armengolli, Mozzone, 2008; Malvicini, Roversi, Marino, 2008; Roversi, Malvicini, 2009) in which the rooted suckers were dug out from the coppices after 1 vegetative season. In this case, the rooted suckers were dug out from the coppices after 2 years. In November 2008, after 2 vegetative seasons, the rooted suckers were dug out, and ratings of commercial marketability were made, as nurserymen usually do. Then, some quality parameters were measured and recorded for all 5 commercial categories.

In particular, the total percentage of extra and first category rooted suckers, gave a very high percentage (see fig. 1) of saleable rooted suckers. Their value was 67.7% (Hyd.), 70.2% (IBAK) and 84.4 for both theses.

B) At digging time

- Rooting percentage

As shown in table 2, the application of Hydroretenteur, IBAK or both, gave a very high rooting percentage, starting from 91.1% for Hyd. to 98.20% for Hyd. + IBAK.

While the percentage of extra and first category rooted suckers was null for the test, with the application of Hyd., IBAK and both, the same percentage significantly increases.

In any case, the diameter at the collar of rooted suckers was over 31 mm for the coppices in the nursery. In the previous period (June 2007), the following theses were considered:

- Diameter at the collar

The application of Hyd. and IBAK or both brings about an increase in the collar diameter of the rooted suckers, especially for IBAK and Hyd. + IBAK, as shown in fig. 3.

In any case, the diameter at the collar of rooted suckers was over 31 mm for the coppices in the nursery. In the previous period (June 2007), the following theses were considered:

- Diameter at the collar

The application of Hyd. and IBAK or both brings about an increase in the collar diameter of the rooted suckers, especially for IBAK and Hyd. + IBAK, as shown in fig. 3.

Table 1. Characteristics of the coppices at the beginning (July 2007) of the trials.

<table>
<thead>
<tr>
<th>Tesi</th>
<th>Suckers height</th>
<th>Suckers number</th>
<th>Ringed %</th>
</tr>
</thead>
<tbody>
<tr>
<td>test</td>
<td>65.5 a</td>
<td>35.1 a</td>
<td></td>
</tr>
<tr>
<td>Hydretenteur</td>
<td>63.9 a</td>
<td>36.0 a</td>
<td>86.8 a</td>
</tr>
<tr>
<td>IBAK</td>
<td>66.6 a</td>
<td>35.3 a</td>
<td>92.1 a</td>
</tr>
<tr>
<td>Hyd. + IBAK</td>
<td>64.7 a</td>
<td>34.8 a</td>
<td>87.5 a</td>
</tr>
</tbody>
</table>

Table 2. Characteristics of the coppices at the end of the vegetative season.

- Rooting percentage

As shown in table 2, the application of Hydroretenteur, IBAK or both, gave a very high rooting percentage, starting from 91.1% for Hyd. to 98.20% for Hyd. + IBAK.

While the percentage of extra and first category rooted suckers was null for the test, with the application of Hyd., IBAK and both, the same percentage significantly increases.
The application of the 3 experimental theses. This means that the coppices, together with their rooted suckers, remained in the same place in the nursery for 2 vegetative seasons.

At digging time (November 2008), the results show that all the applied treatments, especially Hyd + IBAK, were able to improve the rooted suckers’ quality. In particular, as expected, the rooting percentage results very high, the diameter at the collar and the height of rooted suckers was much higher than those obtained from coppices only forced for 6 months, as usual. The rooted suckers’ quality obtained after 2 vegetative seasons was very appreciated by the local hazelnut growers who, generally, prefer very strong plants: collar diameter over 25 mm and height over 200 cm.

The results of these trials would suggest a positive opportunity for the nurseryman, when market demand for hazelnut plants is very poor.

### REFERENCES


### Table 2. Results of hazelnut mounding layer at digging time (November 2008).

<table>
<thead>
<tr>
<th>Tesi</th>
<th>Rooted %</th>
<th>Percentage rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>extra</td>
<td>first</td>
</tr>
<tr>
<td>Test</td>
<td>45.37 A</td>
<td>.0 A</td>
</tr>
<tr>
<td>Hydoretenteur</td>
<td>91.11 B</td>
<td>43.4 B</td>
</tr>
<tr>
<td>IBAK</td>
<td>96.51 BC</td>
<td>50.0 C</td>
</tr>
<tr>
<td>Hyd. + IBAK</td>
<td>98.20 C</td>
<td>60.8 C</td>
</tr>
</tbody>
</table>

### Figures

- Figure 3. Diameter at the collar of rooted suckers as related to commercial category and thesis.
- Figure 4. Average height of rooted suckers as related to commercial category and thesis.
- Figure 5. Average fresh mass root as related to commercial category and thesis.
WALNUT NATIONAL / REGIONAL PROGRAMME IN FRANCE

NETWORK AND DEVICE
Ctifl-Regional Stations of Creysse in the Southwest and SENuRA in the Southeast of France

The walnut program is built according to the walnut expectations and objectives of this professional industry. The Ctifl assumes the role of technical coordinator and coach at the national level through its two engineers who provide technical responsibility for the two stations under the Professional Authority.

In the interest of coordination and coherence, respecting the choices of strategic national and regional professional walnut organizations, it is necessary to:

- Ensure complementarily programs involved at the two regional stations SENuRA and Creysse, and Ctifl. Other partners are associated such as INRA, SRAL, ANSES, IRTA, Girona University, and Chambers of agriculture and producer organizations.

- Distribute shares with those responsible by theme and subject: the corresponding Ctifl, stations and other resource people.

The recovery of business is achieved through a Ctifl national walnut working group which gathers the entire French national walnut channel. These exchanges allow the presentation of experimental work in progress but also to focus on the French walnut track and collect the needs and business priorities.

The Ctifl undertakes its actions according with the guidelines of the Producers Association (PDO Dynamic walnut) and the inter-walnut in addition to the experimental programmes involved on the two regional stations. These programmes are presented in Ctifl Commission planning. Regional stations rely on their governing boards and experimental commissions that issue requests and needs. This Council approves the regional programmes based on the available resources of the Station.

THE PRIORITIES OF THE NATIONAL REGIONAL CONCERNS:

Bacterial blight, the main walnut disease in France, as it causes significant crop losses up to 50% nut necrosis some years. This phenomenon increases from year to year. The research focuses on the characterization of bacterial strains, the study of the risk of loss of effectiveness or non-sensitivity of copper treatment of *Xanthomonas arboricola* pv. *juglandis*, the search for new alternatives to copper as well as taking into account prevention measures in terms of conduct and maintenance of soil orchard.

Selection of new varieties of French walnut hybrids and new rootstocks from programmes initiated by INRA and Ctifl. The goal is to have early bearing age, good yields, good quality nuts with the caliber and experimental commissions that issue requests and needs. This Council approves the regional programmes based on the available resources of the Station.

The new rootstocks must enable the achievement of more vigor and greater homogeneity than conventional rootstocks from seedlings and be tolerant to the black line virus.

Protection against husk fly *Rhagolepis completa* for unprotected orchards to avoid up to 80% damage. It is a new pest identified in France for the first time in 2007. In Europe it is listed on Annex A1 and therefore it is subject to a monitoring plan and a compulsory control, if detected. The experiment focuses on several areas: evaluation of different substances in officially recognized testing, evaluation of specific attractants for this fly, to get a massive capture in a trap for controlling and limiting the damage, evaluation of different control strategies with monitoring of unintended effects vis-à-vis by the auxiliary team.

Orchard pruning of traditional varieties, including “Franquette”; adult orchards needs to ensure light penetration inside the orchard. What kind of pruning is best suited for dense orchards?

Further topics are under study, including the development of crop management and environment-friendly alternatives for incorporating Integrated Fruit Production practices (protection against Anthracnose, codling moth) and maintenance of orchard soils.

Ctifl stakeholders
Jean-Pierre PRUNET Engineer Manager of the National Technical and Technical Manager of Creysse station

Agnes VERHAEGHE Engineer Technical Manager of SENuRA

For the Creysse station
Jean-Loup PEROYS Engineer experiment
Guillaume PAGES Engineer experiment

And support of Didier MERY, Dordogne chamber of Agriculture for the animation of the Technical Southwest Walnut Group.

For SENuRA
Stephanie RAMAIN Engineer experiment
Florence NOTON Engineer experiment
And support of Ghislain BOUVET, Chamber of Agriculture for animation Isère Group Technical Walnut.

Technical contribution from producer organizations with the mission to disseminate research.

J. P. Prunet1, A. Verhaeghe2
1Ctifl / Station Expérimentale de Creysse, Perrical 46800 Creysse, France
E-mail: jp.prunet.creysse@wanadoo.fr
2Ctifl / SENuRA
385A rue de St. Marcellin,
38160 Chatte, France
E-mail : averhaeghe@senura.com

Treatment with a new product to fight walnut blight.
The pistachio nut belongs to the genus *Pistacia* of the family Anacardiaceae. *Pistacia* genus has 11 species. Some of the species play an important role in vegetation at the Mediterranean and Asian regions and most of them have proved successful as rootstocks for top working the cultivated pistachio nut. Except for *Pistacia vera*, the other species are not economically viable. They are called wild pistachios. In Afghanistan, Iran, Pakistan, Turkey and all The Mediterranean countries there are millions of wild pistachio trees or bushes, which belong to different *Pistacia* species. *Pistacia* species are grown at 30-40º altitude and they are suited for microclimate areas all over the world.

**HISTORY**

Pistachio cultivation began around 7000 B.C. and pistachios were consumed by different civilizations. There are records that this plant was grown in Southeastern Turkey during the Hittites and served as a snack for kings and members of the royal family. It is further recorded in ancient documents that this tree was also planted in the fabulous Hanging Gardens of Babylon. In the documents of the Assyrians and ancient Greeks, pistachios were recommended as an aphrodisiac and against the bites of poisonous animals. Because of its distinctive beautiful color, many efforts were made to use this nut as a dying agent during these periods.

As a result of its unique nutritious properties and long shelf life, pistachios also became one of the first internationally traded agricultural commodities that were exported to China via the Silk Road. In the following centuries, pistachios were extensively used by the soldiers of the Roman Empire, from where they spread to Italy and France, around the first century A.D. The usage of pistachios as a medicinal remedy also continued during the Middle Ages; Avicenna suggested their use against liver diseases.

Today, as a result of the desire for a healthy life style, consumers in different parts of the world have begun to rediscover the extraordinary taste of pistachios, together with their various health benefits, which are now being studied with modern laboratory techniques (Babadogan, 2009).

**THE IMPORTANCE AND ORIGIN OF PISTACHIO CULTIVARS**

Large variety of nut fruits, such as hazelnut, pistachio, walnut, chestnut and almond are endemic to Turkey (Aksoy et al., 2008). Almost all nut varieties are conventionally grown in Turkey. During the period 2007-2008, Turkey accounts for 65% of the world hazelnut, 14% of the world pistachio, 10% of the world walnut, 4% of the world chestnut and 2% of the world almond productions (FAO, 2009).

Originating from the genus *Pistacia*, the species *Pistacia vera* is the only edible species that covers at least 10 different sub-species and has a commercial value in the nut industry as a snack food. The green seed, which is the pistachio nut, is in a crusty shell that is being cracked during consumption. Apart from its snack value, pistachio kernels are very popular ingredients used in meat products like salami or sausages, or in the confectionary industry as a part of chocolate, cakes, Turkish Delight, baklava, ice cream and other traditional Turkish sweets (Babadogan, 2009).

The pistachio tree has two major habitats. The first habitat is the Near East gene center, covering the regions Turkey, Caucasian, Iran, and high elevations of Turkmenistan, and the other habitat is the Middle Asia gene center. The gene centers for hybrid forms of pistachios are said to be Turkey, Iran, Syria, Afganistan and Palestine. Currently, pistachio cultivation is possible in areas lying between 30-45º North-South parallels and generally in the Northern Hemisphere, where microclimatic conditions are suitable (Tunalioglu and Taskaya, 2003).

The hybrid forms of widespread Turkish pistachios are *Pistacia kirkii*, *Pistacia terebinthus*, *Pistacia atlantica*, *Pistacia palestina* and *Pistacia vera*. While many varieties of pistachio nuts have been developed in the world, few cultivars adapted well to the conditions in Turkey. These pistachio cultivars include Uzun, Kirmizi, Siirt, Halebi, and Iranian Ohadi. Among these cultivars, Uzun, Kirmizi and Halebi have longer nuts, while Siirt and Ohadi have round shaped nuts. Cultivars with longer nuts are preferred on account of their kernel colors, while cultivars with round nuts are preferred, due to their larger size and higher split rates (Anonymous, 1993). Most propagated pistachio cultivars in Turkey are ‘Kirmzi’ and ‘Uzun’. However, these cultivars are not very popular in international markets, due to their lower split rates and kernel yields (Table 1). Aside from the cultivars named above, other pistachio cultivars such as ‘Keteni’ ‘Gomlegi’, ‘Beyaz Ben’, ‘Degirmi’, ‘Cakmak’, ‘Sultani’, ‘Vahidi’, ‘Mumtaz’, ‘Sefidi’ and ‘Haci Serif’ are also grown in Turkey but in less amounts.

Turkish pistachios are thinner and smaller than Iranian pistachios. Siirt pistachios are similar to Iranian pistachios and their shapes are somewhat in between Gazerantep and Iranian pistachios. Siirt pistachios, about 15 percent of the total production, are bigger and command higher prices on the market than the traditional Turkish pistachios. In Turkey size is direc-

<table>
<thead>
<tr>
<th>Property</th>
<th>Uzun</th>
<th>Kirmizi</th>
<th>Halebi</th>
<th>Siirt</th>
<th>Ohadi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Long</td>
<td>Long</td>
<td>Flat-long</td>
<td>Oval</td>
<td>Spherical</td>
</tr>
<tr>
<td>Split Ratio (%)</td>
<td>70</td>
<td>67</td>
<td>78</td>
<td>92</td>
<td>94</td>
</tr>
<tr>
<td>Weight of 100 Kernels (g)</td>
<td>110,69</td>
<td>120,96</td>
<td>126,72</td>
<td>134,38</td>
<td>143,08</td>
</tr>
<tr>
<td>Length (mm)</td>
<td>22,48</td>
<td>23,96</td>
<td>23,48</td>
<td>23,46</td>
<td>20,83</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>11,66</td>
<td>14,31</td>
<td>11,86</td>
<td>13,08</td>
<td>13,17</td>
</tr>
<tr>
<td>Tickness (mm)</td>
<td>10,77</td>
<td>11,84</td>
<td>13,53</td>
<td>12,55</td>
<td>13,09</td>
</tr>
<tr>
<td>Shell color</td>
<td>Dark Ivory</td>
<td>Dark Ivory</td>
<td>Dark Ivory</td>
<td>Ivory</td>
<td>Ivory</td>
</tr>
<tr>
<td>Crust color</td>
<td>Purple-pink</td>
<td>Red-purple</td>
<td>Violet-pink</td>
<td>Red</td>
<td>Dark Rose</td>
</tr>
<tr>
<td>Nut color</td>
<td>Green-pale Pink</td>
<td>Green-pale Pink</td>
<td>Pale-pink</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Yield (%)</td>
<td>42,48</td>
<td>40,37</td>
<td>42,05</td>
<td>42,64</td>
<td>44,53</td>
</tr>
<tr>
<td>Periodicity</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: Southeast Anatolia Exporters Union.
tachio cultivation and hence account for known to have suitable conditions for pis­Sanliurfa, Mardin, Diyarbakir and Siirt are Kahramanmaras, Gaziantep, Adiyaman, the Southeastern part of Turkey, namely, Anatolia regions. The provinces located in an to the Aegean and even to the Central­provinces, starting from the Mediterrane­1), pistachios can be grown in 56 Turkish the Southeastern part of Turkey (Figure­matic conditions are found particularly in­ cool, short winters. Although these cli­al growing conditions for pistachio trees amount can vary a great deal. The ide­nate­bearing. Therefore, the production­to the fact that pistachio trees are alter­Pistachio production is highly cyclical due­cated to this purpose has reached a very high level.

Pistachio production is highly cyclical due to the fact that pistachio trees are alternate-bearing. Therefore, the production amount can vary a great deal. The ideal growing conditions for pistachio trees are hot, dry summers and moderately cool, short winters. Although these climatic conditions are found particularly in the Southeastern part of Turkey (Figure 1), pistachios can be grown in 56 Turkish provinces, starting from the Mediterrane­an to the Aegean and even to the Central Anatolia regions. The provinces located in the Southeastern part of Turkey, namely, Kahramanmaraş, Gaziantep, Adıyaman, Sancaktepe, Mardin, Diyarbakır and Şırê are known to have suitable conditions for pistachio cultivation and hence account for approximately 94% of Turkey's total pistachio production (Tekin et al., 2001). Plantations continue increasing, as pistachios are replacing olive trees in the rain-fed areas, since farmers can make better­nings are Gaziantep, Sanliurfa, and Adi­yan and the contribution of these three provinces to Turkey's total pistachio production constitutes 87 percent (Tunalioglu and Taskaya, 2005). Sanliurfa province has about twice as many trees as Gaziantep, the traditional growing area.

Historically, Iran has always been the main pistachio supplier, and it continues with this position. At the same time, the United States of America, which was a net importer of pistachios until late 1970s, today is a net exporter leading to a strong competition in the world pistachio market (Emeksz and Sengül, 2001). According to the United Nations’ Food and Agriculture Organization (FAO), the top five pistachio producers in 2007 were Iran with 230,000 t (44 % of the world's production), followed by the USA (108,598 tonnes, 21 percent share), Turkey (73,416 t, 14%), Syria (52,066 t, 10%) and China (38,000 t, 7%). From 1980 to 2007, the reported pistachio world production increased by 581 percent, from 76,029 to 517,823 t. Historical facts show that Iranian production has been the key factor contributing to the global growth trend. However, since 1980, the USA has become the world’s second largest pistachio producer (Table 2).

Turkey is on average the third leading pistachio producer, with productions ranging approximately from 10% to 20% for the period studied (Table 2). Syria holds the forth place with productions ranging from 4% to 13%, followed by China and Greece holding the fifth and sixth places, with productions ranging from 6% to 24% and 1% to 3%, respectively. However, due to the alternate-bearing property of pistachio trees, the ranking of countries can often vary, such as the rank of Turkey, changing from the fifth place in 1980 to the second place in 2006.

According to the 1997/2002 average, the USA holds the first place in terms of yield with an average yield of 2,436.7 kg ha⁻¹, followed by Syria and China with average yields of 1,866.6 kg ha⁻¹ and 1,747.3 kg ha⁻¹, respectively. Turkey stays above the world average (1,119.8 kg ha⁻¹) with an average yield of 1,566.0 kg ha⁻¹, which makes its rank well ahead of the world pistachio production leader Iran with an average yield of 792.2 kg ha⁻¹. Although

**Table 2. Pistachio production shares among major producing countries (%).**

<table>
<thead>
<tr>
<th>Year</th>
<th>Iran</th>
<th>USA</th>
<th>Turkey</th>
<th>Syria</th>
<th>China</th>
<th>Greece</th>
<th>Others</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>30.25</td>
<td>16.11</td>
<td>9.86</td>
<td>10.28</td>
<td>23.68</td>
<td>3.31</td>
<td>6.52</td>
<td>100</td>
</tr>
<tr>
<td>1985</td>
<td>54.81</td>
<td>6.41</td>
<td>18.26</td>
<td>6.28</td>
<td>9.91</td>
<td>2.12</td>
<td>2.40</td>
<td>100</td>
</tr>
<tr>
<td>1990</td>
<td>59.63</td>
<td>19.93</td>
<td>5.19</td>
<td>4.76</td>
<td>8.06</td>
<td>1.26</td>
<td>1.24</td>
<td>100</td>
</tr>
<tr>
<td>1995</td>
<td>60.72</td>
<td>17.07</td>
<td>9.15</td>
<td>3.70</td>
<td>6.36</td>
<td>1.42</td>
<td>1.58</td>
<td>100</td>
</tr>
<tr>
<td>2000</td>
<td>29.73</td>
<td>29.25</td>
<td>19.91</td>
<td>10.60</td>
<td>5.84</td>
<td>2.53</td>
<td>2.15</td>
<td>100</td>
</tr>
<tr>
<td>2005</td>
<td>44.71</td>
<td>24.99</td>
<td>11.68</td>
<td>8.69</td>
<td>6.62</td>
<td>1.82</td>
<td>1.48</td>
<td>100</td>
</tr>
<tr>
<td>2006</td>
<td>40.19</td>
<td>18.87</td>
<td>19.22</td>
<td>12.79</td>
<td>6.29</td>
<td>1.44</td>
<td>1.20</td>
<td>100</td>
</tr>
<tr>
<td>2007</td>
<td>44.42</td>
<td>20.97</td>
<td>14.18</td>
<td>10.05</td>
<td>7.34</td>
<td>1.74</td>
<td>1.30</td>
<td>100</td>
</tr>
</tbody>
</table>


**Table 3. Pistachio export shares by country (%).**

<table>
<thead>
<tr>
<th>Year</th>
<th>Iran</th>
<th>USA</th>
<th>Syria</th>
<th>Turkey</th>
<th>China</th>
<th>Greece</th>
<th>Others</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>68.83</td>
<td>0</td>
<td>16.31</td>
<td>0</td>
<td>3.07</td>
<td>11.77</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>63.32</td>
<td>6.62</td>
<td>23.39</td>
<td>0</td>
<td>0.14</td>
<td>8.53</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>74.74</td>
<td>4.60</td>
<td>1.52</td>
<td>2.50</td>
<td>0.01</td>
<td>0.12</td>
<td>16.52</td>
<td>100</td>
</tr>
<tr>
<td>1995</td>
<td>67.88</td>
<td>7.96</td>
<td>2.05</td>
<td>0.89</td>
<td>1.14</td>
<td>0.19</td>
<td>19.89</td>
<td>100</td>
</tr>
<tr>
<td>2000</td>
<td>61.67</td>
<td>9.53</td>
<td>2.24</td>
<td>0.14</td>
<td>0.82</td>
<td>0.07</td>
<td>25.52</td>
<td>100</td>
</tr>
<tr>
<td>2005</td>
<td>51.04</td>
<td>18.55</td>
<td>0.15</td>
<td>0.31</td>
<td>1.85</td>
<td>0.45</td>
<td>27.66</td>
<td>100</td>
</tr>
<tr>
<td>2006</td>
<td>56.18</td>
<td>16.70</td>
<td>0.44</td>
<td>0.30</td>
<td>1.35</td>
<td>0.28</td>
<td>24.75</td>
<td>100</td>
</tr>
<tr>
<td>2007</td>
<td>47.78</td>
<td>18.98</td>
<td>0.33</td>
<td>0.31</td>
<td>1.76</td>
<td>0.42</td>
<td>35.42</td>
<td>100</td>
</tr>
</tbody>
</table>


**Figure 1. Major pistachio producing provinces of Turkey.**
World export and import figures can vary. Producing countries meet their needs by imports, being not self-sufficient in pistachio production in an economic sense.

Worldwide pistachio supply and demand are generally in equilibrium and the producing countries usually also are consumers. While Iran, Turkey, USA, and Syria are the top consumers, the highest consumption among the European countries is in Italy. Most pistachios grown globally (60%-70%) is consumed as salted roasted snacks, and 30%-40% is consumed in the confectionary industry as an ingredient in chocolate, cakes, ice cream and other sweets. In the USA and Europe, however, 90% of pistachios are consumed as salty nuts (Tunalioglu and Taskaya, 2003).

**FOREIGN TRADE IN PISTACHIOS**

Considering the global picture, Iran is the only consistent leader in pistachio exportation, with export shares ranging from 48% to 75% over the period 1980-2007. However, Iran’s export shares are not stable during the period and show great variation, perhaps depending on periodicity (Table 3). The USA increases its export share from null in 1980 to 19% in 2007. Turkey exports only a small proportion of its production. Primary destinations are the European Union and the USA. In 2004, the average export price for shelled pistachios was about 1,009 $ per tonne and for processed pistachios it was about 6,900 $ per tonne, while for in shell pistachios it was about 6,600 $ per tonne (Sarigedik, 2005). Through a larger perspective, however, Turkey looses its export share drastically, starting from 16% in 1980 to 0.3% in 2007. Thus, important is to periodicity. The top grower countries such as Iran, USA, and Turkey do not import pistachios in general but they rather engage in exportation only, except China. Hong Kong is the world’s leader in pistachio imports with a share of about 18% in 2007. Among the European countries, however, Germany is the top importer with approximately 13% share (Table 4). Other European countries have kept similar small market shares, ranging from 3.00% to 5.44% in the same period. While the USA was among the top importers of pistachios for a long time, it currently managed to be a nut exporter by boosting its exportation, triggered by increased production.

**DOMESTIC CONSUMPTION**

Unfortunately, data on pistachio consumption are not available and therefore, the need for additional research in finding answers to questions on pistachios consumption levels in Turkey is deemed urgent. Having in mind this consideration, data supplied by FAO on domestic consumption, calculated as the difference between the sum of total production, imports, and stock levels at the beginning of the year and the sum of total exports and stock levels at the end of the year are several useful parameters to shed some light on this subject.

Pistachio consumption increased in Turkey from 49,500 t to 68,100 t over the period 2000 to 2006, reaching its peak (113,000 t) in 2004. Per capita consumption ranged from 770 g to 1,668 g but the consumption amount per capita was not a monotonous increase, but rather rendering ups and downs. Based on data gathered from 2000 – 2006, while the average domestic pistachio consumption amounts 70,029 t, the per capita consumption averages about 1,045 g (Table 5).

**GOVERNMENT’S ROLE IN THE MARKET**

Our nation's government policies applied during the period 1980 – 2007 include support purchases and subsidies to producers in terms of inputs, products, credits, etc. The year 2000 was a milestone in the history of government involvement, as agricultural policies applied earlier started to change drastically then due to: (1) exogenous factors related to the European Union, the World Trade Organization, the International Monetary Fund, and the World Bank, and (2) endogenous factors such as the burden of supports on the national budget, current account deficits and some peculiar issues in Turkish agri–
culture. Other pecuniary aids such as direct income payments and premium payments and also alternative product supports have been extensively furnished by the government since the year 2000.

Three sales cooperatives united to form the union of Pistachio agricultural sales cooperatives in 1940 with its headquarters located in Gaziantep. This union started to purchase pistachios directly from farmers during the harvest period. Since it was a State-run cooperative, the purchase price was determined by the government, who set the floor price to protect farmers against price fluctuations. Due to late payments from the union, however, farmers were sometimes forced to sell their pistachios at the prevailing market price, which was usually lower than the floor/support price. In 1968 four other agricultural unions specialized in red peppers, raisins, olive oil, and leguminous products were established and in 1989 they merged into one single union, together with the union of Pistachio agricultural sales cooperatives, forming the latest union of Southeast agricultural sales cooperatives (with the Turkish acronym, GURUYDOGUBIRLIK). Although pistachio production is high and prices are low, in general, the Union buys only a very small proportion of the crop because of financial difficulties. GURUYDOGUBIRLIK announces its price two months after the harvest is completed and stops buying products shortly after finishing the harvesting process. The Union does not receive any financial assistance from the government (Sarigedik, 2004). In 2004 it procured 1529 t of pistachios and paid 3.00 Turkish Liras per kg for pistachios with soft red skins.

Turkey has started to lessen its support to agriculture, due to its accession process to the European Union, and the restrictions fixed by the World Trade Organization. The government, who gave financial support to agricultural unions, is no longer available for funding and therefore recently many agricultural unions have shut their operations and they have run out of business. Those who are still running their business have to find different sources to fund their operations such as Banks, members etc. As such, GURUYDOGUBIRLIK is still in the business with its 9 member cooperatives and more than 15.000 member farmers. Today, it procures pistachios along with other crops, such as red lentils and red peppers (Anonymous, 2009).

The pistachio producers sell their products husked and shelled upon their harvest. As always, producers have the flexibility to sell products to either GURUYDOGUBIRLIK at the support/floor price or to local merchants at the prevailing market price. Table 6 depicts the 24 years-history of pistachio producer price versus production costs during the period from 1980 to 2003. In order to lift the effects of inflation, these price and cost figures are deflated, using a producer price index deflator, taking the year 2003 as the base year. Based on data covering the years 1980 – 2003, while pistachio producer prices per kg amount to 5.82 Turkish Liras on average, average costs per kg amount 4.76 Turkish Liras. Unfortunately, since there are no cost data beyond 2003, the analysis could not cover the most recent years. During the same period, the cost ratio as to producer price per kg ranges from approximately 38% to 163% with an average ratio amounting to 83%. The lower the cost ratio, the more profitable it is to farmers to grow pistachios. However, as shown in Table 6 and Figure 2, a substantial amount of prices received by producers is taken up by costs, leaving very small benefit margins to producers. On the other hand, in some years costs exceeded producer prices and therefore it usually is more profitable for farmers to do business with GURUYDOGUBIRLIK. However, due to quotas, restrictions, and late payments by this


<table>
<thead>
<tr>
<th>Year</th>
<th>Producer Price (2003=100)</th>
<th>Production Cost (2003=100)</th>
<th>Cost/Price (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>3.75</td>
<td>4.89</td>
<td>130.37</td>
</tr>
<tr>
<td>1981</td>
<td>6.75</td>
<td>5.01</td>
<td>74.09</td>
</tr>
<tr>
<td>1982</td>
<td>6.11</td>
<td>5.05</td>
<td>82.74</td>
</tr>
<tr>
<td>1983</td>
<td>7.29</td>
<td>5.79</td>
<td>38.98</td>
</tr>
<tr>
<td>1984</td>
<td>6.06</td>
<td>5.45</td>
<td>89.95</td>
</tr>
<tr>
<td>1985</td>
<td>5.56</td>
<td>4.41</td>
<td>79.25</td>
</tr>
<tr>
<td>1986</td>
<td>6.03</td>
<td>5.16</td>
<td>85.69</td>
</tr>
<tr>
<td>1987</td>
<td>6.76</td>
<td>5.66</td>
<td>83.64</td>
</tr>
<tr>
<td>1988</td>
<td>5.93</td>
<td>5.35</td>
<td>90.17</td>
</tr>
<tr>
<td>1989</td>
<td>6.16</td>
<td>4.77</td>
<td>77.45</td>
</tr>
<tr>
<td>1990</td>
<td>4.95</td>
<td>3.88</td>
<td>78.31</td>
</tr>
<tr>
<td>1991</td>
<td>5.39</td>
<td>2.99</td>
<td>55.53</td>
</tr>
<tr>
<td>1992</td>
<td>5.01</td>
<td>1.91</td>
<td>38.22</td>
</tr>
<tr>
<td>1993</td>
<td>5.53</td>
<td>2.51</td>
<td>45.31</td>
</tr>
<tr>
<td>1994</td>
<td>5.84</td>
<td>3.62</td>
<td>61.96</td>
</tr>
<tr>
<td>1995</td>
<td>6.61</td>
<td>4.44</td>
<td>74.72</td>
</tr>
<tr>
<td>1996</td>
<td>6.00</td>
<td>5.39</td>
<td>89.98</td>
</tr>
<tr>
<td>1997</td>
<td>4.85</td>
<td>7.88</td>
<td>162.56</td>
</tr>
<tr>
<td>1998</td>
<td>5.88</td>
<td>6.94</td>
<td>118.07</td>
</tr>
<tr>
<td>1999</td>
<td>6.43</td>
<td>7.29</td>
<td>113.40</td>
</tr>
<tr>
<td>2000</td>
<td>7.32</td>
<td>6.07</td>
<td>82.93</td>
</tr>
<tr>
<td>2001</td>
<td>5.12</td>
<td>4.56</td>
<td>89.08</td>
</tr>
<tr>
<td>2002</td>
<td>5.23</td>
<td>3.93</td>
<td>75.06</td>
</tr>
<tr>
<td>2003</td>
<td>5.01</td>
<td>3.80</td>
<td>75.95</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>5.82</strong></td>
<td><strong>4.76</strong></td>
<td><strong>83.03</strong></td>
</tr>
</tbody>
</table>

**Fig. 2. Pistachio producer prices versus costs per kg (2003=100).**
Union, many pistachio farmers are obliged to find alternatives.

CONCLUDING REMARKS

As in many other agricultural commodities, the pistachio sector in Turkey has some problems to be solved, starting from production to consumption. Exposing these problems will undoubtedly bring suggestions towards their solution. Demand-supply equilibrium can not be met due to the negative impacts of periodicity (alternate bearing) on pistachio production in Turkey. Yet, the yield factor may keep improving, while the periodicity tendency keeps decreasing, applying some agricultural practices, particularly irrigation. The opinion that pistachios are best fit for arid regions is no longer a valid propaganda.

In order to increase the competition power of the Turkish pistachio sector, production costs have to be reduced and also new cultivars oriented towards international markets must be developed or adopted. On the other hand, issues on farming and marketing have to be resolved. Agricultural practices in irrigated pistachio orchards contribute to maintain both the demand-supply equilibrium and the stability in international markets and therefore, the Southeastern Anatolia Project is an opportunity in this respect. Nevertheless, Turkey consumes its own domestic production, representing a closed economy.

Varietal choice, production and price stability are essentially important factors in pistachio export. The first question to be found out is which varieties are most desired at international level: roasted nut varieties or varieties used in confectionery industry? In other words, what are the criteria of other countries on this matter? It is important to determine correctly the best answer to these questions. Problems often arise when it comes to pistachio storing after harvest. For example in recent years, Iran is repeatedly having export problems arisen from defects in pistachio storage. The Southeastern region of Turkey, where pistachios are grown widely, has an advantage in this respect, since the dry and hot climate prevailing in the region provides for safe storage conditions free of aflatoxin, which is suspected to cause liver cancer in animals and human beings. Iranian pistachios, illegally introduced in Turkey, are perceived as Turkish pistachios, leading to problems when they are consumed either on the domestic or international market (imported from Turkey). Thus, Turkey should prevent illegal and unregistered entrance of Iranian pistachios on the one hand, and create an international image of high quality Turkish pistachios on the other hand. Another important point is the problem of unstable price policies. Different price policies each year have negative impacts on both domestic and international markets. It is possible to solve existing problems pertaining to an agricultural crop like pistachios native to Turkey by applying serious and stable policies, it feels quite frustrating not to be dominant on global pistachio markets. As it was mentioned before, Hazelnut is the first nut for Turkish economy, but pistachio is also very important for the South East Anatolia Region. Therefore, governmental support is provided last decades. Support is especially provided for the irrigation of non-irrigated pistachio orchards.

REFERENCES

Babadoyan, G. (2009), Pistachios. IG­EME-Export Promotion Center of Turkey.
FAO (2009). Website: http://faostat.fao. org/site

NOTES AND NEWS

REPORT OF THE VIIth COORDINATION BOARD MEETING, OF FAO-CIHEAM NUT NETWORK CIHEAM-IAMZ, ZARAGOZA, SPAIN 3-4th NOVEMBER, 2009

Participants: A. Ramos Monreal (Depu­ty DG for International Affairs, INIA, Spain), D. Gabiña (Deputy Director, CIHEAM, Spain), A. López-Francos (Co­operative Research Administrator, CIHEAM, Spain), M. Rovira (Nut Network Coordinator, IRTA, Spain), F.J. Vargas (La­ison Officer of Almond, IRTA, Spain), I. Battie (Liaison Officer of Genetic Re­sources, IRTA, Spain), B. E. Ak (Liaison Officer of Pistachio, Harran University, Turkey) and S. Mutke (Liaison Officer of Stone Pine, INIA, Spain).

G. Beccaro (Torino University, Italy), sub­stitute of G. Bounou (Liaison Officer of Chestnut), can not attend the meeting due to a strike at Torino airport. A.I. Kok­sal (Ankara University, Turkey) and N. Alexandrova (REAU, FAO), excused their attendance to the meeting. These 3 people send their communications for the meeting to the Nut Network Coordination.

The meeting followed the agenda pro­posed:

Monday, 2 November, 2009
Arrival and accommodation of partici­pants (Hotel Goya)
Tuesday, 3 November, 2009
8.30. Pick up of the participants at Hotel Goya
9:00-11:30: Presentations and Discussion
1.- Opening of the Meeting.
- Brief Participants presentation.
- M. Rovira, Nut Network Coordinator
- Welcome of CIHEAM representative
- Welcome of FAO representative
- Welcome of INIA representative
2.- Brief Information about FAO-CIHEAM-INIA Meeting, held in July, 2009
3.- Information Nut Network report.
- M. Rovira, Nut Network Coordinator
11:00-11:30. Coffee break
11:30-13:30. Continuation of Presentations and discussion
4.- Sub network Liaison Officers’ reports of activities:
past and prospects
- Almond: F. J. Vargas (IRTA, Spain)
- Chestnut : G. Beccaro (Università di Torino, Italy)
  (instead of G. Bounous)
- Hazelnut: M. Rovira (Ankara University, Turkey)
  (instead of A.I. Köksal)
- Pistachio: B.E. Ak (Harran University, Sanliurfa, Turkey)
- Stone Pine: S. Mutke (INIA, Spain)
- Genetic Resources: I. Batlle (IRTA, Spain)

13:30-14:30. Lunch
14:30-17:30. Continuation of presentations and discussion

5.- Other issues (M. Rovira)
- NUCIS Newsletter
- FAO ESCORENA web site
- Presence of Nut Network in International Research Projects
  (European Projects, COST, AECI, etc.)
- Others

17:30. Return to the Hotel Goya
20:30. Dinner

Wednesday, 4 November, 2009
8.30. Pick up of the participants at Hotel Goya
9:00-11:00. Presentations and discussion

6.- The future of the Network.
New proposals and activities (open discussion):
- Renewal of the Liaison officer for walnut and pecan
- Pistachio Inventory
- International Meeting on Mediterranean Stone Pine for
  Agroforestry systems
- Courses
- Inventories: actualization and digitalization
- Punctual actions
- Proposal for the VIII Coordination Board

11:00-11:30. Coffee break
11:30-13:00.

7.- Continuation of Discussion and Conclusions
13:00. Closing of the Meeting
13:15-14:15. Lunch and return to the Hotel or departure

NOTE: The approximate timetable could be modified depending on the proposals and suggestions made by the attending people at the meeting. The most important issue is to have time to discuss and share ideas about our Network.

1.- Opening the Meeting
D. Gabiñà, welcomed the participants to the Meeting in the CIHEAM headquarters, A. Ramos expressed his gratitude to be in the Meeting, and M. Rovira, welcomed also all people attending the meeting, especially, B.E. Ak and S. Mutke, the new Liaison officers of Pistachio and Stone Pine, respectively.

M. Rovira informed the participants about the aims of the meeting, and presented the financial situation of the network. Since 2004, Spanish INIA is not giving support to FAO for the Nut Network. Since then the activities have been developed with the remaining from other years and with CIHEAM’s support. We accorded that A. Ramos, would ask the Director of INIA to continue the financial support to the FAO for the Network and M. Rovira, would write to the IRTA’s Director to request to the INI-AS’s Director for the same support. These two actions were made without succeeding.

3.- Nut network report.
M. Rovira presents the Nut Network report from 1990 to 2009. In the different activities exposed, she presents a list of the researchers that received some financial support to attend meetings of the Network. From the report, several issues can be pointed out:

It is necessary to look for a new Liaison Officer for Walnut. Since E. Germain from INRA, France, retired, the responsible of walnut has been changed several times. J. Chat replaced E. Germain, but only for some months due to her change in the job. Currently, the Director of INRA Bordeaux, M. Legrait, proposed M. Lafargue for this position, but she never attended any meeting, neither she answer any message. Therefore, it was accorded to look for another person. We agreed that M. Rovira would prepare a letter to A. Ramos, and he would send it to the Director of INRA Bordeaux, asking him for some other person to be appointed as responsible of this crop. If France does not have anybody suitable to cover the post, a new representative will be selected from other country.

Referring to Economics, M. Rovira informs that L. Albisu, Liaison Officer of Economics is not working any more on nuts, after considering that he has done a very good job on the Network, and thanks him for his effort. The participants consider that it will be important to look for another person to occupy this post. All participants suggested to provide names for a substitute. Currently this subnetwork is integrated within the General Coordination.

4.- Subnetwork Liaison Officers’ reports of activities: past and prospects
Liaison officers present the activities of their Networks. In addition, M. Rovira presents those of A.I. Koksal and G. Beccaro (not present at the Meeting), I. Batlle, expresses his will to stop working for the Network, since he is working also in some other tree crops. He considers that as Liaison Officer of Genetic Resources, he has made a contribution in relation the Inventories of Germplasm of different crops, and in this sense the work can be considered quite finished (only the Pistachio Inventory is still pending). Also he expresses his will to resign as Editor of NUCIS. He informs to the participants, that M. Rovira will be the new NUCIS editor. M. Rovira, and all members of the Network, thank I. Batlle for all the effort he has made for the Network over the last 15 years.

5.- Other issues
NUCIS Newsletter. All participants agree that this Newsletter is very important for the Network, as it gathers all people working in nuts, and it is important not to stop its edition. M. Rovira proposes that all crop Liaison Officers would be involved in the newsletter, asking for some articles to
be published, and also, in collecting information, notes, scientific works, etc. concerning their crop. Liaison Officers agree to look for this information, and to help in the edition of NUCIS. It was suggested that Liaison Officers may take the opportunity of international conferences and symposiums to ask for contributions. It is planned to publish the next issue, during 2011. It would be interesting to maintain colour illustrations for the on-line version.

FAO-ESCORENA Web site. M. Rovira informs about ESCORENA activities, and about the last Meeting that has been held in Poznan (Poland) in April, 2008. The current situation is that there is no budget for Network activities, but one of the aims of ESCORENA, is to create a web page with all the information concerning the Network activities. Looking at this web page, we confirm that ESCORENA uses the web page of CIHEAM, concerning the activities of the Nut Network. We decided to improve this page in the following aspects: obtain a direct link to the Germplasm Inventories edited by FAO, and to the Descriptors edited by IPGRI and Bioversity International, this work will be carried out by CIHEAM. M. Rovira will send, also, to CIHEAM the Data Base concerning the articles published in NUCIS, to be accessible for all people interested.


Pistachio Inventory. B.E. Ak and N. Kas ks, started the inventory some years ago. B. E. Ak, is committed to finish the inventory during next year (2010). He will ask information to Iranian people and UC Davis repository. It will also be necessary to up date the inventory, M. Rovira and B.E. Ak, will request to people involved in the inventory to update the data.

Inventories: actualization and digitalization. The Germplasm inventories have been edited some years ago and it is time to update them. All the data are now in an old informative system. M. Rovira and I. Battle will collect all the informatics data that exist now, and will send them to CIHEAM to try to adapt this information to a current informatic system. These files will be used to add new information on the Germplasm inventories.

Courses. Members of the Network agree that the two courses about Nut Production and economics, have been very useful for all people who attended them, and it would be interesting to organize another one. We discuss about the content of this new course, species (all nuts or only some), issues of interest, etc. Finally, we agree to make the course on almond, pistachio and stone pine and focus it on production and economics, making special attention in harvest, postharvest, nut quality and health. CIHEAM, will study the proposal of organising and hosting the course. A tentative date could be 2012-2013.

International Meeting on Mediterranean Stone Pine for Agroforestry systems. Sven Mutke, expresses his will to organize an International Meeting on Stone Pine. His aim is to organize not a big International Congress, but more a work shop (40-50 people), to discuss about the situation of Stone Pine. A probable date could be in September-October 2011, in Valladolid (Spain). Sven Mutke will have all the support he will need from the Network (Coordinator and CIHEAM).

VX GREMPA Meeting of Pistachio and Almonds. Last GREMPA Meeting was held in Athens, so it would be preferable to organise next one in a country from North Africa. L’Institut de l’Olivier in Tunisia was proposed, to be the host, but its Director seems not to be convinced and supportive. CIHEAM will write to him saying the advisability to organize the Meeting, and offering all their support.

Punctual actions. M. Rovira received the requested from O. Kodad (Morocco) about the possibility to have financial support from the Network to establish an Almond Collection in ENA (École Nationale d’Agriculture), in Meekness. This request has been rejected by the Network members, as it was agreed that the cost of this action is not high and the ENA should be able support it.

Proposal for the VIIIth Coordination Board. All participants agree in the convenience to meet together each two years, in order to follow better and have the opportunity to talk about the different activities carried on in the Network. At this sense the next Coordination Board, will be held in 2012.

CD of the Meeting. By the end of the VII Coordination Board Meeting, a CD of the presentations given by the participants was prepared and delivered by the CIHEAM to the participants.

M. Rovira
FAO-CIHEAM, Nut Network Coordinator
IRTA-Mas de Bover, 18th November, 2009

PRESENTATION OF THE NEW STONE PINE’S LIAISON OFFICER

S. Mutke lives since 1991 in Spain, though he was born in Germany where he had taken pre-graduate lectures (Vordiplom) in Biology at the University of Bonn. When coursing Forestry Degree (1996) and Master in Forestry (2000), he collaborated in R+D projects about Mediterranean pines, especially on Mediterranean stone pine as nut tree. His PhD Thesis at the Technical University of Madrid was about Crown architecture and cone yield modelling in grafted stone pine orchards, and he has published more than 30 scientific or technical papers or books, mostly about this pine. Since 2006, he holds a position at the Spanish National Institute for Agricultural and Food Research and Technology (INIA). In 2009, he assumed the charge of Liaison Officer for stone pine in the FAO/CIHEAM Inter-Regional Research Network on Nuts.
IN MEMORIAL: ERIC GERMAIN

Last December we heard the sad news of the death of Eric Germain. It is difficult to write about him without pain and sorrow, but good memories of Eric encourages me to talk about him.

E. Germain in the VIIth International Congress on Hazelnut, in Tarragona (Spain, 2004).

As all researchers working on nuts know, E. Germain has been a leader in hazelnut and walnut tree crops. He was the former responsible of hazelnut and walnut breeding programmes in France and has made great contributions and valuable researches on these species. Two of his outstanding books are "Le Noisetier" and "Le Noyer", both edited with Ctifl's collaboration. Also, the "Inventory of walnut research, germplasm and references", edited by FAO, is a reference for all people working in this species. He also was the convener of the 4th International Walnut Symposium at Bordeaux (France) and he was the former chair of the ISHS Walnut Working Group in 1999. His work as Liaison Officer of the walnut Network of the FAO-CIHEAM Inter-regional cooperative Research Network is well known. His contributions to NUCIS (number 1 and 4) on walnut and hazelnut, respectively, are a sign of his interest on sharing his knowledge with all the people involved in nuts. Besides his activity in research and development, he was also closely linked to the producing sector, keeping a tight relationship with Ctifl technicians in France. He showed rigour, tenacity and professionalism at work. He was always keen to cooperate, to explain his experiences and learn from other researchers worldwide. We cannot forget his human side, always trying to meet the needs and questions of those who were at his side.

As many other people, I was one of his students. I had the opportunity to work in his lab d’Arboriculture Fruitière INRA (Bordeaux), for two years. He provided us with enthusiasm, knowledge on hazelnut and walnut tree crops which were, and still are part of the base of our work and research. Most people know E. Germain’s full dedication to research, but he also was very dedicated to his family. I remember that sometimes he left work earlier than usual, apologising: "today I have to go to the supermarket". His wife Rosen and his three children Jean, Isabelle and Pierre, have been “my second family”, for two years. I was warmly received as one more member of their family. Back in Spain, when I returned to my work at IRTA-Mas de Bover, I did my doctoral thesis on genetics in hazelnut. For my thesis work, E. Germain sent me some offspring families from crosses of his Hazelnut Breeding Program. Without these materials, this thesis would not have been possible.

The good relationship with E. Germain and his family, has always been maintained. We have met each other in different hazelnut and walnut Meetings and visits we conducted at INRA (always including a dinner at home) or at Mas de Bover. He was always interested in how our researches were going on both nut species.

Together with my colleagues N. Aletà and F. Vargas, I attended his retirement party. A party that he prepared accurately (at home) or at Mas de Bover. He was warmly received as one more member of their family. Back in Spain, when I returned to my work at IRTA-Mas de Bover, I did my doctoral thesis on genetics in hazelnut. For my thesis work, E. Germain sent me some offspring families from crosses of his Hazelnut Breeding Program. Without these materials, this thesis would not have been possible.

The good relationship with E. Germain and his family, has always been maintained. We have met each other in different hazelnut and walnut Meetings and visits we conducted at INRA (always including a dinner at home) or at Mas de Bover. He was always interested in how our researches were going on both nut species.

Together with my colleagues N. Aletà and F. Vargas, I attended his retirement party. A party that he prepared accurately in Toulonne, Gironde (France). The farm where he had spent many hours doing crosses, controlling trials and seeing walnut trees grow.

M. Rovira
FAO-CIHEAM Nut Network Coordinator

Note: If anyone wishes to write a contribution on their relationship with E. Germain, it will be a pleasure for us to publish it in the next NUCIS issue.

NEW JOURNALS

We welcome two new journals which are being published since 2010: Corylus & Co. (Rivista del Centro Studi e Ricerche sul Nocciolo e Castagno) (Italian language) and IJNR (International Journal of Nuts and Related Sciences) (English language). The first comes from the Viterbo University and Ce.FAS, the special agency of the Chamber of Commerce and Agriculture in Viterbo (Italy), and the second, from the Islamic Azad University-Damghan Branch Deputy of Research and Development.

CONGRESSES AND MEETINGS

XIV GREMPA MEETING ON PISTACHIOS AND ALMONDS

The XIV GREMPA meeting on Pistachios and Almonds took place in Athens, Greece, at the Acropol Palace Hotel in the city center. The meeting was organized by the agricultural University of Athens and the Kalamatas Technological Education Institute, in Collaboration with the interregional FAO-CIHEAM Cooperative Research Network on Nuts, and lasted 5 days (31 March-4 April). The conveners were E. Tjamos and G. Zakyntinos.

More than seventy participants from 13 countries, such as Algeria (1), Australia (4), Belgium (1), France (3), Greece (26), Iran (8), Italy (6), Morocco (2), Portugal (2), Spain (7), Tunisia (2), Turkey (2) and USA (7) attended the XIV GREMPA Meeting.
More than 100 contributions were received, but for different reasons some delegates did not attend the meeting. However, their presentations were delivered by other colleagues as posters.

Out of the 138 abstracts sent and included in an abstract book distributed to the participants, 68 communications were presented as oral presentation and 24 as posters. The oral and the poster presentations were distributed into different sessions which included: “Cultivars and Rootstock Breeding”, “Orchard management”, “Physiology, Biology and Biotechnology (including pollination, fruit setting)”, “Pest Diseases”, “Industry, Harvesting, Marketing and Quality” and “Control and Safety”.

The first working day was dedicated to topics which covered two sessions: the session on “Cultivars and rootstock breeding” and the session on “Flower pollination and fruit setting”. On the second day, participants made a field trip to Aegina island, a site of scientific and archaeological interest, where the Pistachio Cooperative was visited and a discussion with pistachio growers and technicians was held about different problems related to pistachio production and processing. A small orchard was also visited. Moreover, participants tasted salted and unsalted ‘Aegina’ pistachios offered by the Cooperative. Afterwards, participants made a small trip around the island and visited the archaeological site in Aphaia temple. The Temple of Aphaia (or Aphaea) is located within a sanctuary complex dedicated to the goddess Aphaia on the Greek island of Aegina, in the Saronic Gulf. It stands on a circa 160 m high peak on the eastern side of the island, approximately 13 km East by road from the main port. Then the group visited a traditional “Greek tavern” restaurant and tasted its delicious dishes. The third working day (the 2nd of April) included oral presentations on “Orchard Management” and a brief coffee break around Acropolis and Plaka area, after the break a Poster session was organized. On Thursday, 3th of April, participants had a tight visit schedule. They visited the most compatible pistachio area of Greece in Fthiotide prefecture. In Makri, 250 km from Athens in north and central Greece, participants were shown the modern side of pistachio cultivation in Greece. They discussed with growers and saw pistachio harvesting and processing machinery adapted to small-scale orchards and pistachio productions. Then participants tasted a very nice lunch in the Gorgopotamos area with traditional pies and roasted lamb. The almond production center of central Greece was the next stop. After lunch, a 150 km long trip was undertaken to visit an almond production area. Participants were able to see almond orchards and processing machines. In accordance with the scientific programme, on Friday the 3rd of April, 24 communications were presented in two sessions: the first was on “Physiology, Biology and Biotechnology” and the second session was on “Pest and Diseases”, being the last session of the 2008 Athens GREMPA Meeting.

We would like to thank the FAO, CIHEAM, TEL Kalamatas, and the Agricultural University of Athens for their encouragement and support during the organization of the 2008 Athens GREMPA Meeting. We would also like to thank the local authorities of Aegina Island, and Fthiotide (Makri) prefecture. Finally we would like to express our gratitude to the Scientific Organizing Committee of the meeting and to all participants for their contributions to the GREMPA family, which is becoming larger year after year, gathering more scientific knowledge and new ideas. We hope this meeting has contributed with new challenges for further research and stronger links between more members of the GREMPA family generating new joint initiatives among participants and members of the nut network.

G. Zalynthinos and E. Tjamos
1 Technological Educational Institute of Kalamata, Department of Agricultural Products, Antikalamos, 24100 Kalamata (Greece)
2 Agricultural University of Athens, Department of Plant Pathology, Votanikos 11855 Athens (Greece)

SUMMARY OF THE VIIth INTERNATIONAL HAZELNUT CONGRESS

The last edition of the International Congress on Hazelnut, organized by the Hazelnut Research Centre together with the International Society for Horticultural Science (ISHS), University of Tuscia and the Local Chamber of Commerce was held in Italy in June 2008. The 5-days congress, supported by many public institutions, as well as by private local companies, took place in Viterbo, a town of 60.000 inhabitants, 80 kilometres north of Rome.

Viterbo is located nearby the Monti Cimini, the core of one of the principal hazelnut production areas of the world (figure 1). In this area, there are over 9,000 farms that produce hazelnuts covering approximately 18,000 ha and giving an average yearly production of 40,000 tons mainly of the cultivar ‘Tonda Gentile Romana’ (about 5% of the world’s production). The highly productive specialization has contributed to the creation of a very dynamic sector, where several hazelnut farmer associations, as well as firms specialized in assembling specific harvesting machines or in processing and marketing are present.

The conference was attended by over 150 people coming from 20 different countries and representing all 5 continents (figure 2). The opening session has been dedicated to two general communications held by the invited speakers.

In the first communication S. A. Mehlenbacher, Chair of the ISHS Working Group on Hazelnut (Department of Horticulture, Oregon State University, USA), gave an overview of the state-of-the-art and future perspective of genetic resources for hazelnut reporting the objectives and results obtained in the hazelnut breeding program at Oregon State University. This institute has recently released six cultivars, eight pollinizers, and two ornamentals. The invited speaker highlighted the status of hazelnut micropropagation that in USA allows routine, and focused the attention on the recent collection of cultivars preserved in several genebanks, as in the collections in Corvallis house where there are more than 900 accessions of Corylus, of which 500 are C. avellana. Genetic studies have identified several simply inherited traits in hazelnut. Most economically important traits are quantitative with moderate to high heritability. Climatic adaptation is rarely a concern in the major production areas, but expansion of hazelnut plantings into marginal areas will require the development of adapted cultivars from diverse germplasm and identification of suitable pollinizers. More than 150 microsatellite markers have been developed and placed on the linkage map where they serve as anchor loci, and many also amplify Betula.

Furthermore, S. A. Mehlenbacher stressed out how “eastern filbert blight” caused by Anisogramma anomala is a major concern in North America. Several sources with high levels of resistance have been identified and are being used in breeding, with selection facilitated by DNA markers. A bacterial artificial chromosome (BAC) library will allow map-based cloning of important genes, including “eastern filbert blight” resistance from ‘Gasaway’, an old pollinizer, and the S-locus that controls pollen-stigma incompatibility.
In the second communication the world hazelnut situation and the research programs agenda was sketched by C. Fideghelli (Horticulture Research Centre of Rome, Italy).

The official statistics of FAO actually classify 32 countries as hazelnut producers whereas, about ten years ago, only 15 countries were listed as hazelnut producers. In the meantime, the total production has increased from 617,000 to about 960,000 tons highlighting how Asia has increased it more than Europe (+ 64,7% and + 40,6% respectively).

In spite of the increasing number of producing countries, the hazelnut crop is still concentrated in two Mediterranean countries: Turkey and Italy, covering together about 85% of the world production. Other important hazelnut producers are the USA (4,3%), Spain (2,8%), Iran (1,9%), and China (1,5%).

The invited speaker also reported that the main varieties adopted in these countries are still traditional and in some of these a selection of non-suckering rootstocks is requested.

Furthermore, it is needed to reduce initial low cropping of new orchards, promoting the tendency to increase the plant density that has been proved to be positive and gradually replacing the multisystem bush training system (figure 3), which is the most common system in hazelnut cultivations. Finally, the invited speaker highlighted that the mineral fertilization has been the object of a wide research activity.

A total number of 133 scientific papers, divided in 58 oral presentations and 75 posters, was presented covering the themes of the six different scientific sessions: 1) Germplasm and Genetic Improvement, 2) Biology and Physiology, 3) Orchard Management, 4) Pests and Diseases, 5) Post Harvest, Quality and Industry, 6) Marketing, Economics and Policies.

All communications stressed how the productive, technical and market context of the hazelnut sector is rapidly changing. The main and most innovative issues discussed in each session are summarized in the following sections.

Germplasm and Genetic Improvement

One of the most interesting communications of this session emphasized on a Community programme on the conservation, characterisation and utilization of genetic resources in agriculture (SAFE-NUT project - Safeguard of almond and hazelnut genetic resources from traditional uses to modern agriindustrial opportunities). This represents an example of a resourceful strategy for re-organizing and sharing in a more efficient manner the genetic resources, upgrading the knowledge on their value and uses. One of the main objectives of the project was the centralization of available hazelnut germplasm, harmonizing the standard descriptors for a common characterization of cultivars. This included the creation of a core collection and gene banks. The project involved 11 partners from 6 European Countries (Italy, Spain, Portugal, France, Greece and Slovenia) including the ONGs Lega Ambiente and Farmer's Association.

Another innovative contribution reported about the research activities carried out by the Catalan Research Institute (IRTA-Reus). The topic focused on solving some problems related to local hazelnut cultivation, since, in this area, trees of the main adopted cultivar ‘Negret’ tend to develop low vigor, iron chlorosis and high sucker emissions. Thus, a rootstock selection started in the early 1990s in Catalonia and the promising ‘Negret-N-9’ clone was grafted onto four clonal rootstocks (‘Dundee’, ‘Newberg’, ‘Tonda Bianca’ and ‘IRTA-MB-69’ selection) and compared to an own-rooted ‘Negret-N-9’ clone. The most interesting results have been presented.

A paper about the activities conducted in the USDA Agricultural Research Service of Corvallis (Oregon, USA), where a gene-

bank representing world hazelnut diversity (Corylus spp.) is present, was discussed.

Other out-standing communications of this session focused on hazelnut candidate genes for pathogen perception and on new sources of resistance to “eastern filbert blight” and its linked markers.

Almost twenty posters were related to this session, highlighting many aspects on genetic improvement as the current progress in hazelnut breeding programs spread in the world, the evaluation of genetic diversity among Corylus spp and relationships among Italian and Spanish cultivars, using ISSR and RAPD markers. Some of these contributions reported on agronomic observation of new interspecific hybrids recently obtained in China, studies of biological methods to reinforce selection efficiency in hazelnut and a hazelnut BAC library for map-based cloning of disease resistance genes.

Biology and Physiology

In this session traditional vegetative propagation and rooting of hazelnut were reported as rather problematical and, some reports, focused on the importance to obtain commercial production of certified plant materials using in vitro techniques. A three-step protocol for efficient micro-propagation using TDZ medium for improving axillary bud formation has been discussed.

Furthermore, in this session some researchers highlighted that the European hazelnut is a monocious tree that exhibits sporophytic self-incompatibility. This is related to a genetic system that prevents the self-fertilization allowing the pistil to throw back the pollen of genetically close individuals. Self-incompatibility is controlled by a single multi-allelic locus (S locus) and, although studies on gene regulation of fertility, pollination and fertilization in hazelnut are few, new contributions to the knowledge about the mechanism of sporophytic self-incompatibility in hazelnut were proposed.
Ten posters were presented in the session reporting recent innovations about physiological aspects of propagation, improving micropropagation techniques, cutting and grafting in the *C. avellana* and *C. columna* germplasm and focusing on the need to obtain certified material of propagation and non-sucker rootstocks.

Results about evaluation of cold resistance hybrids of *C. avellana* x *C. heterophylla* were also reported.

**Orchard Management**

In session 3 the discussion emphasised that hazelnut is sensitive to water stress. Because of low water availability and irregular yearly rain distribution, drought conditions are becoming common in many hazelnut areas, as in Latium, which is the second area of hazelnut production in Italy. Drip irrigation based on water balance is then an appropriate technique to improve production and growth, optimising water use. In this area a water supply of 75% of evapotranspiration has resulted a valid irrigation level for hazelnut cultivars ‘Tonda Gentile Romana’, ‘Tonda di Giffoni’ and ‘Nocchiene’.

Communications about pruning of mature hazelnut trees of Italian cultivars, the effect of foliar boron application on fruit set in 'Tombul' hazelnut, foliar fertilizers in Oregon (USA) and the evolution of the hazelnut harvesting technique have been discussed.

About twenty posters were presented in the orchard management session, discussing many aspects of cultural techniques applied in the different world hazelnut production areas, as soil management, irrigation requirement and systems, summer pruning, alternative sucker control, mechanical pruning and biomass recycling and evaluation of safety and health aspects of workers exposed for a long time to dust, noise and vibration.

**Pests and Diseases**

The most relevant topics discussed in this session regarded the constitutive and induced resistance in hazelnut cultivars as the chemical inducers acibenzolar-S-methyl (BTH), β-aminobutyric acid (BABA) and potassium monophosphate (KH₂PO₄) for their capacity to control hazelnut cankers caused by *Cytospora corylicola*, *Botryosphaeria obtusa* and *Biscogniauxia mediterranea*. These chemical inducers were used for the induction in hazelnut tissues of pathogenesis related (PR) proteins β−1.3 glucanase, chitinase and peroxidase, as biochemical indicators of resistance.

The latest on the control of “Gray necrosis” of hazelnut fruit, a fungal disease caused by *Fusarium lateritium*, were reported.

Finally, new information management technologies, such as geographic information techniques (GIS) and geostatistics, which have been recently applied in the study of spatially related data in plant pathology have been presented underlying this innovative approach in the hazelnut cultivation.

Sixteen posters were presented in this session mainly focusing on new approaches in control of common hazelnut pests and diseases, applying both conventional and organic approaches, and also highlighting new problems that recently occur in some hazelnut cultivation areas.

**Post Harvest, Quality and Industry**

Researchers discussed about some chemical markers to evaluate quality and safety of roasted hazelnut in order to define the consequent aroma development and eventual toxic compounds that could be produced de novo during roasting, as e.g. carcinogenic acrylamide.

Other important aspects treated in this session were related to non-destructive approaches to measure quality of hazelnuts during storage as NIR and MRI instruments and focused on phenolic characterization of some hazelnut cultivars from different European germplasm collections.

Twenty posters were presented in this session highlighting the chemical composition and nutritional properties (phenols characterization, vitamin E, minor sugars components) and sensory seeds evaluation, as well as the recent in-vitro applications to produce bioactive molecules and phenols extract from *C. avellana* tissues using bioreactor cultures.

**Marketing, Economics and Policies**

Several papers debated the economic and commercial interest for hazelnut cultivation. The main aspects reported in this session were: effects of organic cultivation methods on productivity and profitability; effects of Turkey’s accession to the EU on hazelnut markets; trade effect of European aflatoxin standards on Turkish hazelnut exports.

As reported by many authors, organic hazelnut cultivation shows remarkable differences within the area as compared to the conventional system, both from a structural and territorial diffusion point of view.

A presentation is focused on how Turkish agricultural policy should be harmonized with the EU Common Agricultural Policy before the accession. The results have shown that liberalization of the hazelnut market and harmonization of the hazelnut policies causes a decrease in hazelnut prices. In spite of the decreasing domestic supply, hazelnut demand would be increased by these low prices both in Turkey and the EU. In welfare terms, while hazelnut producers would lose, consumers and taxpayers would gain both in Turkey and the EU. However, Turkey should conform to further issues such as residual food security rules, environmental measures and higher product quality. More specifically, the EU aflatoxin standard, which is obeyed compulsorily by importer countries, affects mostly Turkish export due to its market share of hazelnut.

Finally, six posters were presented in this session. The synthesized results showed that today Italy and Turkey are developing a modern hazelnut production system, by applying organic farming methods. Another fact raised to the attention of the congressists by Americans and Europeans was the consumer’s demand for specific quality standards.

Apart from the scientific sessions, two technical tours were organized. The first tour included a visit to Stelliferi & Itavex s.p.a. company, which is an enterprise that is specialised in processing, packaging and marketing of Italian and foreign nuts. Then, a germplasm collection field and some orchards were visited.

The third day of the Congress was dedicated to mechanization aspects, thus a visit to FACMA s.r.l., an international company that creates machinery for all kind of agricultural activities, and a mechanical harvest demonstration at the APRONVIT hazelnut growers association were organized.

Within this context, the 7th International Congress on Hazelnut gave the opportunity to strengthen relations among researchers and experts of the different countries. The scientific communications, the technical tours, the round table, focused on innovation and market topics, and even the informal and convivial moments, gave an opportunity to discuss about the state-of-the-art and the possible development of the hazelnut sector. The next International Congress on Hazelnut will be held in Temuco (Chile) in March 2012.

V. Cristofori* and B. Pancino**

*Members of the Editorial Board of the Seventh International Congress on Hazelnut Proceedings
**Department of Agriculture, Forests, Nature and Energy (DAFNE). University of Tuscia, Via San Camillo de Lellis sn, 01100 Viterbo, Italy. e-mail: valerio75@unitus.it

*Department of Economics & Management (DEIM). University of Tuscia, Via del Paradiso 1, 01100 Viterbo, Italy. e-mail: bpancino@unitus.it
THE 4th INTERNATIONAL CHESTNUT SYMPOSIUM

The IVth International Chestnut Symposium was held in Miyun, Beijing from 25-28 September, 2008. It was organized by Beijing University of Agriculture, Miyun People’s Government of Beijing and Miyun Municipal Rural Affair Committee under the auspices of the International Society for Horticultural Science.

At the opening ceremony Q. Ling, Symposium Convener, expressed a cordial welcome to all participants. She was followed by G. Bounous, Chair of the ISHS Working Group on Chestnuts, and D. Avanzato, Chair of the ISHS Section Nuts and Mediterranean Climate Fruits. Q. Ling was awarded the ISHS Medal in recognition of her service to the Society as Convener of this International Symposium.

The participation was impressive. Present were 200 participants from 15 countries including China, USA, Italy, Turkey, Romania, Portugal, New Zealand, Korea, Japan, Hungary, Slovakia, Czech Republic, etc.

About 40 oral presentations and posters on a wide range of topics relating to chestnut were presented. The symposium mainly consisted of the following five sessions:

1. Chestnut Growing, Economy, Marketing, Harvest and Fruit Processing
2. Biology, Physiology and Ecology
3. Genetics, Breeding, Biotechnology and Plant Development
4. Plant Protection
5. Orchard and Forest Management

In the first thematic area, Chestnut Growing, Economy, Marketing, Harvest and Fruit Processing, the emphasis was laid on the chestnut tree as a major resource. D. Avanzato gave an overview on the International Society for Horticulture Science and on the chestnut industry in the EU and former communist European countries. Mr. Wang Tie-ming, director of Beijing Miyun Forest Breuer, introduced the development situation of chestnut in theory and in practice in Miyun District in Beijing.

The thematic area Biology, Physiology and Ecology was opened by an interesting keynote lecture presented by Z. Cheng-le on the “Study of variation of mineral elements content in chestnut stands”. Also, cryopreservation, propagation and micro-propagation of chestnut were reported in this session.

The session Genetics, Breeding, Biotechnology and Plant Development started with the topic “Chromosomal location of ribosomal genes in Chinese and American chestnut”, presented by N. Islam-Faridi. F. Dane from Auburn University presented the comparative phyllogeography of Castanea species.

For the session Plant Protection there were 12 presentations on the diseases and protection of chestnuts and one poster with the dispersion of Cryphonec-
tria parasitica in chestnuts of different progenies. Some of them reported on the chestnut diseases using aerial photography and geostatistical methods. Other presentations focussed on the main chestnut diseases.

In the last session, Orchard and Forest Management, the work and information on the management of coppice forests, orchard cultivation of coppice forests, irrigation, soil management practices and the effect of cultivation on the nutrient budget and nut quality were discussed.

The field visit of the symposium was organized to the Miyun Mountain Region and chestnut orchards. All of the participants saw the chestnut cultivation and growing situation in the Miyun district.

The chestnut production has been effectively increased and its excellent quality has been maintained by using modern management methods, modern technology for tree control in intensive (compact) planting orchards and an efficient control of vermin and diseases, soil improvement and the corresponding technology as to orchard/tree height control.

Concerning the technology applied to intensive (compact) planting orchards, the idea of organic planting was adopted in order to improve the quality of the chestnut and its environment. For the pesticide management, the “IPM” idea was adopted to reduce and control pests and diseases. For instance, black light lamps and animals were used to trap and combat pests. In order to control tree height, reasonable pruning was performed to improve light and space, and the nutrition was balanced to ensure tree health.

At the closing ceremony, the conclusions of the IVth International Chestnut Symposium, composed by the Scientific Committee and with the agreement of the Organizing Committee, were presented by the Chairperson. These were as follows:

1. Over the years, researchers working with the chestnut tree have shown their dedication and love to this multipurpose tree and have achieved important and innovative scientific results.

2. Our love and trust in the chestnut tree should be shown. Trust that chestnut can contribute significantly to the development of rural economy, trust that roasted chestnuts will smell in the big city squares and corners of major streets all over the world.

3. The cooperation in chestnut research should be strengthened, especially in prevention and control of ink disease, collection and exchange of chestnut germplasm resources, and shortened breeding cycles of chestnut cultivar.

4. Chestnuts are in shortage in the world market, but they have much untapped potential development. It is our duty to convince our governments to implement policies and to support the growers to increase their production in a combined effort to promote the chestnut tree, its precious nuts and its valuable timber.

At the end of the symposium, the Chairperson on behalf of the Organizing Committee thanked all the participants for coming to the symposium from all over the world to present the results of their work and share their experience. The symposium ended with a loud and long applause by the participants to the Chinese organizers in appreciation of the immense task of hosting the IVth International Chestnut Symposium in such an excellent way. W. MacDonald of West Virginia University will host the 5th International Chestnut Congress in October 2012. His e-mail address is: macd@wvu.edu.

Q. Ling
College of Plant Science and Technology, Beijing University of Agriculture
Address: No.7 in Beinong Road, Huilongguan, Changpin District, Beijing, The People’s Republic of China - Post code: 102206
E-mail: qinling@bac.edu.cn qinlingbac@126.com

6TH INTERNATIONAL WALNUT SYMPOSIUM HELD IN MELBOURNE, AUSTRALIA

The 6th International Walnut Symposium held in Melbourne in February 2009, was a great success and a significant milestone for the Australian Walnut Industry Association. It began with a Pre Symposium Tour where walnut researchers from all parts of the globe gathered together with walnut industry members from Australia and New Zealand to learn about walnut production in Australia.

The tour began in Griffith which is located in the Murray Irrigation Area in central New South Wales and the first stop was Walnuts Australia. This walnut project is Australia’s largest with trees covering 865 hectares. The area is flat and the red soil is well-drained for medium clay. Delegates enjoyed the coach tour and learned about the history of this young orchard. Planting began in 2004, the orchard layout is 8 x 4 m and soil preparation work included deep ripping of the tree lines with GPS steered machines and mounding of the top soil. The first commercial harvest was due to commence a few weeks after our visit. Other orchards visited on the pre-symposium tour were located south of the Murray River in Victoria and delegates were also treated to some real Aussie bush experiences.

The Conference in Melbourne began with an official welcome and to the delight of the overseas guests; the few short speeches were followed by an interactive show of Australian wildlife where delegates were greeted by a laughing koala, colourful parrot, cuddly koala, and a range of reptiles including a python, crocodile and frill-necked lizard. Two nights later the Symposium dinner also offered an Aussie flavour with didgeridoo welcome and songs and dancing to a bush band.

To launch the Symposium, Convenors, L. Titmus and B. Goble, introduced Victoria’s Minister of Agriculture, Hon. J. Helper MP, who officially opened the Symposium. They then welcomed International Society for Horticultural Science Executive Committee member, D. Avanzato.

The first Keynote Address, “A global perspective of walnut production”, was presented by D. McNeil, Scientific Committee Chairman and Director of Tasmanian Insti-
Some of the most interesting and visually captivating presentations described the diversity of the walnut genus, including species native to forests in China and the rocky foothills in Iran. This genetic diversity is, of course, of particular interest because many genetic characteristics are utilised in breeding programs. Delegates were also most interested to hear presentations highlighting the differing nut and tree characteristics valued in breeding programs and evaluation of different cultivars and rootstocks, particularly as many of the cultivars such as those from Romania, Iran, Hungary and China, were unknown to most delegates.

Propagation technology was another topic of great fascination for delegates who learnt of developments in tissue culture and in root cuttings for rootstock propagation. Of particular interest to Australian delegates whose crops had recently been affected by sunburn during a spell of extreme summer weather, was the presentation outlining the mitigating effect of kaolin spray on walnut quality in California. Other sections of the Symposium included presentations on Orchard Management, Pest Management, Walnut Physiology and Post Harvest. The final presentation on the benefits of walnut consumption made a positive conclusion. The numerous Poster presentations covered a diverse range of topics and created much informal discussion between sessions.

Before closing the Symposium, ISHS Executive Committee member, D. Avanzato, congratulated G. McGranahan on being re-elected Chair of the ISHS Working Group on Walnuts. Congratulations were also extended to J. Tian, representing China, on China’s successful bid to host the 7th International Walnut Symposium in 2013.

The Symposium was a success on many levels but perhaps the most valuable outcome was the exchange of scientific knowledge between different countries. Congratulations go to the IWS 2009 Convenors and all the organising Committee on a very successful Symposium.

J. Wilkinson
Editor of Australian Nutgrower and member of the Australian Walnut Industry Association.
PO Box 1, DARGO Victoria Australia 3862
Email: nutgrower@eastvic.net

FIFTH INTERNATIONAL SYMPOSIUM ON PISTACHIO AND ALMOND

The 5th International Symposium on Pistachio and Almond under the auspices of the International Society for horticultural Science (ISHS) was very successfully held in Sanliurfa, Turkey from 06 to 10 October 2009. Participants from Turkey and all continents of the world took part. The Symposium was organized by the University of Harran, the Faculty of Agriculture - Department of Horticulture. It was supported by University Directories, the Governor of Sanliurfa and other Government Companies such as the the Mayor of Sanliurfa and GAP Research and Development Administration, GAP Soil Water Resources and Agricultural Research Institute, Gaziantep Pistachio Research Institute, Sanliurfa Regional Directorate of Agrarian Reform, Gaziantep Trade and Industry Chamber, Sanliurfa Trade and Industry Chamber, Agriculture Chamber, Regional Directorate State Hydraulic Works (D.S.I.), Sanliurfa Trade Exchange, and other supporters for this meeting from private sectors.

The opening ceremony started with a welcome lecture by B. E. Ak, convener of the symposium and head of the Department of Horticulture, in which he extended his thanks and gratitude to the distinguished participants, particularly those from other countries. He also very cordially thanked the members of the Scientific and organization Committees and his colleagues of the Faculty of Agriculture and the Gaziantep Pistachio Research Institute. He continued his speech thanking the Directorate of ISHS, and Rector of our University, Harran for his encouragement and support to organize this meeting and the Dean of Agriculture Faculty. Special thanks were addressed to the Chair D. Avanzato of the Nuts and Mediterranean Climate Fruit Section and the CIHEAM-IAMZ Zaragoza, FAO-CIHEAM Nut Network and Gaziantep Pistachio Research Institute for their support, apart from other kind of sponsorships and support.

B. E. Ak gave an overview on the Southeast Anatolia Region. The South East Anatolia Region, where Sanliurfa is located is one of major regions where pistachio is grown intensively. Before the Atatürk Dam was established, agriculture used to continue under drought conditions without irrigation. However, today pistachio and other agricultural crops are grown applying irrigation facilities. Water supply will contribute to obtain higher yields and improved crop quality. Although pistachio has been grown in this region for many years under drought conditions with low air humidity, today almond orchards show an increasing development in this region because of different advantages. Dr. Ak stated that such meetings are very useful for the exchange of scientific knowledge in relevant fields and genetic material among the different contributing countries and an efficient collaboration network can be initiated and also better relationships should be developed among the related countries to improve opportunities to grow pistachio and almond.

The second presentation was delivered by M. A. Cullu, Dean of the Agriculture Faculty. He was most warmly welcomed by the prominent participants and the esteemed scientists participating in this symposium. M. A. Cullu reported on the faculty facilities. The third presentation was made by D. Avanzato, representative of ISHS. At first he warmly welcomed all the distin-
guished guests and expressed his deep appreciation and thanks to all organizers of this symposium. He stated that this symposium would be a good opportunity for exchanging the latest research highlights, meeting other participating researchers and collaborators in order to get more acquainted with new advances and new technologies. He made a short introduction and gave additional information about ISHS activities and invited all participants to join the ISHS to strengthen this international society.

The fifth presentation was made by I. H. Mutlu, who is the rector of the University. He gave some information about the University and Sanliurfa and he offered the University facilities for future collaboration with all countries on scientific and educational topics.

The program was as follows:

Tuesday October 06 - After the welcoming ceremony, two scientific sessions (morning and afternoon) were conducted.

Wednesday October 07: A scientific session was scheduled in the morning while the afternoon was dedicated to a technical visit in the historical place of the Harran ruins.

Thursday, October 08: A technical visit was programmed to the experimental almond and pistachio orchards and to a private production and processing farm at Ceylanpinar State Farm.

Friday October 09: Two scientific sessions were conducted before the closing ceremony.

Saturday October 10: A technical trip was organized to the Gaziantep region, which is the most popular zone for pistachio growing. Visit to the Pistachio Research Institute.

Scientific Programme Different countries were represented: Algeria, Australia, Bulgaria, Croatia, Greece, Iraq, Iran, Israel, Italy, USA, Morocco, Portugal, Serbia, Spain, Tunisia, and Turkey. This programme received 246 presentations: 113 oral and 133 poster presentations, which gathered 132 contributions on pistachio and 114 on almond. The papers were divided into nine sessions, including:

1. Pollination and fruit set
2. Physiology and nutrition
3. Propagation and rootstocks
4. Cultivars and breeding
5. Biotechnology
6. Orchard management
7. Plant protection
8. Harvesting and processing
9. Economics and marketing

Among the topics developed by the different speakers, germplasm characterisation and assessment, development of new varieties, pollinators and new rootstocks through hybridisation aim to improve the expansion of these crops, their productivity and their environmental adaptation. The effect of conservation and processing techniques on quality products has also been emphasised. Moreover, more interest was performed on the post-harvest stage effect to ensure healthy and good quality products, especially on aflatoxin contamination. At local and international level, pistachios and almonds market surveys in different countries are conducted to increase market share through the improvement of product quantity and quality, the development of new post-harvest treatment systems, processing and packaging and the adoption of effective marketing strategies.

Technical Programme

Technical tours scheduled gave information about the fruit tree orchards in the University of Harran. Similarly, the visit to the experimental orchards of pistachio and almond in the Ceylanpinar area gave an overview of the research programs underway and some results obtained. In the experimental orchard visits, different studies were conducted on the effect of rootstocks on growth and productivity of pistachio, the scion/rootstock compatibility, the assessment of main Turkish varieties in comparison with foreign varieties and the effect of irrigation on production. All the steps of pistachio (cv. ‘Siirt’) mechanical dehulling were observed in a private post-harvest processing manufacture. The last day of the Symposium, an excursion was made to Gaziantep, the main pistachio growing area. The visit of several pistachio orchards showed the orchard

![Participants of the Symposium.](image-url)
management adopted, the advanced age of some plantations, the scions/rootstocks incompatibility specific in a few rootstocks and some sanitary problems such as aphids and septoria on Pistacia vera leaves. Finally, the trip ended with a visit of the Pistachio Research Institute of Gaziantep. The current research activities in the laboratories of physiology, soil analysis and plant protection were presented. During the tour in the experimental orchards of this institution, the participants visited the nurseries producing grafted pistachio and almond seedlings, the assessment plots of male and female varieties and progenies issued from hybridization. An overview was presented on several varieties and pollinators features obtained by hybridization.

Visit to pistachio orchards during the Symposium.

At the beginning of the symposium a special ceremony was held to award an ISHS medal to B. E. Ak by D. Avanzato, ISHS representative. Also N. Kaska received ISHS’s medal for his dedication to pistachio and almond growing.

At the end of the Friday afternoon session, the closing ceremony was held. First B. E. Ak thanked the participants and explained the tour to be done on Saturday to Gaziantep. Then he invited D. Avanzato to speak as to determine the next meeting. Three proposals were received for hosting the 6th Symposium: from Italy, Spain and Morocco. The researches from the corresponding countries gave a review on their countries and facilities to organize the next meeting. After voting, Spain was elected as the host for the next symposium.

CASTANEA 2009, FIRST EUROPEAN CONGRESS ON CHESTNUT

Under the auspices of the FAO/CIHEAM Nut network, the International Society for Horticultural Science (ISHS) and the Italian Society of Horticultural Science (SOI), Castanea 2009 was organized, the 1st European Congress on Chestnut, held in Cuneo (Italy) in October 2009, together with the 5th Italian Congress of Chestnut.

The cooperation among FAO/CIHEAM Nut network, ISHS and SOI allowed to involve a large number of experts coming from many countries.

More than 300 scientists, researchers, industry managers, stakeholders, farmers, policy makers, students and technicians involved with science and business of chestnut, attended Castanea 2009. Countries represented, other than Italy, included: Albania, Australia, Brazil, Bulgaria, People’s Rep. of China, Croatia, Czech Republic, France, Greece, Hungary, Japan, Lebanon, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, South Korea, Switzerland, The Netherlands, Turkey, United Kingdom, and the United States of America for a total of 25 European and extra European Countries, representing 4 Continents.

The congress coincided with the XIth National Chestnut Fair, the largest Italian commercial fair and exhibition on chestnut. The activity of the FAO/CIHEAM Nut network was presented by the Coordinator M. Rovira, who emphasized the role of the network to promote the activities related to nut production.

The opening ceremony started with the cordial welcome speech of A. Valmaggia, Mayor of the town of Cuneo, followed by the address of E. Barberis, Dean of the Faculty of Agriculture, University of Turin. D. Avanzato, Chair of the ISHS Section Nuts and Mediterranean Climate Fruits, gave an update on ISHS activities and membership and P. Inglese, President of the Italian Society for Horticultural Science, emphasized the role of R&D for the progress of horticulture. Authorities representing the agricultural sector of Piemonte Region, Cuneo Province, Local Bank Foundations, Local Chamber of Agriculture and Commerce, welcomed the audience.

In his opening remarks G. Bounous, FAO/CIHEAM Liaison Leader of the Subnetwork on Chestnut and Chairperson of the ISHS Working Group on Chestnuts, stated that the chestnut has not only a glorious past but also a promising future. The nuts, which are in shortage in the world market, are sold as a large array of commodities; timber and coppice are used in many

B. E. Ak
University of Harran. Faculty of Agriculture
Department of Horticulture
63200 Sanliurfa, Turkey
E-mail: beak@harran.edu.tr; beak_63@hotmail.com; baakbekir62@gmail.com

Visit to pistachio orchards during the Symposium.

Chestnut harvesting.
ways and the species is a good contributor for carbon sequestration in the atmosphere and, in addition, the renewable energy and biomass produced by the chestnuts can reduce our dependence from fossil fuels. Furthermore, in mountainous and marginal areas the chestnut ecosystem plays a fundamental role in soil protection and in the perspective of social welfare.

A total of 210 papers (1 plenary, 8 invited, 85 oral and 116 posters) were presented during the European and Italian congresses. The 7 sessions concerned: history, landscape and ecology; biology and genetic resources; chestnut culture; pests and diseases; economics and marketing; harvest, post-harvest, quality and processing; biomass and energy.

The session on history, landscape and ecology was opened by the plenary lecture entitled “The European civilization of the chestnut woods” given by J. P. Pitte (France) who said that in the Mediterranean ecosystems “in the Middle Ages and Renaissance and on acid soils, the chestnut tree produced more calories per acre than cereals”. The session, moderated by V. Galán (Spain) and M. Conedera (Switzerland) was rich in contributions: among others the talks regarded the natural and landscape values of the chestnut ecosystems (M. Devecchi-Italy), a review of the perspectives of the chestnut between the second and third millennium (M. Adua-Italy) and chestnut wood in cultural heritage (Aresti et al.-Italy).

In the late morning, D. Avanzato presented the ISHS volume of the series *Scripta Horticulturae*: “Following Chestnut Footprints” (editors D. Avanzato and G. Bouhours). The text, written by authors with a high knowledge and experience on chestnut research, deals with culture, folklore, history, gastronomy, cultivation and management of the species in 27 countries and on 4 continents.

In the afternoon S. L. Pereira (Spain) was the chairman of the second session focused on biology and genetic resources and opened with the lecture titled: “An integrated approach to assess the genetic and adaptive variation of Castanea sativa Mill.” Other papers were focused on breeding, genetic diversity, and molecular characterization of chestnut genotypes.

The third session on chestnut culture was moderated by T. Caruso and opened by A. Martins (Portugal) with an invited lecture on different orchard management techniques and their effects on productivity and sustainability. The session was also related to the actions to restore chestnut plantations, considerations about the effects of cultural practices in chestnut stands, grafting and micrografting techniques.

The fourth session, chaired by S. Diamandis (Greece) and A. Vannini (Italy), focused on pests and diseases issues, was very rich in presentations (16 talks) and covered a lot of topics, in particular the biology and control of the gall wasp (*Dryocosmus kuriphilus*), a new insect recently introduced in Europe. The keynote speaker was A. Alma (Italy) with the lecture: “The Italian experience in fighting *Dryocosmus kuriphilus*. Reproducing, spreading and setting of *Torymus sinensis*” provided a complete overview on the subject. Other papers concerned canker blight and ink disease control. The fifth session was focused on economics and marketing issues and two keynote speakers highlighted the situation of the culture in Italy (C. Prirazzoli) and in China (Q. Ling), by far the leading producer of chestnuts in the world. The session was moderated by A. Soylu (Turkey) and L. Radocz (Hungary).

Harvest, post-harvest, quality and processing issues were discussed in the sixth session (chairperson P. Piccarolo-Italy) and the keynote speaker, D. Fulbright (USA), presented the lecture: “Efficacy of postharvest treatments for reduction of molds and decay in fresh Michigan chestnuts”. The last session (chairman S. Baldini-Italy) was dedicated to biomass and energy production: a very interesting approach in perspective of global climatic changes and fossil fuels shortage. The invited speech of Lauteri et al. (Italy) studied the chestnut as a model tree species to develop long term strategies for the conservation of its genetic resources in face of global climatic change; G. Lancha emphasized the potentiality of carbon sequestration of chestnut systems of the Iberian Peninsula.

In the evening of the first congress day, at the Faculty of Agriculture was inaugurated Expo-Castanea, an exhibit organized by G. Beccaro in cooperation with E. Bellini. The Expo presented “the chestnut world” and all what it includes: semi processed and processed traditional and innovative produce for an increasing market demand (dried chestnuts and chestnut flour, honey, flakes, marrons glacés and in syrup, creams, beer or liquors, etc.). Samples of the best chestnut cultivars were also presented. At the Expo twelve private companies working in production, nut and timber processing, furniture, tannin, pellets, and machinery for chestnut processing, presented their activities and interacted with the participants. The Expo was also opened to the visitors of the Chestnut Fair and to the students of the local primary and high schools: a good way to disseminate information and knowledge around the chestnut world.

The technical visits provided a range of different experiences. The participants chose from the two possibilities offered: a visit to the technical structures
of storage, packaging and chestnut processing industries or a field tour. During the “industry tour” participants visited Agrimontana Ltd., a leader company for the production of marrons glacés, and Ballario Ltd., involved in fresh chestnut sorting, storage and packaging. In the field tour the participants assisted to a demonstration of mechanical harvesting (Monchiero and Chianchia companies) and pruning through the technique of tree climbing. Old plantations and modern chestnut orchards were also visited. In the old plantations of Susa valley the participants were welcomed by the notes of the songs of a mountain choir in a typical ethnic costume. During both visits the owners of the farms or food industries offered the participants typical cakes and roasted chestnuts.

Participants and accompanying persons were entertained at the welcome dinner offered by the Mountain Community and during several lunches, where they had the opportunity to taste the local wine & food specialties and enjoy the concert of the Cuneo symphonic orchestra.

Furthermore, Castanea 2009 was organized paying attention to the environmental cost of such kind of events. In order to make the congress more “environmentally friendly”, the organizing committee decided to apply the international procedure (protocol EMAS-ISO 14001) for the quantification of the CO₂ emitted. To balance the amount of the CO₂ produced by Castanea 2009 the Organizing Committee decided to devolve part of the registration fees to the Otonga Foundation in Ecuador, in order to compensate for the produced CO₂ emissions.

At the business meeting the participants voted that the 2nd European Chestnut Congress will be held from 9 to 12 October 2013 in an itinerant way: Hungary (Debrecen), Romania and Slovak Republic.

The congress was a great opportunity for the participants to share a lot of information, experiences and knowledge. Feedback from the participants indicated that they enjoyed the technically informative, warm and friendly feeling of the event.

The photo gallery of the event is available on the official web site of the congress (http://www.arboree.unito.it/castanea 2009).

---

G. Bounous
Chairman ISHS Working Group on Chestnuts
Liaison Leader, Subnetwork on Chestnut, FAO/CIHEAM Nut network
Head, Dipartimento di Colture Arboree
Università degli Studi di Torino
Grugliasco (TO), Italy
Email: giancarlo.bounous@unito.it

---

Publication released in the frame of the SAFENUT project.

**FINAL MEETING OF THE SAFENUT AGRI GEN RES ACTION 068**

Minutes of the hazelnut meeting
(Viterbo, 20 September 2010)

The final meeting of the SAFENUT Action (“Safeguard of Hazelnut and Almond genetic resources: from traditional uses to novel agro industrial opportunities”) was held on 20-22 September 2010 in Viterbo and Avezzano, focusing respectively on hazelnut and almond issues. The choice to split the meetings in two parts was purposely taken in order to give the due prominence and visibility to each species in traditional areas of cultivations.

The first part of the meeting, held at the Agriculture Faculty of the University of Tuscia (Viterbo), was organized by ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development), coordinator of SAFENUT; the Academy of Georgofili and the Faculty of Agriculture at the University of Tuscia, under the aegis of the Italian Society of Horticulture (SIO). The program, hereby attached, included a series of presentations describing the hazelnut state of the art at local, national and European level.

The first part of the meeting was chaired by F. Loreti, President of the “Accademia dei Georgofili”, who introduced the following speakers:

- G. Dono (University of Viterbo) presented an economic overview of hazelnuts in the area of Viterbo.
- E. Contardo (Producers’ Association), focusing on the hazelnut industry.
- E. Rugini (University of Viterbo, focusing on hazelnut industry.
- E. Rugini (University of Viterbo) pinpointed the hazelnut production issues.
- L. Varvaro (University of Viterbo), talking about the plant protection aspects.
- R. Biasi (University of Viterbo) described the evolution of the hazelnut landscape.
- L. Bacchetta (ENEA) introduced the SAFENUT Action, main objectives and general results.
- O. Diana (AGRI GEN RES) presented the EC policy on agricultural genetic resources and future opportunities.
In the afternoon the meeting was chaired by E. Porceddu who introduced the presentations of the SAFENUT partners which focused on the final results of the project as well as on the importance of the hazelnut crop in the different European Countries:

- R. Botta (University of Turin - Italy) showed the molecular hazelnut’s results.
- D. Avanzato (Italian Agricultural Research Council (CRA), Italy) presented the latest achievement on the recovery of traditional knowledge and its importance also for future generations as proved by the results of the SAFENUT questionnaires.
- M. Rovira (Institut de Recerca i Tecnologia Agroalimentàries (IRTA), Spain) focused on the centralization and recovery of the hazelnut germplasm.
- J. P. Sarraquigne (Association Nationale des Producteurs de Noisette (ANPN), Lamouthe - France) provided information on the hazelnut production in France, emphasising the role of the SAFENUT networking.
- A. Solar (Univerza v Ljubljani, Biotehniška Fakulteta, Slovenia) discussed the results on phenolic compounds on European hazelnut cultivars.
- P. Drogoudi and I. Metzidakis (National Agricultural Research Foundation - Institute of Olive Trees and Subtropical Plants (NAGREF - ISPOT), Greece) produced the data on mineral content of the European germplasm.
- A. P. Silva (Universidade de Trás-os-Montes e Alto Douro (UTAD), Portugal) focused on the morphological characterization of hazelnut cultivars in Portugal.

At the end of the presentation the discussion drew attention to the significance of the preservation of genetic resources in agriculture, the importance of the core collection as a tool for a more efficient use of the germplasm, mainly for a crop like hazelnut, a perennial species, with high maintenance costs. In this frame a special attention was also given to the young generations, directly involved in the SAFE-NUT action. The importance of the information provided on the EC future financial opportunities on agro-biodiversity was also stressed. As a conclusion, the synergic, multi-disciplinary approach proved to be the most efficient and fruitful strategy to enhance such a species, and its high global index, at local, national and European level.

L. Bacchetta, B. Di Giovanni
ENEA, LITAGRI
Agenzia Nazionale per le Nuove Tecnologie, l’Energia e lo Sviluppo
Economico Sostenibile Cassaccia, Via Anguillanese 301
000125 Rome, Italy

INTERNATIONAL MEETING ON MEDITERRANEAN STONE PINE FOR AGROFORESTRY-AGROPINE 2011

Last 17th-19th November, the International Meeting on Mediterranean Stone Pine for Agroforestry - AGROPINE 2011 was held in Valladolid, Spain, organised by the Stone pine subnetwork of the FAO-CIHEAM Research Network on Nuts. The meeting brought together about forty experts, researchers, public and private forest managers and land owners, as well as representatives of pine nut processing enterprises from Spain, Portugal, Tunisia, Turkey and Lebanon, with some contribution from France and Chile, in order to review the current state of the art in Mediterranean pine nut production in forests and orchards, and to discuss the challenges of the future.

The pine nut, the edible kernel of the Mediterranean stone pine, Pinus pinea, is one of the world’s most expensive nuts. Although well-known and planted since Antiquity, pine nuts are still gathered mainly from natural forests in the Mediterranean countries, and the crop has only recently taken the first steps from wild harvested to domestication as an attractive alternative
on rain-fed farmland in Mediterranean climates. The Iberian Peninsula accounts for about 75% of stone pine area in the world, Portugal being the main pine nut producer, followed by Spain, Turkey, Lebanon and Italy.

During the last century, the Mediterranean stone pine has experienced a range expansion, especially in the Southern and Eastern Mediterranean Basin, as well as a large increase in planted area in its native countries, both by forest restoration and farmland afforestation. The species performs well on poor soils and needs reduced cultural practices. It is affected by few pests or diseases and it resists climate adversities such as drought and extreme or late frosts. It is light-demanding and hence has potential as crop in agroforestry systems in Mediterranean climate zones around the world, in tree lines such as shelterbelts adjacent to farmland or pastures or in proper low density orchard plantations.

The AGROPINE Meeting 2011 presented the current knowledge and on-going researches about ecological and silvicultural aspects of stone pine forests in the Mediterranean basin and the management applied for cone production as one of the multiple forest functions, fully compatible with soil and watershed protection, wildlife conservation, and landscape values. The main technological innovation in the last years has been the generalized use of tree shakers adapted to stone pines for the mechanical cone harvesting, which makes the manual cone yield by tree climbers, a very dangerous job, obsolete.

Another innovation to increment the world production of Mediterranean pine nuts are plantations of grafted stone pines, as specific orchards or as agroforestry systems that combine with grazing or farming. Plantations on farmland could yield in the future more pine nuts than the natural forests, contributing to rural development and employment for local communities. This “next step” in the way to domesticate this tree allows the specific use of selected genotypes for higher cone yields, obtained from decades of evaluation in grafted multi-site trials.

The greatest interest during the meeting aroused in the round table about two major problems of the pine nut sector. The first challenge will be a more effective control of the cone pests, especially two native cone-boring larvae, the pine cone weevil *Pissodes validirostris* and the pine cone moth *Dioctria mendacella*, as well as the Western Conifer Seed Bug *Leptoglossus occidentalis*, recently introduced from Northern America to Europe. The damages caused by these insects reduce considerably the cone yield in amount and quality, and an effective biological and integrated control of the pests would improve considerably the economic benefit from stone pine.

Thus pine nuts from different species are, and must be recognised as being, distinct products and should be differenced in the market, as an issue of consumers’ rights and even of food safety. This is especially true for Chinese pine nuts, whose com-
Commercial lots have been found sometimes mixed and mingled with seeds from other pine species, some of them even non-edible because of irritating terpenoids and other compounds. The ingestion of Chinese pine nuts (especially from *P. armandii*) is in the origin of the Pine Mouth Syndrome, an unpleasant bitter, metallic taste disturbance that can appear 1-3 days after consumption and last for days or even for weeks, sometimes combined with food aversion and other symptoms. Beside these consumer’s health aspects, the lack of traceability and correct product labelling, identifying the botanical species and the country of origin, is a clear incompliance with current legal requirements for food labelling and traceability in Europe (*Regulation EC 178/2002*), based on principles such as transparency, risk analysis and prevention, the protection of consumer interests and the free circulation of safe and high-quality products within the internal market and with third countries. The stone pine supply chain must fulfill these regulations.

The follow-up of the 2011 meeting will be in form of the Stone pine subnetwork within the FAO-CIHEAM cooperative research network on nuts, an inter-regional network participated by CIHEAM and the Regional FAO Offices FAO-REUR (Europe) and FAO-RNE (North Africa and the Middle East). This Network forms part of the European System of Cooperative Research Networks in Agriculture ESCORENA. The next plenary meeting about stone pine is foreseen in 2015 in Portugal.

The abstract proceedings and all communications presented at the AGROPINE 2011 meeting are uploaded at the meeting web page [www.iamz.ciheam.org/agropine2011](http://www.iamz.ciheam.org/agropine2011).

Acknowledgements
The 2011 meeting was supported by the Spanish National Institute for Agriculture and Food Research and Technology INIA (ACCION COMPLEMENTARIA AC2011-00031-00-00), the Mediterranean Agronomic Institute of Zaragoza IAMZ-CIHEAM, the FAO-CIHEAM nut Network, the Forestry and Forest Industry Services and Promotion Centre of Castilla y León CESEFOR, the Junta de Castilla y León, the Sustainable Forest Management Research Institute U. Valladolid-INIA, the Catalanian Institute for Research and Technology in Food and Agriculture (IRTA), the Technology Centre of Catalonia (CTFC), Piñonsol (Soc. Coop.), FAO, AECID and FEDER.

TO BE HELD:

Almond and Pistachio

Sixth ISHS Symposium on Almonds and Pistachios-GREMPA Meeting
Date: May 27-31, 2013
Place: Murcia (Spain)
Convener: Federico Dicenta, CEBAS-CSIC
E-mail: almond.pistachio.2013@cebas.csic.es96309
Tel: 968 396 309

Hazelnut

Eight ISHS Congress on Hazelnut
Date: March 19-22, 2012
Place: Temuco (Chile)
Convener: Pablo Grau, Miguel Elena
E-mail: pgrau@inia.cl; fellena@inia.cl
Tel.: +56-45-215706
http://hazelnuts2011.cl

Chestnut

Fifth ISHS Chestnut Symposium
Date: September 4-8, 2012
Place: Shepherdstown, WV (United States of America)
Convener: William MacDonald
Address: 1090 Ag. Science Building, West Virginia University, Morgantown, WV 26506-6108, United States of America.
E-mail: macd@wvu.edu
Tel.: (1)304 293 8818, Fax: (1)304 293 2960
http://chestnutsymposium.wvu.edu/

Walnut

Seventh ISHS Walnut Symposium
Date: July 20-23, 2013
Place: Taiyuan, Shanxi Province (China)
Convener: Prof. Jianbao Tian
Address: Pomology Institute of Shanxi, Academy of Agricultural Sciences, Shanxi, Taiyu 030815 China
E-mail: tianjb-001@163.com
Tel.: (86) 0354-6215006

Stone Pine

Meeting of Stone Pine
Date: 2015
Place: Portugal


HAZELNUT


Bruck, D. J.; Walton, V.M., 2007. Susceptibility of the Filbertworm (Cydia- latiferreana, Lepidoptera: Tortricidae) and Filbert Weevil (Curculio occiden- tallis, Coleoptera: Curculionidae) to Entomopathogenic Nematodes. J In- vert Path, 96: 93-96.


Cristofori, V.; Rouphael, Y.; Mendoza-de Gyves, E.; Bignami, C., 2007. A simple model for estimating leaf
area of hazelnut from linear measurements. Scientia Horticul- turae, 113 (2): 221-225.


Sathuvalli, V.R.; Mehlenbacher, S.A., 2011. Characterization of American hazelnut (Corylus americana) acces- sions and Corylus americana x Cory-


NUTS

Arcan, İ.; Yemencioğlu, A., 2009. Antioxidant activity and phenolic content of fresh and dry nuts with or without the seed coat. Journal of Food Composition and Analysis, 22 (3): 184-188.


PISTACHIO


STONE PINE


WALNUT


Mešš, M.; Miklavc, J.; Matko, B.; Lešnik, M.; Vajs, S.; Solar, A., 2011. Spremljanje sezonske dinamike ore-hove muhe (Rhagoletis completa Cresson) v SV Sloveniji = Seasonal dynamics of walnut husk fly (Rhagoletis completa Cresson) monitored with yellow sticky plates in NE part of


BOOKS


BOOK CHAPTERS


THeses


Çelik, M., 2009. Trabzon iline Akçaaabat yöresinde yetiştirilen bazı badem (Corylus avellana L.) çeşitlerindeki vitamin E düzeylerinin HPLC ile belirlenmesi [Determining vitamin E levels with HPLC method in some kind of hazelnut species which are grown in the Akçaaabat region of Trabzon] (in Turkish).


Font Forcada, C., 2008. Estudio de la variabilidad y de la heredabilidad de la composición de la almendra como criterio de mejora para la calidad (in Spanish). Instituto Agronómico Mediterráneo de Zaragoza (Spain).

Geyik, R., 2010. Antepçifti zarafetleri arası karışan bazi pestisitlerin laboratuvar koşullarında Antocoris minki dohurn. (Hemiptera:Anthocoridae)’ye etkilerinin belirlenmesi [The determination of effects of some pesticides, used against pistachio pests on Anthocoris minki dohurn. (Hemiptera:Anthocoridae) under laboratory conditions] (in Turkish).


UNIVERSITY FINAL REPORTS


Güngör, M., 2007. Kahramanmarasi yöresinde yayılış gösteren cicev (Juglans regia L.) bitkisinin yapraklarından bazı naftakinonların (Juglon ve 1,2 naftakinon) kromatograf izoselayonları ve teknik boyar maddesi [Chromatographic isolations of some naphtaquinone groups (Juglon and 1,2 naftaquinone) which spread show walnut (Juglans regia L.) in Kahramanmaraş region and investigation of using textile dye material] (in Turkish). Kahramanmaraş Sütçü İmam Üniversitesi-Fen Bilimleri Enstitüsü-Kıyma Anabilim Dalı.


<table>
<thead>
<tr>
<th>Network</th>
<th>Coordination Centre</th>
<th>Network Coordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nut tree crops</td>
<td>IRTA - Mas de Bover, Mediterranean Fruit Trees</td>
<td>M. Rovira</td>
</tr>
<tr>
<td>Genetic Resources</td>
<td>Ctra. Reus – El Morell, km 3.8, E-43120 Constantí (Spain)</td>
<td></td>
</tr>
<tr>
<td>Economics</td>
<td>Tel: 34- 977 32 84 24 Fax: 34- 977 34 40 55 E-mail: <a href="mailto:merce.rovira@irta.cat">merce.rovira@irta.cat</a></td>
<td></td>
</tr>
<tr>
<td>Subnetworks</td>
<td>Liaison Centre</td>
<td>Liaison Officer</td>
</tr>
<tr>
<td>Almond</td>
<td>IRTA - Mas de Bover, Mediterranean Fruit Trees</td>
<td>J. Vargas</td>
</tr>
<tr>
<td></td>
<td>Ctra. Reus – El Morell, km 3.8, E-43120 Constantí (Spain)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tel: 34- 977 32 84 24 Fax: 34- 977 34 40 55 E-mail: <a href="mailto:francisco.vargas@irta.es">francisco.vargas@irta.es</a></td>
<td></td>
</tr>
<tr>
<td>Hazelnut</td>
<td>Ankara University, Faculty of Agriculture. Department of Horticulture. 06110 - Ankara (Turkey)</td>
<td>A. I. Köksal</td>
</tr>
<tr>
<td></td>
<td>Tel: 90- 312 3179 550 Fax: 90- 312 3179 119 E-mail: <a href="mailto:ikoksal@agri.ankara.edu.tr">ikoksal@agri.ankara.edu.tr</a></td>
<td></td>
</tr>
<tr>
<td>Walnut and Pecan</td>
<td>Institut National de la Recherche Agronomique INRA Unité de Recherches sur les Espèces Fruitières et la Vigne. B.P. 81 -33883 Villeneuve d’Ornon (France)</td>
<td>M. Lafargue</td>
</tr>
<tr>
<td></td>
<td>Tel: 33- 556 843 277 Fax: 33- 556 843 274 E-mail: <a href="mailto:mlafargue@bordeaux.inra.fr">mlafargue@bordeaux.inra.fr</a></td>
<td></td>
</tr>
<tr>
<td>Pistachio</td>
<td>University of Harran, Faculty of Agriculture. Department of Horticulture. 63200 – Sanliurfa, Turkey</td>
<td>B.E. Ak</td>
</tr>
<tr>
<td></td>
<td>Tel: 90- 414 24 76 97 Fax: 90- 414 24 74 80 E-mail: <a href="mailto:beak@harran.edu.tr">beak@harran.edu.tr</a>; <a href="mailto:baakbekir62@gmail.com">baakbekir62@gmail.com</a></td>
<td></td>
</tr>
<tr>
<td>Chestnut</td>
<td>Università degli Studi di Torino. Dipartimento di Culture Arborée. Cattedra di Arboricoltura Via Leonardo Da Vinci, 44. 10095 Grugliasco (TO) - Italy. Tel: 39- 011 6708653. Fax: 39- 011 6708658. E-mail:<a href="mailto:bounous@agraria.unito.it">bounous@agraria.unito.it</a></td>
<td>G. Bounous</td>
</tr>
<tr>
<td>Stone Pine</td>
<td>Centro de investigación forestal CIFOR-INIA Ctra. la coruña km 7.5 - 28040 Madrid (Spain)</td>
<td>S. Mutke</td>
</tr>
<tr>
<td></td>
<td>Tel +34 91 347 6862 Fax +34 91 347 6767 E-mail: <a href="mailto:mutke@inia.es">mutke@inia.es</a></td>
<td></td>
</tr>
<tr>
<td>FAO</td>
<td>Regional Office for Europe REU: Benczur utca, 34. H-1088 Budapest (Hungary). Tel: 36 1 461 2033 Fax: 36 1 351 7029. E-mail: <a href="mailto:fernanda.guerrieri@fao.org">fernanda.guerrieri@fao.org</a></td>
<td>F. Guerrieri</td>
</tr>
<tr>
<td>CIHEAM</td>
<td>Instituto Agronómico Mediterráneo de Zaragoza IAMZ. Apartado 202, 50080 Zaragoza, (Spain)</td>
<td>D. Gabiña A. López-Francos</td>
</tr>
<tr>
<td></td>
<td>Tel: 34- 976 71 60 00 Fax: 34- 976 71 60 01 E-mail: <a href="mailto:gabina@iamz.ciheam.org">gabina@iamz.ciheam.org</a> E-mail: ló<a href="mailto:pez-francos@iam.ciheam.org">pez-francos@iam.ciheam.org</a></td>
<td></td>
</tr>
</tbody>
</table>