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IRTA Mas de Bover • Coordination Centre of the Research Network on Nuts

IRTA RESEARCH & TECHNOLOGY FOOD & AGRICULTURE

FAO CIHEAM Nut Network

Hazelnut young orchard in Girona (North-East Spain).

EDITORIAL

Welcome dear readers,

It is a delight to be back, although in a different format. This time the issue is not printed on paper. From now on, the NUCIS Newsletter will be edited on-line. We have been forced to make this decision due to the economic crisis that has affected us for some years. But we are thrilled because we have seen that this newsletter, with all your efforts, is still very much alive. The last NUCIS (issue 15) was published in December 2011, and now, two and a half years later we are presenting this new edition on-line. We are now able to provide colour images, another advantage of the digital format.

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 held over the last two years. This issue contains articles on hazelnut (2), almond (4), walnut (2) and pistachio (2). Contributions come from Chile (1), Italy (1), Spain (2), Morocco (3), Hungary (1), Tunisia (1) and Israel (1). We always strive to present the scientific development in all nut crops worldwide and whenever possible we are committed to include a wide representation of countries.

Activities 2012-1013

During this period the FAO-CIHEAM Inter-regional Cooperative Research Network on Nuts has participated in several activities. Two International Meetings were organized in 2012: in March, the 8th International Congress on Hazelnut was held in Temuco, Chile; and in September, the 5th ISHS Chestnut International Symposium was held in Shepherdstown, USA. In 2013 three new Congresses were organized. In May 2013, Murcia, Spain, hosted the ISHS VI International Symposium on Almonds and Pistachios. In July, 2013 the ISHS 7th International Walnut Symposium was held in Shanxi, Taigu, China. And, finally, in October, the II European Chestnut Congress took place in Debrecen, Hungary. The proceedings of these Five Meetings are being prepared. The proceedings of the "Agropine 2011" Meeting were published in 2013 (see the section en New books).

During the celebration of the ISHS "VI International Symposium on Almonds and Pistachios", in Murcia (Spain), 2013, the XV GREMPA Meeting was programmed for two hours. The last Meeting was held in April 2008 in Athens (Greece). Since then, it has been difficult to arrange another GREMPA meeting, mainly due to lack of financial support, but also because we seek to improve these meetings as participants want more participation and confer more importance to the discussion of issues than presenting results. In order to carry out the meetings under this premise, we asked people attending the meeting to draw up a brief, schematic list of the lines of research work carried out in research centers/universities in different countries of the Mediterranean Basin. This information will be very useful to address the future and particularly to organize the forthcoming GREMPA Meeting to be held in Morocco next year. For more information, please, read the "To Be Held" section, at the end of this Bulletin.

During these two years Prof. Koksal, from Ankara University (Turkey), has retired. He was Hazelnut Liaison Officer in the FAO-CIHEAM Inter-Regional Cooperative Research Network on Nuts since 1994 until his retirement. We would like to thank him for his important work on the hazelnut in the Network over the years and wish him well in this new phase of his life. Prof. Veli Erdogan, also from Ankara University, will replace Prof. Koksal as the new Hazelnut Liaison Officer. Readers are invited to read more about this change in the "Notes and News" section.

New books

We are glad to present some new books on nuts (walnut, stone pine and chestnut). More details of these books can be found in the "New Books" section.

FAO European Regional Office and CIHEAM (IAMZ)

Ms. N. Alexandrova is our Regional Representative of the FAO Regional Office for Europe and Central Asia (REU) based in Budapest, Hungary. Mr. D. Gabiña and Mr. A. López-Francos, from the IAMZ of Zaragoza, Spain are our CIHEAM representatives.

The Nut Network on the web

Basic information is included in the REU website for ESCORENA (www.fao.org/world/regional/REU/content/escorena/index_en.htm). Additional information about the Nut Network can be found at www.iamz.ciheam.org/en/pages/paginass/pag_investigación2a.htm

NUCIS on the web

A full electronic version of each NUCIS (Issues 1 to 16) is now available on the CIHEAM website (www.iamz.ciheam.org/en/pages/paginas/pag_investigación2a.htm). The contents of this Newsletter can be browsed, saved and printed. Readers will find the whole set of NUCIS issues, some of which were already out of print.

Contributions to NUCIS

The NUCIS Newsletter is published only on the internet. The dissemination of information originated by the Network is of paramount importance and has been largely successful through this bulletin.

As in past NUCIS issues, we ask researchers on nuts for 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 conducted in the network or to publish short articles and reports on relevant horticultural subjects of general interest. Information provided should be well structured and clearly written in standard English.

Contributions can be sent via e-mail to the Scientific Editor. This bulletin is reproduced in black and white with color pictures. Please send your contributions for the next issue, number 17, by the end of December 2015. We will attempt to edit a new number every two years.

Finally, we would like to express our gratitude to all who have contributed to this issue, those who have published a short article, and those who have written reports of symposia held recently. Thank you very much to you all for your cooperation.

The Editor

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ARTICLES AND REPORTS

DEVELOPMENT AND SITUATION OF THE HAZELNUT IN CHILE

ABSTRACT

More than 13,000 hectares are currently being planted with hazelnut in Chile and this trend is still growing, particularly in the central and southern areas of the country. The competitiveness of Chile on the world market –based on high-quality fruits, agro-industry and direct fresh counter-season consumption– is increasing continuously. Within a few years this competitiveness will be transferred to nuts and especially the hazelnut.

Keywords. Hazelnut varieties – INIA – New orchards – Nursery.

INTRODUCTION

The hazelnut (*Corylus avellana* L.) is native to Mesopotamia, the geographical area corresponding to modern-day Iran, Iraq and Turkey, and is currently spread across the Mediterranean basin, North America (Oregon) and more recently South America, namely Central-South and South of Chile in an area between the regions of Maule and Los Lagos (Osorno province).

The species was introduced in Chile by European colonists and, in particular in the South of the country by German, Italian, Spanish and Swiss immigrants, mainly in the communes of Gorbea, Villarrica, Loncoche (Cautín province, Araucanía region), La Unión, San Pablo, Osorno (Osorno province, los Lagos region).

In the past years, hazelnut cultivation has developed commercially in the above-mentioned areas, from Talca (Maule) to Osorno in the South of the country. The first commercially important orchards date back to the 90s, when plant material from Italy was introduced, in particular, the varieties 'Tonda Gentile delle Langhe' (TGDL) and 'Tonda di Giffoni' (TG) as well as the corresponding pollinizers. After a two-year quarantine period in greenhouse controlled conditions, these varieties were established in the communes of Curicó and Talca in farms owned by the Italian company Ferrero. Later, thanks to research conducted by the INIA, hazelnut cultivation spread to the South, mainly to the regions of Araucanía, Los Ríos and Los Lagos (Fig. 1).

Commercial production of hazelnut is recent in Chile and is essentially related to the establishment of northern hemisphere agro-food companies in Chile seeking to satisfy their demands. Later, exporting companies interested in this sector developed in view of the existing domestic demand for hazelnuts due to the beneficial nutritional properties of this nut for human health.

For Chilean agro-food firms, namely in the South, hazelnut is an alternative to more traditional products such as livestock, annual crops like wheat, oats or rapeseed and is complementary to some other tree species such as apple, cherry, bilberry or raspberry.

CURRENT SITUATION

Hazelnut cultivation in Chile has experienced significant development in the past years and there are currently around 13,000 ha planted (Ellena, 2011) although according to official statistics commercial cultivation of hazelnut started only in 1990 with less than 100 hectares.

Most commercial orchards (nearly 6,000 ha) are currently located in the southern regions of La Araucanía, Los Ríos and Los Lagos, followed by Maule and in particular Talca, Curicó and Linares (5,500 ha). Other regions such as Bío-Bío are less important in hazelnut production (1,500 ha) (Fig. 1). Taking into account the growth of the tree and that specialized nurseries in Chile produce around 600,000 plants per year, it is estimated that by 2019-2020 the surface area of hazelnut trees in Chile will reach at least 25,000 ha, most of it in the South of the country.

Figure 1. Map of Chile showing the main hazelnut production areas.

TYPES OF PROPERTY

Regarding the types of farms growing hazelnut trees in Chile, there are small and medium size farms (SMEs) (from 2.5 to 15 ha), medium size farms (from 15 to 50 ha) and large agribusinesses (from 50 to-500 ha). The world's largest hazelnut orchard is located near Talca (Maule region) and

Photo 1. Mature hazelnut orchard, cv. 'Barcelona', Linares, Maule.

has nearly 2,000 ha. The oldest commercial orchard in Chile, more than 30 years old, is in Linares and is owned by the company Sotella (Photo 1).

PLANT MATERIAL

At present 7 large specialized nurseries in Chile produce around 600,000 hazelnut plants per year. The main varieties are 'Barcelona' and 'Tonda di Giffoni' and their corresponding pollinizers. In the case of 'Barcelona', the main pollinizers are 'Blanco', 'Azul', 'Rojo' (ecotypes), 'Daviana', 'Butler', among others, and in the case of 'Tonda di Giffoni' mainly 'Barcelona', 'Casina', among others. Hazelnut trees are mainly propagated by mound layering (Photo 2) using a collar around the base of the tillers. This technique is used by several nurseries in central and southern Chile and yields good results as regards rooting rate and plant quality.

Other propagation techniques such as chip budding or wedge grafting (Photo 3) and microcuttings (Photo 4) have yielded good experimental results but have not been widely used. Micropropagation may be another alternative in the near future, especially for spreading new or recently introduced selections and varieties (Photo 5). However, it is true that Chile lacks an efficient and economically viable commercial protocol for micropropagation of this species. This is due to certain problems in the process, in particular the difficulty to obtain crops from explants of adult trees because of the release of phenolic compounds, contamination, tissue vitreousness, low multiplication rate, excess callus production and low rooting rate of some materials (Ellena, 1998).

HAZELNUT ORCHARDS

In South Chile, hazelnut trees are usually planted on deep and acidic soils particularly rich in organic matter (10-20%). Annual average rainfall is 1153 mm in the region of Araucanía and 643-716 mm in the Maule region (Talca and Curicó).

In general, orchards have an average density of 400-500 trees per hectare, with single- and multi-trunk training systems, mainly with single-trunk training for the variety 'Barcelona' which exhibits greater vigour (Photos 6 and 7). Orchards with greater plantation density have been recently established (667-800 plants per hectare) by adopting 5x3 m and 5x2 m "dynamic frameworks". The purpose is to achieve a faster start to crop production and increase unit yields during the first 8-10 years until there is excessive competition and shading of the trees (Photo 8).

VARIETIES

Concerning varieties, 'Barcelona' is the most widespread, since it is well adapted to the different agroecological conditions where hazelnut is cultivated (Centre and South and South of Chile) and has good yields (3,000 kg/ha) (Photo 9). Nevertheless, these high yields have a low shelling percentage (39-40%) compared to other varieties. The "Chilean" 'Barcelona', well adapted to Centre-South and South of Chile, is a heterogeneous variety, corresponding to a population of individuals exhibiting some variability and this influences size and other nut characteristics. With the aim of better characterizing this cultivar, a breeding programme using clonal selection was established at the INIA Regional Research Centre Carillanca, located in Vilcún, Araucanía region. The second important variety for the hazelnut industry in Chile is the Italian cultivar 'Tonda di Giffoni', which has become very important in recent seasons because of its high quality. 'Tonda di Giffoni' has average vigour, good productivity (2,500-3,000 kg/ha) and a high shelling percentage (45-47%). It is highly appreciated by the chocolate industry because of the medium size of the seed (14 mm) and its organoleptic characteristics (Photo 9). Other Italian varieties introduced in Chile such as 'Tonda Gentille delle Langhe' seem to adapt quite well to Chile's soil and climatic conditions, al-

Photo 2. Mound layering, main propagation method for hazelnut in Chile.

Photo 3. Wedge grafting made at the end of winter.

Photo 4. Hazelnut seedlings, cv. 'Barcelona' obtained from semi-woody cuttings, "Frutas del Sur" Fruit growing Plaform, INIA-Carillanca.

Photo 5. Hazelnut seedlings from in vitro multiplication in the process of acclimatisation to the greenhouse.

though the flowering period is very short which negatively affects fruit set. In the central-southern area and in some areas in the South where there are microclimate conditions (Angol, Renaico) productivity is acceptable, but the variety is highly sensitive to water and heat stress. Because of their excellent organoleptic properties this variety commands higher prices in Chile than the other varieties.

HAZELNUT DEVELOPMENT PROSPECTS IN SOUTH CHILE

As indicated above, hazelnut cultivation in Chile is an alternative for farmers in the South who are currently involved in other less profitable activities such as livestock production, dairy farming and annual crops (cereals).

The positive trend followed by hazelnut prices in the past years means that farmers in the South (Araucanía, Los Ríos and Los Lagos regions) will continue to invest heavily in this crop with the aim of exporting hazelnuts off-season to the international market (Europe, United States, China, Brazil), when there is no production in the northern hemisphere.

Hazelnut production in Central-South and South of Chile is experiencing growth and is based on the 'Barcelona' (70%) and 'Tonda di Giffoni' (30%) varieties. Some other foreign and local varieties are being assessed at the INIA Research Institute in Carillanca and by private companies.

Photo 6. Hazelnut orchard, cv. 'Barcelona' in a single-trunk training system.

Photo 7. Hazelnut orchard, cv. 'Barcelona' in a multi-trunk training system.

Photo 8. Studies on planting densities conducted by INIA-Carillanca, Vilcún commune, Araucanía region.

Photo 9. Two cvs, "Chilean" 'Barcelona' and 'Tonda di Giffoni'.

PRODUCTION

Hazelnut production in Chile amounts to nearly 5,000 tons per year and is almost entirely exported to Europe, United States and some to Asia and South America. Some is also destined to the domestic market as a shelled product and a small amount is sent to the agro-food industry. It should be noted that during the 2011-2012 season nearly 5,000 tons of in-shell hazelnuts were exported totalling 15,776 USD (thousand USD FOB) at an average price of 3.16 USD per kilogram. Regarding shelled hazelnuts, 109 tons were exported totalling 835 USD (thousand USD FOB) at an average price of 7.64 USD per kilogram.

As for the surface area used for hazelnut production, approximately 10,000 ha are in the process of preparation, thus a strong increase in supply is foreseen for the coming years. Over the course of the 2010-2011 season, Chile exports were worth millions of dollars. Chile's main business partner is Italy, importing millions of dollars (Banco Central de Chile, 2011).

HAZELNUT PRODUCTION MANAGEMENT AND RESEARCH AND DEVELOPMENT IN LA ARAUCANÍA AND LOS LAGOS REGIONS

The INIA – Carillanca ("Frutas del Sur" fruit platform) together with hazelnut producers from the South, GTT-Avellano Europeo and PROFO (organization of hazelnut producers) is conducting research and development work with the aim of growing and enhancing this sector in the South of the country. The INIA also organizes technical and practical courses on pruning, nutrition, weed control, pollination, etc. (Photo 10).

As regards research by INIA-Carillanca, the work has been conducted in collabo-

Photo 10. Technology transfer actions, Gorbea area, Araucanía region.

ration with producers following a request for technologies made by “Frutas del Sur“ fruit platform. Among others, these are some of the most important studies: assessment of varieties, training systems, planting density, pruning, nutrition, soil management, irrigation, tillering control, pollination and the use of windbreaks.

Emphasis should be laid on the studies carried out on pruning within the framework of a project funded by CORFO, INIA and the producers and counting on the collaboration of Prof. Alessandro Roversi from the Catholic University Sacro Cuore, Faculty of Agricultural Sciences – Piacenza, Italy.

INIA research projects have provided local producers with more information for establishing orchards and managing their farming activities.

The introduction of new and higher yielding crops is key to the economic and social development of agriculture in South Chile, and hazelnut offers particularly good prospects taking into account the world’s increasingly growing demand and the few producing countries, especially in the southern hemisphere, where Chile is basically the sole supplier. Researchers at INIA have realized that producers need diversification and other alternatives that complement cereal, meat and milk production, since both cereal and livestock sectors have experienced severe market crises, particularly milk and meat producers.

CHILE‘S STRENGTHS IN HAZELNUT PRODUCTION

The main advantages Chile offers for hazelnut production, mainly in the South, are:

- Good soil and climate conditions for hazelnut production. In particular, there are some areas with deep volcanic soils and high organic matter content.

- Fruit quality and lower production costs: the regions in South Chile (Araucanía, Los Ríos and Los Lagos) have a temperate and cold climate and good conditions for producing top quality hazelnuts and at significantly lower costs (land, water, labour) than the central regions and Europe and United States.

- High professional capacity of Chilean businessmen and new entrepreneurs, trade operators and exporters.

- Chile’s political and economic stability as compared to other South-American countries or countries of the former Soviet Union (Balkans) which porduce hazelnuts.

CONCLUSIONS

Chile has the capacity to successfully compete on the international markets with other hazelnut producing countries (United States, Europe, Brazil, Mexico, Asia), because of its better agroecological conditions, large availability of water, lower labour costs and in some cases because of interesting “economies of scale”.

The positive trend followed by hazelnut prices in the past years and the many advantages of Chile’s hazelnut industry suggests that hazelnut growing land will rapidly increase, mainly in the southern regions.

Between March and May, Chile is the main hazelnut exporter in the southern hemisphere, and exports are growing significantly.

This trend will prevail in the coming years because of the increased surface area, the strong position of Chilean products and the growth of demand on international markets.

For many years Chile has been recognized as one of the main suppliers of high-quality fresh fruit in the southern hemisphere and in the near future it will also be of nuts such as hazelnut.

Regarding the establishment of new orchards, it is estimated that future production will increase heavily so it will be necessary to enlarge markets, mainly in Asia and particularly in China as well as in other European countries.

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OBSERVATION ON HAZELNUT MECHANICAL AND MANUAL PRUNING APPLIED TO THREE DIFFERENT TRAINING SYSTEMS

SUMMARY

In order to control the lateral vegetative development to obtain the widest space between rows for easier machinery management and better crown lighting, some pruning alternatives were compared. These were **H**edging, **H**edging+**T**opping, **T**opping and **M**anual pruning with an **U**npruned control group. The observations were made in the year of pruning and in the following 2 years. The results did not show important effects on yield. The lateral dimensions of the crown were reduced in the year of pruning, facilitating machinery management and better crown lighting. However, the plant's reaction to pruning stimulated the development of new vegetation and the free space between rows became narrow again. Therefore the time interval between 2 prunings has to be planned considering the plant training system, age and soil fertility.

Key words. Hazelnut, interrows, pruning, training system, yield.

INTRODUCTION

As reported in our previous experimental works (Roversi *et al.,* 2007; Roversi *et al.,* 2009; Ughini *et al.,* 2009), hazelnut orchards in Italy are not usually pruned. When they are pruned only very old or dead branches are cut out. In order to obtain experimental answers to questions of some hazelnut growers, our Institute (the first in Italy) began mechanical pruning trials (Roversi *et al.,* 2002) in Langhe and Monferrato (Roversi *et al.,* 2011) districts (Piedmont). The results of our first trials raised interest among hazelnut growers and manual and mechanical pruning systems began to spread. Our first trials were carried out on plants with only 2 trained systems (*palmetta* and bush). Subsequently, other new trials were set up as from 2010, including multi-trunk bushes.

MATERIAL AND METHODS

For these new trials, we chose 3 hazelnut orchards in the Monferrato district (Piedmont) with different training systems such as palmetta, bush and multi-trunk, as listed below:

1st orchard: palmetta trained 8-year old plants (Mr. Manfredi), 5x4m spaced;

2nd orchard: multi-trunk bush 10-year old plants (Mr. Meda), 5x5m spaced;

3rd orchard: bush trained 13-year old plants (Mrs. Ribaldone), 5x5m spaced.

In 2 of the 3 orchards chosen (Meda and Ribaldone), the free spaces between the rows were too narrow to allow the machinery easy access. In these conditions, soil management, sucker removal, chemical applications and fruit harvest were very difficult.

In Spring 2010, with a BMW mechanical pruner, the following alternative pruning systems were tested at the end of March in the above mentioned hazelnut orchards.

Hedging = Plants pruned on both sides;
Topping = Plants pruned only at the top;
Hedging + Topping = Plants pruned on both sides + topping;
Manual = Plants hand pruned;
Unpruned = Control plants.

Each alternative pruning system was applied to 3 rows of a minimum of 22 plants each row. Among these rows, one row was left out of the experimental design.

Vegetative and productive data were collected for 6 repetitions for each orchard, pruning system and year.

Productive data. The yield of each pruning system, orchard and year, was measured (kg/plant) for 6 plants in each case. A representative quantity of 2 kg of fruits was sampled for qualitative studies.

Vegetative data. *Plant dimensions:* The first data was collected on the lateral growth of plants before pruning, measuring the lateral dimension of the crown. Immediately after pruning, the lateral dimension was also measured. In both cases, before and after pruning, the lateral dimension was recorded separately for the east and west side of the plant at 150 cm from ground level. During the mechanical and manual pruning operation, the time was recorded both for all the rows and all the repetitions of each system.

Free Space: With this expression, we refer to the interrow space not occupied by the lateral plant vegetation. Of course this space must be wide enough to facilitate machinery management; without pruning this space will become smaller over the years.

The value of this parameter is obtained as the difference between the dimensions of the eastern and western sides of the crown in the interrows and the spacing between 2 rows.

RESULTS

Time required for plant pruning

As expected, the required pruning time (Table 1) was very variable between the different hazelnut orchards and the pruning systems.

Manual pruning clearly required the longest time. This fact was especially evident in Ribaldone orchard with 266.3 sec/plant. As for mechanical pruning, longer time requirements (11.0 sec/plant) were observed in Meda orchard for hedging. In the other 2 orchards, the time was slightly over 7.0 sec/plant. For topping, the minimum time required was 6.8 sec/plant for Meda orchard and significantly higher, for the other 2 orchards.

From Table 1 we can also observe that the longest time required for manual pruning, hedging, topping and hedging + topping, was recorded in Ribaldone orchard in which the plants were 13 years old and bush trained. However, manual pruning took less time in Manfredi orchard with 8 year-old palmetta trained plants.

For manual pruning, topping and hedging+topping, the heaviest training system was the bush (Ribaldone orchard), while the less demanding work took place in Manfredi orchard (palmetta trained) only for manual pruning and hedging.

The time required for mechanical pruning (Table 1) was significantly different between orchards, in particular for the hedging and hedging+topping pruning system.

Finally mechanical pruning saves a lot of time because it requires from 9 to 16 times less than manual pruning.

Table 1. Required time for pruning as related to orchard and pruning system (sec/plant).

Pruning system	U	M	H	T	H+T
Manfredi	–	125.0 A	7.5 A	8.1 B	13.9 A
Meda	–	173.2 A	11.0 B	6.8 A	13.7 A
Ribaldone	–	266.3 B	7.6 A	8.6 B	16.8 B

Table 2. Average production (kg/plant) as related to pruning system, orchards and years.

	Manfredi			Meda			Ribaldone		
Pruning system	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
Hedging	1.84 a	2.97 a	3.92 a	2.17 a	3.09 ab	2.95 a	3.91 a	6.32 a	8.53 a
Topping	2.63 a	3.34 a	4.18 ab	2.81 a	2.97 a	2.82 a	3.92 a	5.51 a	8.36 a
H + **T**	2.46 a	3.08 a	4.98 b	2.17 a	3.05 a	3.84 ab	3.73 a	5.15 a	8.37 a
Manual	2.17 a	3.80 a	3.44 a	3.20 a	6.35 b	4.21 b	4.99 b	5.80 a	8.27 a
Unpruned	3.28 a	2.73 a	4.05 a	3.11 a	3.62 ab	2.93 a	4.73 ab	6.25 a	7.83 a

PRODUCTIVE DATA

The average yield, in kg/plant, was very variable (Table 2) according to the orchards, the pruning system and the years. The orchard age had an important effect because the youngest orchard (Manfredi of 8 years old) produced the lowest yield (with a triennial average of 3.26 kg/ plant) and the oldest orchard (Ribaldone of 13 years old) produced the highest yield with a triennial average of 6.11 kg/plant.

Manfredi orchard

In the pruning year (2010) the plant yield decreased considerably, as shown in our other previous work (Roversi *et al.,* 2009; Roversi *et al.,* 2011; Malvicini, *et al.,* 2012) for all pruning systems (Table 2).

Of course this result was due to the heavy removal of twigs and branches with several female flowers. In the year after pruning, the yield of all the pruning systems was higher than the control group, but not significantly. The best result (0.80 kg/plant) was obtained from the manually pruned plants.

Two years after pruning, in 2012, the plants pruned on both sides had a lower yield (3.92 kg/plant) than the control group (4.05 kg/plant) as observed in the pruning year.

The best yield (4.98 kg/plant) was provided by the plants pruned on both sides + topping.

The cumulative yield (Table 2 and Figure 1) confirms that the worst result was obtained from the plants pruned on both sides without any significance in comparison with the production of the unpruned plants.

Meda Orchard

In this orchard, in the pruning year (2010), all the mechanical pruning systems reduced the yield (Table 2), but manual pruning produced a little more (3.20 kg/plant) than the control group. One year after pruning we observed a strong and significant increase in yield (6.35 kg/plant) in the manually pruned plants.

Two years after pruning (2012) the yield from all the mechanically pruned plants did not differ from that of the control group (Table 2). The manual pruning provided a much higher yield (4.21 kg/plant) (2.93 kg/plant) than in the unpruned plants.

The cumulative yield shows (Table 2 and Figure 2) a better result in the manually pruned plants and a worse result in those pruned on both sides, as observed in previous orchards.

Ribaldone orchard

As in the two previous orchards, in the first year of observations, the mechanical pruning gave (Table 2) a lower yield than the control group. In the same year we did not find significant differences between the yield of the control group and that of the manually pruned plants.

In the second year of observations (2011) neither mechanical nor manual pruning had a significant influence on plant productivity.

Two years after pruning (Table 2 and Figure 3) both the mechanical and the manual thesis increased yield even if it was absolutely not significant.

The cumulative yield shows (Figure 3) the best results of the **M**anual and **H**edging pruning that are not significant in comparison with the **U**npruned alternative.

VEGETATIVE DATA

Manfredi orchard

Plant dimensions: As shown in Tab. 3, the lateral dimension of palmetta trees before pruning was almost the same (little more than 130 cm) for both east and west sides without any significance between alternative systems.

Free space: The free space between rows (Table 6) was at about 230 cm. After 3 vegetative seasons after pruning, just for the 3 theses in which the lateral parts of the crown were pruned (Table 6), the free space was about the same as the initial space. However, in the manual pruning thesis the result was worse than that ob-

Figure 1. Cumulative yield (kg/plant) for the years 2010-2012 in Manfredi orchard.

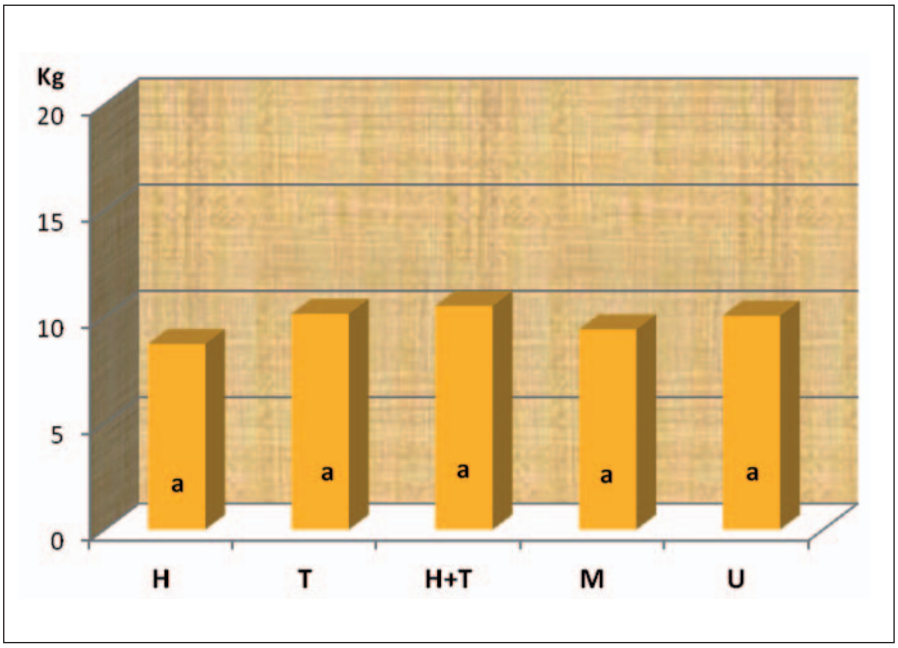

Figure 2. Cumulative yield (kg/plant) for years 2010-2012 in Meda orchard.

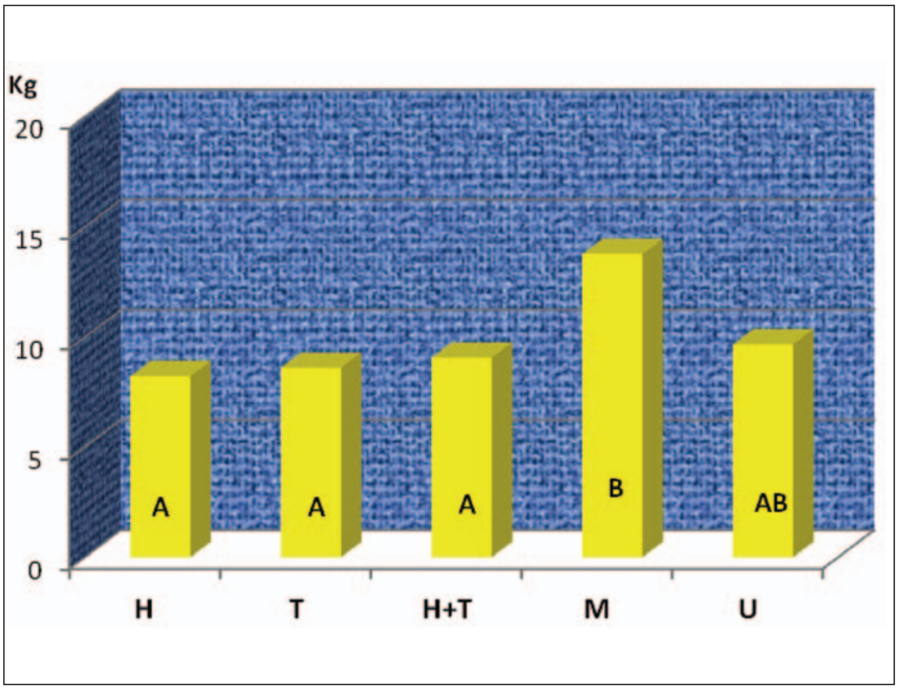

Figure 3. Cumulative yield (kg/plant) for -years 2010-2012 in Ribaldone orchard.

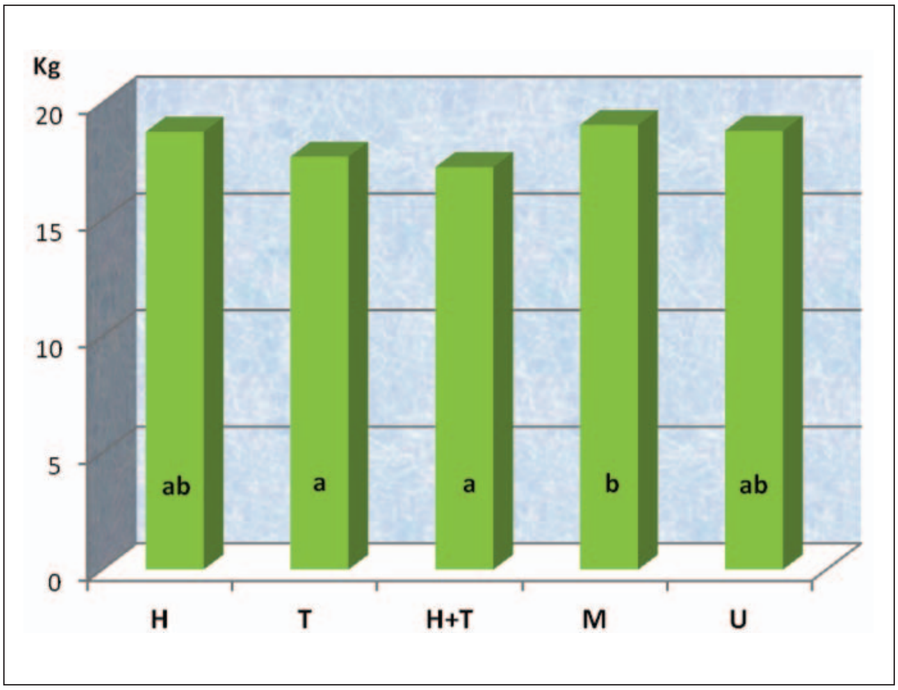

Table 3. Plant lateral dimensions (cm) as related to pruning system and time in Manfredi orchard.

	Year of Pruning (2010)				After 3 vegetative seasons (2012)	
	Before pruning		After pruning			
Pruning system	**E**	**W**	**E**	**W**	**E**	**W**
Hedging	132.0 a	131.6 a	114.2 A	115.5 A	134.5 a	133.3 a
Topping	133.4 a	131.4 a	131.0 AB	120.0 AB	145.8 ab	153.3 b
H + T	133.1 a	133.2 a	115.2 A	116.1 A	131.7 a	140.0 ab
Manual	135.5 a	129.3 a	121.8 A	121.8 AB	156.7 ab	170.0 b
Unpruned	136.6 a	134.0 a	136.0 A	133.7 B	160.8 a	156.7 b

tained with the mechanical pruning and the free space decreased to 173 cm.

Meda orchard

Plant dimensions: The lateral dimension of the multi-trunk plant in this orchard, before pruning, was (Table 4) higher than the one of the previous orchard, with an average of 185.9 cm for the east side and 175.5 cm for the west. As observed in the previous orchard, no significance was observed between the pruning systems.

Free space: The free space (not occupied from the lateral dimension of the crown) between rows, before pruning, was of 139 cm. This access was not enough for machinery management. After 3 vegetative seasons following mechanical pruning, the free space between rows (Table 6) was wider than the initial season, but, insufficient to allow easy machinery access. After manual pruning, the free space decreased a great deal and moreover machinery management was insufficient.

Ribaldone orchard

Plant dimensions: The bush trained plants of Ribaldone orchard, were the ones with the largest lateral dimension of the crown (always more than 2 meters, as shown in Table 5). Before pruning, as in the other 2 orchards, no significant difference was observed in the lateral dimension of the crown. Therefore we can affirm that the rows chosen for the trial were very homogeneous.

Free space: The space not occupied by the lateral dimension of the crown, both before and after pruning, was very insufficient. After 3 vegetative seasons, only manual pruning showed a further reduction of the free space (about 20 cm) and it resulted almost impossible even to walk between them. In this orchard, mechanical pruning increased the free space between rows despite the new vigorous vegetation due to the previous cuts.

DISCUSSION AND FINAL CONSIDERATIONS

Three years of observations on mechanical and manual pruning in three different hazelnut orchards show that production was only slightly influenced by the type of pruning, especially in Manfredi orchard. In fact, the yield data showed a much greater influence of orchard and year. On the contrary, plant pruning showed significant effects on the kernel quality as will be presented and discussed in a further contribution.

Concerning the first goal, control of the crown's lateral expansion between rows, the following points are noteworthy:

Table 4. Plant lateral dimensions (cm) as related to pruning system and time in Meda orchard.

	Year of Pruning (2010)				After 3 vegetative seasons (2012)	
	Before pruning		After pruning			
Pruning system	E	W	E	W	E	W
Hedging	169.4 a	166.6 a	122.0 A	114.0 A	148.6 a	150.8 A
Topping	193.0 a	199.8 a	191.5 B	199.5 B	205.5 b	214.2AB
H + T	193.7 a	170.9 a	153.0 AB	133.5 A	182.0 a	157.1 A
Manual	181.6 a	163.4 a	154.0 AB	143.1 AB	186.7 a	218.8 B
Unpruned	191.7 a	177.0 a	191.0 B	176.5	208.5 b	202.5 A

Table 5. Plant lateral dimensions (cm) as related to pruning system and time in Ribaldone orchard.

	Year of Pruning (2010)				After 3 vegetative seasons (2012)	
	Before pruning		After pruning			
Pruning system	E	W	E	W	E	W
Hedging	204.8 a	211.3 a	110.0 A	128.0 A	147.5 A	150.0 A
Topping	217.8 a	208.1 a	216.5 B	207.5 B	232.0 B	239.5 B
H + T	211.5 a	228.4 a	110.0 A	135.8 A	187.5 AB	162.5 A
Manual	206.4 a	215.4 a	190.5 AB	188.9 AB	245.5 B	234.6 B
Unpruned	217.0 a	215.0 a	217.0 B	214.6 B	251.7 B	236.5 B

Table 6.Average of free space (cm) between 2 adjacent rows with the same pruning system.

	Manfredi orchard		Meda orchard		Ribaldone orchard	
Pruning system	Before pruning (2010)	After 3 vegetative seasons (2012)	Before pruning (2010)	After 3 vegetative seasons (2012)	Before pruning (2010)	After 3 vegetative seasons (2012)
Hedging	236	232	164	201	84	202
H + T	238	238	135	161	60	189
Manual	235	173	155	95	78	20

• Manual pruning is very time consuming, more than 9 to 16 times longer than mechanical pruning.

• The reduction of the lateral dimension of the crown due to manual pruning was much less out of all the pruning systems considered.

• After two years, the increase in the lateral dimension of the crown shown in manual pruning, was the highest in all the orchards considered.

• All mechanical pruning in the three orchards considered, shows a strong reduction in the lateral dimension of the crown.

• Two years after pruning the free space between rows was occupied, as expected, by new vegetation.

• With the single exception of Manfredi orchard, the free space between rows is not enough for machinery management; especially with manual pruning.

Finally the target of the mechanical pruning trials, namely the reduction of the plants' lateral crown dimension to obtain wider spaces between rows for easier machinery management and better crown lighting, was not reached by manual pruning. For this and other reasons, hazelnut manual pruning will have to be abandoned progressively. With the exception of Manfredi orchard, after pruning, the free space between rows became insufficient once again to allow for hazelnut orchard mechanisation. Higher pruning frequency may be suggested but further research is needed.

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THE ALMOND BREEDING PROGRAMME OF CEBAS-CSIC, MURCIA (SPAIN)

INTRODUCTION

The Almond tree is one of the most iconic crops in Spain and is part of our agricultural economy and landscape. In our country, it is cultivated under mainly rainfed and frequently poor culture conditions. Despite this, because of the more than 450,000 ha cultivated, Spain is the second largest producer of almonds worldwide.

The mean productivity of the Spanish plantations is very low (about 100 kg of kernel/ha), which does not cover cultivation costs. This average productivity does not reflect the situation of new irrigated plantations where yields are similar to those in California (about 2,000 kg of kernel/ha). More recently, the sharp increase in prices has greatly boosted the almond sector in Spain, where it is perceived that suitable cultivation of selected varieties can be a profitable business.

The causes of low productivity of the traditional almond plantations in Spain are diverse:

- The main cause is poor growing conditions. Around 90% of the plantations are rainfed. Under these conditions, the amount of water available depends on the rainfall, often no more than 300 mm per year. In addition, almonds are often grown on marginal soils and with little care. Given the low productivity of almonds in these conditions, the farmer does not invest in plantations and low yields are maintained. When rainfed orchards are carefully cultivated, production can easily be doubled. Furthermore, when almonds are grown in good soil, with irrigation, fertilizers and suitable treatments, 100 kg/ha are multiplied by 20 or more.
- On the other hand, cultivation areas have spread to cold areas inland in Spain. In these new areas, traditional early flowering varieties bloom in the months of February and March, and late frosts often cause production loss. This is an easily remediable situation, using late or extra-late flowering varieties.
- In addition, many of the cultivated varieties are self-incompatible, forcing farmers to cultivate orchards with two or more inter-compatible varieties with the same flowering time and to introduce beehives. With these self-incompatible varieties, cross-pollination may be deficient for several reasons, including lack of coincidence in flowering time, little or no presence of pollinating bees, and unfavourable weather conditions during flowering (rain, wind, cold, fog). This problem also has a solution: cultivating self-compatible varieties.

Therefore, the main objective of the Almond Breeding Programme of CEBAS-CSIC since its origin has been obtaining late flowering and self-compatible varieties, to overcome the cited problems.

Growing self-compatible varieties allows for the establishment of solid orchards, with the following advantages:

- All planting area is occupied by the same variety, without using surface for the pollinator varieties, which are usually less interesting.
- The coincidence of flowering time and floral compatibility is assured, since there is only a self-compatible variety in the orchard.
- The bad weather and the absence of bees have not such a negative effect on production, since their own pollen is capable of pollinating each flower. It is not necessary (but highly recommended) to install beehives.
- The harvest is simultaneous and the commercial product is homogeneous.

Although some farmers have had some concerns about cultivating solid orchards (due to the traditional culture of self-incompatible varieties), in CEBAS-CSIC we have shown that self-compatible cultivars are equally effective when pollinated with their own pollen or with pollen from another variety, from all points of view (productivity and fruit characteristics). This allows for the replacement of traditional orchards, with two or more varieties, by solid orchards with the new self-compatible varieties.

THE ALMOND BREEDING PROGRAMME OF CEBAS-CSIC

The almond breeding programme of CEBAS-CSIC began in 1971 with prospective plant material at the regional, national and international level. Starting in 1975, a collection of 81 varieties was studied for 10 years, and in 1985 the first crosses were performed, selecting parents and combinations depending on the established objectives: late flowering and self-compatibility. Productivity, drought resistance, good kernel, absence of double seeds and resistance to fungal diseases were of course also considered.

The breeding strategy was to incorporate the following traits into autochthonous cultivars adapted to drought (but early flowering and self-incompatible): the late flow-

Main characteristics of the CEBAS-CSIC varieties ‘Antoñeta’, ‘Marta’ and ‘Penta’.

	‘ANTOÑETA’	‘MARTA’	‘PENTA’
Tree			
Vigour	High	High	Intermediate
Habit	Open	Upright	Balanced
Ramification	Abundant	Balanced	Balanced
Disease resistance	Intermediate	Intermediate	High
Flowering			
Floral density	High	High	High
Time of flowering	Late	Late	Extra-Late
Self-compatibility	Yes	Yes	Yes
Self-fertility	Very high	Very high	Very high
Fruit			
Productivity	High	High	High
Time of maturity	Very early	Very early	Early
Shell hardness	Hard	Hard	Hard
Percentage of kernel	35%	32%	28%
Kernel weight	1.5 g	1.2 g	1.0 g
Kernel shape	Rounded	Elongated	Elongated
Double kernels	0 %	0 %	0%
Empty nuts	0 %	0 %	0%

Figure 1. Late flowering is one of the main objectives of the Almond Breeding Programme of CEBAS-CSIC.

Figure 2. Fruits of 'Antoñeta' almond.

Figure 3. Fruits of 'Marta' almond.

Figure 4. Fruits of 'Penta' almond.

ering of French and Russian varieties and the self-compatibility of the Italian varieties of Apulia.

CEBAS-CSIC varieties were obtained by controlled pollination, seed germination and seedling production. These descendants were studied for several years and the best ones were selected. Following this procedure, we obtained and studied more than 20,000 descendants in order to finally select the new varieties.

Genetic studies

Parallel to our Breeding Programme, in CEBAS-CSIC we have performed numerous scientific studies to address questions related to the main traits involved in almond breeding, among which we must highlight the flowering time, the floral incompatibility and the bitterness of the kernel. Our group has published numerous scientific papers in journals included in the Scientific Citation Index (SCI) on inheritance and genetic control of traits, development of methods for early selection and development of molecular markers on almond. A set with all the papers SCI of our group is available in PDF format upon request to fdicenta@cebas.csic.es.

Description of CEBAS-CSIC varieties: 'Antoñeta', 'Marta' and 'Penta'

'Antoñeta' and 'Marta' varieties come from a cross between the varieties 'Ferragnès' and 'Tuono' made in 1985. 'Penta' is descendant of S5133 (a CEBAS-CSIC selection) and the French variety 'Lauranne' ('Ferragnès' x 'Tuono').

Tree characteristics

'Antoñeta' and 'Marta' are two varieties with great vigour. The habit of 'Marta' is quite erect with strong branches making the tree very easy to prune. 'Antoñeta' however has a more open canopy, with a significant number of lateral branches that requires special attention in pruning the first years. 'Penta' has an intermediate habit with balanced ramification. The three varieties have shown good performance in natural conditions with respect to fungal diseases.

Flowering characteristics

All varieties have high floral density. 'Marta' and 'Antoñeta' have a flowering time similar to 'Ferragnès' while 'Penta' flowers much later. Depending on the areas, 'Penta' can flower between 10 and 20 days after 'Ferragnès'. With 'Penta' we created the term "extra-late flowering" to designate such varieties that bloom in late March or early April in colder areas.

The three varieties are genetically self-compatible. They are also self-fertile, meaning they are able to bear fruit after self-pollination without another variety or bees. In other words, each of these varieties can be grown in solid orchards. Despite self-compatibility of these varieties, we always recommend the introduction of beehives in the plantation to significantly increase production, especially when weather conditions are unfavourable.

Productivity and fruit characteristics

'Antoñeta', 'Marta' and 'Penta' are very productive trees. Nonetheless, their productive capacity will of course depend on culture, especially on the provision of water. 'Antoñeta' is one of the first varieties to ripen. 'Marta' and 'Penta' are also very early maturing.

The three varieties are hard shell with percentage of kernels ranging from 28% ('Penta') to 35% ('Antoñeta'). 'Antoñeta' has a large kernel (about 1.5 g) followed by 'Marta' (1.2 g) and 'Penta' (1.0 g). 'Antoñeta' kernels are somewhat rounded (type 'Marcona'), and 'Marta' and 'Penta' elongated. In all cases, the seeds are attractive and have no double or empty seeds.

'Antoñeta', 'Marta' and 'Penta' varieties are the property of CSIC and can only be obtained in nurseries authorized by CSIC.

CONCLUSIONS

CEBAS-CSIC varieties allow for the cultivation of solid orchards with the huge advantages cited. In our opinion, the self-compatible late flowering varieties 'Antoñeta' and 'Marta' are two interesting options for cold areas where varieties with the flowering time of 'Ferragnès' rarely freeze. In areas where these varieties often lose production due to frost, we recommend the 'Penta' variety for its extra-late flowering.

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NUT SIZE AND BLOOMING TIME IN ALMOND

INTRODUCTION

The objective of plant breeding is the release of new cultivars able to satisfy the agronomical and commercial requirements present in the production and consumption of any crop. In the case of almond, the main objectives of nearly all plant breeding programmes (Socias i Company *et al*., 2012) has been self-compatibility and late blooming, which has been attained with many of the new releases from different programmes. For late blooming, the knowledge of the genetics of blooming time (Socias i Company *et al*., 1999), as well as of the chilling and heat requirements (Alonso *et al*., 2005), has facilitated the design of the crosses in the breeding programmes to delay blooming time and obtain new later-blooming selections.

Other objectives, such as nut quality, were introduced later in the breeding programmes. This is difficult to define and involves both physical and chemical traits (Socias i Company *et al*., 2008). One of the physical traits to be considered in the evaluation of nut quality is kernel size, since large kernels often fetch a higher price on the market, even if small sizes are preferred for some specialty products, such as chocolate bars, chocolates and sugared almonds. Due to the different commercial preferences, one of the objectives of some breeding programmes is the release of cultivars that produce very large kernels (Holland *et al*., 2006). However, when considering the objectives of late bloom and nut quality, aspects other than kernel size have been considered, mainly kernel percentage, double kernel percentage and the general appearances of the kernel (Vargas and Romero, 1988). Furthermore, when considering the possibility of obtaining new late-blooming cultivars with large kernel size, some doubts have been expressed about whether it would be possible to advance in the achievement of both objectives at the same time. In fact, when 'Felisia' (Socias i Company and Felipe, 1999) was released, it was the latest blooming cultivar at that time but its kernel size was small. Similarly, the cultivars 'Penta' and 'Tardona', both of very late blooming time, are distinguished by their small kernel size (Dicenta *et al*., 2008).

Probably all these cultivars had been selected early in order to have late-blooming cultivars to cover the demands of the growers. However, experience in selecting among the offspring of the breeding programmes seems to indicate that there is no correlation between blooming time and nut size. Even though in the hypothetical case that this correlation existed in the first families of the almond breeding programmes, it is not found in the present-day crosses. This situation may resemble that of the possible correlation between late bloom and low productivity (Grasselly and Olivier, 1985), a linkage broken in further crosses, giving rise to late-blooming selections with a high bloom density and, consequently, a high productive potential (Kodad and Socias i Company, 2008).

Therefore, nut size of a series of almond cultivars and selections grown in the same experimental plot was measured in order to determine whether there may be any correlation between nut size and blooming time in these genotypes.

Table 1. Nut and kernel traits of several almond cultivars and selections: weight (g) and dimensions (mm): length (L), width (A) and thickness (E), and shelling percentage.

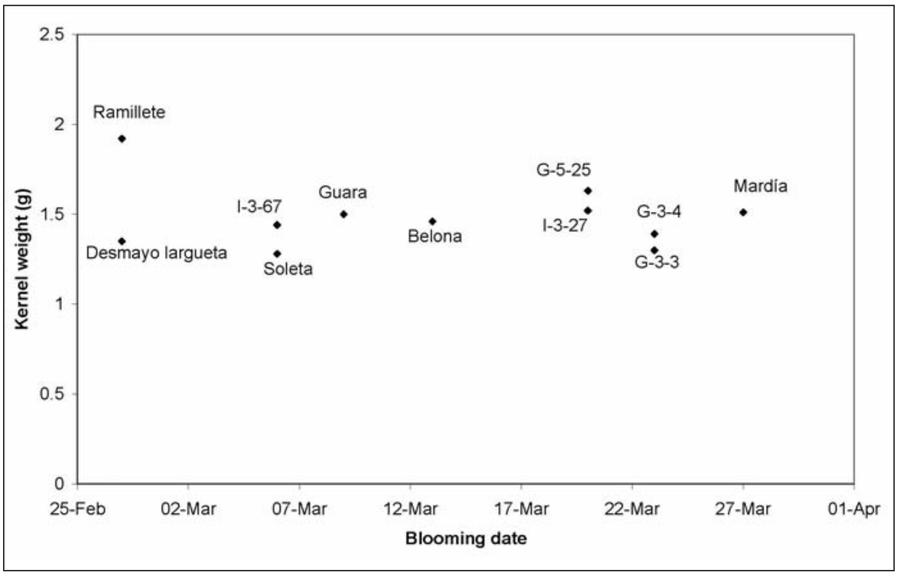
	Nut				Kernel				Shelling percentage
Cultivar	Weight	L	W	T	Weight	L	W	T	
'Belona'	4.40	30.1	25.7	16.0	1.46	24.7	17.2	7.3	33.1
'Guara'	3.50	31.7	23.5	17.2	1.50	25.1	14.8	8.1	42.7
'Soleta'	3.80	34.3	21.5	14.2	1.28	26.7	13.4	7.5	33.6
'Mardía'	5.71	35.5	26.3	17.9	1.51	25.9	16.5	7.8	26.0
I-3-67	4.21	32.8	22.8	17.2	1.44	25.9	14.8	7.9	34.2
I-3-27	5.03	32.6	25.9	17.3	1.52	24.7	17.1	7.9	30.2
G-3-4	5.50	34.8	27.0	16.6	1.39	25.5	17.4	6.6	25.3
G-3-3	4.48	31.8	24.0	16.5	1.30	25.2	15.9	7.8	29.1
G-5-25	5.35	37.0	26.1	16.2	1.63	27.5	16.4	7.4	30.5
'Desmayo Largueta'	4.90	35.6	23.6	14.4	1.35	27.4	14.3	7.4	27.6
'Ramillete'	7.47	41.9	29.5	19.4	1.92	29.5	17.6	7.4	25.7

MATERIALS AND METHODS

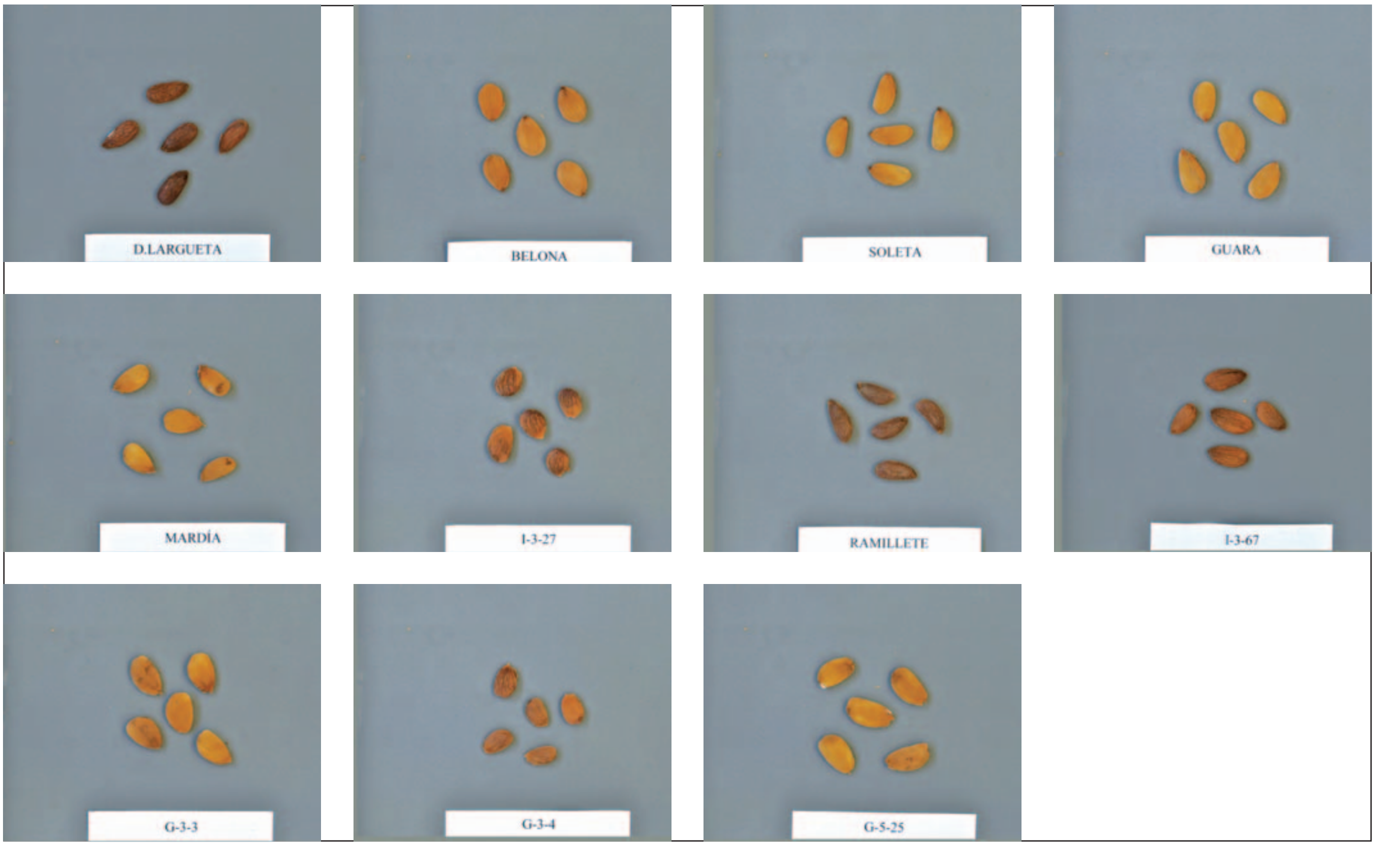
The nuts studied were collected in the experimental almond plot of the Afrucas orchard in Mas de la Punta (Caspe, Zaragoza, Spain). This plot includes several late-blooming cultivars and selections, as well as 'Desmayo Largueta' and 'Ramillete' as early-blooming control cultivars. The plot was established in 2005 on the hybrid peach × almond rootstock GF 677, at a planting distance of 7 × 6 m and drip irrigated. Thus, the crop of 2013 could be considered a plot in full production.

In 2013, the date of full bloom was recorded for each cultivar and selection. A sample of approximately 200 nuts was randomly collected at ripening time from each genotype and taken to the laboratory for evaluation. This was carried out with a

Figure 1. Kernel weight of several almond cultivars and selections as related to the date of full bloom in 2013.



Almond cultivars and selections nuts.



Almond cultivars and selections kernels.

small random sample, measuring the weight, the length, the width and the thickness of both nut and kernel individually, once the nuts had been cracked to obtain the kernels. Therefore the shelling percentage could be calculated and presence of double kernels in each sample could be determined.

RESULTS AND DISCUSSION

Table 1 includes the mean values of the parameters measured for the nut and the kernel of each of the cultivars studied, as well as the shelling percentage. The percentage of double kernels was not included because only 'Guara' showed this kind of kernel. These values agree with the descriptions of these cultivars (Felipe, 2000; Felipe and Socias i Company, 1987; Socias i Company and Felipe, 2007; Socias i Company *et al.*, 2008b) and with the previous observations in the *Unidad de Fruticultura* at CITA, within the levels of variability in the observations in different years.

When the full bloom data of each cultivar and selection were plotted against kernel weight (Fig. 1) the distribution of the dots was almost horizontal. This result concludes that the date of bloom has no effect on kernel size. Evidently, the late-blooming genotypes included in this study were selected in a breeding programme and kernel size has been an evaluation criterion during the selection process, but this same criterion was certainly applied when the traditional cultivars, such as 'Desmayo Largueta' and 'Ramillete' were noticed by our ancestors and clonally propagated because of their good characteristics, kernel size being surely one of the traits taken into account.

If a large number of cultivars was included in this study, as well as the complete offspring of some crosses of the breeding programmes, a different distribution of kernel size and blooming time could be obtained, other than that shown in Fig. 1. However, the objective of any breeding programme is the release of new cultivars possessing extraordinary characteristics distinguishing them from average cultivars. As already mentioned, late blooming has been a main objective of many almond breeding programmes and the results of the present study confirm the possibility of obtaining extremely late-blooming selections, such as 'Mardía', with an average kernel size. Furthermore, these results sustain the possibility of following this research path of obtaining new selections joining the two interesting traits of late bloom and large kernel size.

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KERNEL QUALITY OF LOCAL SPANISH ALMOND CULTIVARS: PROVENANCE VARIABILITY AND END USES

INTRODUCTION

Almond (*Prunus amygdalus* Batsch) is the most popular nut tree crop worldwide in terms of commercial production (faostat.fao.org/site). Spain is the second world producer, with an average production of 223,431 tons of in- shell nuts (Socias i Company *et al.*, 2011). Traditional almond culture utilized open-pollinated seedlings (Socias i Company *et al.*, 2012) 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 for the selection of almond cultivars well adapted to this area (Grasselly and Crossa-Raynaud, 1980; Socias i Company *et al.*, 2012). In Spain, almonds are produced under different climatic conditions: from inland regions characterized by high frost risks at blooming time or soon after (Ebro Valley, Castilla-La Mancha), to coastal regions with mild winters and hot and dry summers (Andalusia, Murcia), and the Balearic and Canary islands with high relative humidity. The high climatic diversity of the different producing regions in Spain forced the local farmers to select genotypes to avoid the harsh environmental conditions that cause decreases in production. In the last 15 years more than 18 million almond plants were produced by the Spanish nurseries, and more than 60% of these plants came fromwere of cultivars released by breeding programmes (Socias i Company *et al.*, 2011). However, the traditional Spanish cultivars, with 24.57% of the plants, still represent nearly a quarter of this total.

The Spanish market only distinguishes two cultivars, 'Marcona' and 'Desmayo Largueta', whilst the rest of cultivars are grouped under the undefined name of "comunas" (Socias i Company *et al.*, 2012). Almond kernels are consumed raw, roasted, blanched, unblanched, served alone or mixed with other foods. Almond kernels are also used fresh or can be processed into many different confectioneries (Socias i Company *et al.*, 2008). The kernels of the "comunas" almonds are used in different confectioneries with unspecified requirements, being mainly processed for production of marzipan and in some types of nougat. However, the modern almond industry demands commercial cultivars characterized by kernels with well differentiated and high quality attributes , since the best end-use for each cultivar is a function of its chemical composition (Berger, 1969). Additionally, the best quality attributes may avoid the use of synthetic additives according to the consumers' trend for foods without any additive (Krings and Berger, 2001).

Determination of the compositional variability of the oil from different countries, locations or cultivars could be imperative for a proper classification of the product and the protection of its authenticity in the market (Kodad *et al.*, 2011a). The information on the chemical composition of the almond kernels available at present is restricted to a reduced number of cultivars, mostly from the country where these cultivars originated or are grown (Kodad *et al.*, 2011b). As a consequence, comparisons between 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 of 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). Thus, our objective was the determination of the oil, fatty acid and tocopherol composition of 44 traditional Spanish almond cultivars from different regions grown in the CITA almond collection, considering their possible industrial implication.

MATERIAL AND METHODS

A total of 44 local Spanish almond cultivars from seven different gene pools were included in the analysis (Table 1). The trees are maintained as living plants grafted on the almond × peach hybrid clonal rootstock INRA GF-677, using standard management practices (Espiau *et al.,* 2002). Nuts from open pollination were harvested during three consecutive years (2008-2010) at the mature stage, when fruit mesocarp was fully dried and split along the fruit suture and the peduncle abscission was complete (Felipe, 1977). Three samples of 20 nuts were collected for each treatment.

Oil content and fatty acid composition were determined during the three years of the study. Kernels were blanched, dried, and ground in a domestic electrical grinder until obtaining fine flour. Total oil content was determined with a 3 gram sample in a Soxtec Avanti 2055 fat extractor (Foss Tecator, Höganäs, Sweden). Fat content was expressed as the difference in weight of the dried sample before and after extraction (% of DW). The fatty acids in the oil were determined by capillary gas chromatography of the fatty acid methyl esters (FAMEs). These FAMEs were prepared according to the official method UNE-EN ISO 5509:2000. Tocopherol concentrations were determined in extracted kernel oil over two consecutive years (2009-2010) according to a modification of the method by López Ortiz *et al.* (2008).

All statistical analyses were performed with the SAS program (Cary, NC, USA). The mean separation was conducted using with the LSD test at $P < 0.05$.

RESULTS AND DISCUSSION

Oil and fatty acid variability. Oil content showed high significant variability among genotypes from different regions (Table 1). The range of variability for oil content in cultivars from the same region was evaluated and the results showed that this range was large in the genetic pools from Aragon (53.4% to 64.9) and the Canary Islands (50.58% to 61.3%), medium for Majorca (53.37% to 62.74%) and Valencia (53.98% to 62.92%), and low for Catalonia (58.9% to 64.95%) (Table 1). The highest mean value was obtained for the cultivars from Catalonia (61.75%), followed by Aragon (60%), and the lowest values were registered for the cultivars from the Canary Islands, Murcia and Andalusia (Table 1). The year effect was significant for all studied variables (Table 1). For oil content, the lowest value was obtained in 2010 (Table 1). It is to be noted that the oil content of the cultivars from Aragon and the Canary Islands were more stable over the three years of study, indicating the same trend of variation of the genotypes from these regions. The year effect has been reported to be significant for oil content in some studies at individual level (Abdallah *et al.*, 1998; Barbera *et al.*, 1994; Sathe *et al.*, 2008), but not at gene pool level such as that reported in the present study. The cultivars from Murcia and the Canary islands showed the highest reduction in oil content in 2010, as compared to the other provenances. These results may indicate the need to carry out the determination of oil content in almond over three years and not only two for a correct evaluation, coinciding with the results reported in olive (León *et al.*, 2004). This trait appears to be under polygenic control (Font i Forcada *et al.*, 2011), with a clear environmental effect (Abdallah *et al.*, 1998; Sathe *et al.*, 2008). Furthermore, these results show clearly that the magnitude of the year effect on the oil content is not limited to the genotype, but also to its geographical origin. This information is useful for breeders when breeding for high and stable oil content in order to take into account the geographical origin of the parents. 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 being absorbed by the almond paste (Alessandroni, 1980). On the contrary, low oil contents are preferred for the production of almond flour or almond milk. Since nuts from these cultivars are marketed under the name of "comunas", those from Aragon and Catalonia could be mostly used for the production of nougat

Table 1. Oil content (% of kernel DW) and major saturated fatty acid (% of total oil content) of the Spanish almond cultivars during the three years of study.

	Oil content				Palmitic ac.				Stearic ac.				SFA			
Region	**2008**	**2009**	**2010**	**Mean**	**2008**	**2009**	**2010**	**Mean**	**2008**	**2009**	**2010**	**Mean**	**2008**	**2009**	**2010**	**Mean**
Andalusia	57.7a	57.8a	56.7a	57.4	5.7a	5.7a	5.8a	5.7	2.13a	2.13a	2.08a	2.11	7.8a	7.9a	7.9a	7.9
Aragon	60.8a	60.3a	59a	60	6.2a	6.1a	6a	6.1	2.22a	2.03ab	1.84b	2.03	8.4a	8.2ab	7.8b	8.1
Canary Islands	58.4a	58.3a	55.1b	57.3	6.3a	6.1a	6.2a	6.2	1.91a	1.86ab	1.78b	1.85	8.2a	8a	8a	8.1
Catalonia	62.2b	60.5a	60.5a	61.1	6.4a	6.3a	6.4a	6.4	1.98a	1.92ab	1.89b	1.93	8.3a	8.3a	8.3a	8.3
Majorca	60.5a	60.2a	57.1b	59.3	6.2a	6.2a	6.3a	6.3	2.09a	2.12a	2a	2.07	8.3a	8.4a	8.3a	8.3
Murcia	57.9ab	58.6a	54.9b	57.1	6.2a	6.1ab	5.9b	6.05	2.04a	2.02a	2.06a	2.0425	8.2a	8.1ab	7.95b	8.125
Valencia	61.2a	60.1a	56.5b	59.3	6.32a	5.92b	5.97ab	6.07	2.07a	1.9ab	1.8b	1.97	8.4a	7.87a	7.8a	8.05
Mean	59.81a	59.4a	57.1b	58.79	6.19a	6.06b	6.08b	6.12	2.06a	2ab	1.92b	2.00	8.2a	8.1ab	8.01b	8.13

Mean values of each component followed by different letters are significantly different between years at $P < 0.05$.

Table 2. Major unsaturated fatty acid (% of total oil content) of the Spanish almond cultivars during the three years of study.

	Palmetoleic ac.				Oleic ac. (O)				Linoleic ac. (L)				R1 (O/L)			
Region	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean
Andalusia	0.38b	0.44a	0.4ab	0.41	73.1b	75.2a	73.7b	74	17.9a	15.6b	17.4a	17.0	4.1b	4.9a	4.4b	4.4
Aragon	0.47b	0.49ab	0.51a	0.49	70.9b	74.2a	74a	73	19.6a	16.6b	16.7b	17.7	3.8b	4.8a	4.7a	4.4
Canary Islands	0.47b	0.51a	0.48b	0.48	71.9b	74.8a	72.4b	73	18.7a	16.1b	17.4ab	17.4	4.1b	4.9a	4.2b	4.4
Catalonia	0.45b	0.45b	0.49a	0.46	68.5b	70.9a	70.2a	69.9	22.1a	19.6b	20.6b	20.7	3.2a	3.7a	3.6a	3.5
Majorca	0.44c	0.46b	0.49a	0.46	69a	70.9a	69.6a	69.8	21.7a	19.6b	20.6b	20.6	3.2a	3.7a	3.5a	3.5
Murcia	0.43b	0.42b	0.46a	0.44	73.4a	73.3a	73.2a	73.3	17.5a	17.2a	17.5a	17.4	4.2a	4.3a	4.4a	4.3
Valencia	0.49a	0.48a	0.45b	0.47	68.4c	72.3a	70.5b	70.4	21.5a	17.4c	19.4b	19.4	3.2b	4.3a	3.7ab	3.8
Means	0.45a	0.46a	0.47a	0.46	70.7b	73.1a	71.9b	71.9	19.8a	17.4c	18.5ab	18.6	3.7b	4.4a	4.1ab	4.0

Mean values of each component followed by different letters are significantly different between years at $P < 0.05$.

and for extracting oil because of their high oil content. Conversely, the “comunas” from Andalusia, Murcia and the Canary islands could be used to produce almond flour and milk.

The region of origin was highly significant regardingf the fatty acid composition (Tables 1, 2). The concentrations of the different fatty acids over the three years ranged between 5.74% in Andalusia and 6.36% in Catalonia for palmitic acid, 0.41% in Andalusia and 0.49% in Aragon for palmitoleic acid, 1.85% in the Canary Islands and 2.11% in Andalusia for stearic acid, 69.81% in Majorca and 74.02% in Andalusia for oleic acid, and 16.97% in Andalusia and 20.74% in Catalonia for linoleic acid (Tables 1, 2). These results show clearly that the fatty acid composition of the kernel oil not only depends on the genotype (Kodad *et al*., 2013; Sathe *et al*., 2008), but also on the gene pool origin. The year effect was significant for all the fatty acids considered (Table 2). The highest values of oleic acid were obtained in 2009 and the lowest in 2008 (Table 2). However, the oleic content of the Murcia and Majorca gene pools was stable between years. Concerning the linoleic acid, the highest values were obtained in 2009 (Table 2). It should be pointed out that the variability of these two components is more important between regions than between years. Fatty acid composition appears to be under polygenic control (Font i Forcada *et al*., 2011), modified by environmental conditions (Kodad *et al*., 2010). All these results indicate that the magnitude of the percentage of the different fatty acids in almond oil depends on the number of additive genes accumulated under specific environmental conditions.

Concerning the variables used as indices of oil stability and resistance against rancidity, the O/L ratio ranged between 3.47 in Catalonia and 4.45 in Andalusia (Table 3), and the SFA content ranged between 7.85% in Andalusia and 8.32% in Majorca (Table 2). The statistical analyses showed that there were no significant differences between Aragon, the Canary Islands and Andalusia for the O/L ratio and for the oleic acid composition (Table 2). It must be taken into account that high O/L ratios imply higher oil stability and, therefore, an index of almond quality and of resistance to rancidity, a trait that must be considered for the Spanish almond cultivars. Considering both the O/L ratio and the SFA percentage, the gene pools of Aragon, the Canary Islands, Murcia and Andalusia, present the most stable almond oil.

Tocopherol concentration. The region effect was highly significant for the three tocopherol homologues (Table 3). The concentrations over the two years for α-tocopherol ranged from 437. 94 in Andalusia to 478.6 mg/kg oil in Majorca; for γ-tocopherol from 12.5 in Valencia to 23.11 mg/kg oil in Catalonia; and for δ-tocopherol from 0.62 in Valencia to 1.29 mg/kg oil in Aragon. Under the CITA climatic conditions, the genotypes from Valencia, Murcia and the Canary Islands showed the highest variability between years for α-tocopherol, whereas the most stable were those from Majorca and Andalusia (Table 3). For γ-tocopherol, the most stable genotypes were those from Catalonia and Valencia. Since tocopherols, mainly α-tocopherol, are considered important components for protecting almond oil against oxidative deterioration (Senessi *et al*., 1996; Zacheo *et al*., 1998; García-Pascual *et al*., 2003), the high concentration of α-tocopherol and of oil content of the almond kernels from the cultivars of Aragon and Catalonia indicate that these kernels could be intended for industrial processing with the assurance that the product could stand processing manipulation without noticeable oxidative deterioration, as well as to be stored for a long time in adequate storage conditions.

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Table 3. Tocopherol concentration (mg/kg oil) of the kernel oil of the Spanish almond cultivars during two consecutive years.

	δ-tocopherol			γ-tocopherol			α-tocopherol		
Region	2009	2010	mean	2009	2010	mean	2009	2010	mean
Andalusia	0.65b	0.91a	0.78	12.02a	14.72a	13.37	425.83a	449.15a	437.49
Aragon	1.04b	1.55a	1.30	17.12a	16.82a	16.97	422.93b	494.82a	458.87
Canary Islands	1.01a	1.04a	1.03	19.61a	17.64a	18.63	421.22b	523.02a	472.12
Catalonia	1.18b	1.61a	1.39	20.90b	31.56a	26.23	451.26b	526.51a	488.89
Majorca	1.08a	0.96b	1.02	18.62a	16.91a	17.77	466.75a	479.33a	473.04
Murcia	0.67a	0.72a	0.69	10.94b	17.73a	14.33	392b	484.62a	438.31
Valencia	0.64a	0.66a	0.65	10.29b	16.05a	13.17	403.02b	495.19a	449.11

Mean values of each component followed by different letters are significantly different between years at $P < 0.05$.

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PHYSICAL FRUIT TRAITS IN MOROCCAN ALMOND SEEDLINGS: QUALITY ASPECTS AND POST-HARVEST USES

INTRODUCTION

Almond is the most important nut tree cultivated in Morocco. The total almond acreage is about 146,100 ha and two important production systems could be differentiated: modern and traditional (Anonymous, 2011). The modern system is characterized by the dominance of four cultivars, 'Marcona', 'Fournat de Brézenaud', 'Ferragnès' and 'Ferraduel' (Lansari *et al.*, 1994), with a density of 150 to 300 trees/ha (Loussert *et al.*, 1989). Trees are mostly grafted on 'Marcona' seedlings and conducted according to modern techniques under favourable climatic conditions. Although most modern almond orchards are located in production areas where irrigation is possible, only a few are irrigated (Mahhou and Denis, 1992). The traditional system covers more than 70,000 ha and is found in inauspicious regions, mainly in mountain regions and arid areas (Lansari *et al.*, 1998). In this traditional system almonds are grown under conditions where one or more environmental requirements are limiting. These include water during the growing season, soil depth, and nutrient availability, primarily N. Trees (mostly open-pollinated seedlings) are planted on slopes and hillsides, along streams, or interplanted with field crops, and are given little or no care (Mahhou and Denis, 1992), at an average density of 80 trees/ha, and are neither pruned nor sprayed. This system represents more than 80% of the almond surface in Morocco, with an estimated average production of 80 kg/ha (Anonymous, 2011), harvested by the local farmers, used by the family or sold locally.

Despite their low productivity, seedling trees represent a potential source of germplasm, both for selecting new cultivars and for use as parents in breeding programmes. Several studies have been conducted to evaluate the genetic diversity of the local almond seedlings in Morocco in order to select the best genotypes to be introduced in reference collections. The genetic structure of these populations has shown the presence of a great variability between genotypes of the same population (Lansari *et al.*, 1994), but also between populations (Lansari *et al.*, 1998). Selection of local almond genotypes for late-bloom, and frost and disease resistance have been carried out since 1975 (Laghezali, 1985). These studies have allowed the identification of genotypes of high yielding potential due to high spur density, or with kernels of good physical quality (Lansari *et al*., 1994).

One of the most important objectives of the new strategy of the Ministry of Agriculture in Morocco is enhancing almond production in the traditional sector in order to improve its marketing and to increase the income of local growers (Anonymous, 2011), taking into account the high level of poverty in these regions and the importance of almond in the economy of the households (Lebrigui, 2011). Almond commercial quality refers to all aspects related to the external appearance of the product, including size, shape, surface texture, kernel colour, absence of double kernels, and, ultimately, the level of marketable kernels (Socias i Company *et al*., 2008). The first step to improve the commercialization of any horticultural product is its characterization and description. Thus, the main objective of the present work was the evaluation of the physical fruit quality traits in the main important local almond populations in Morocco and its possible impact on the commercial value of the crop.

MATERIAL AND METHODS

Plant material and fruit traits. This study was carried out in five different regions rich in almond genetic resources: Aknoul and Al Hoceima situated in the Rif Mountains (North of Morocco), Azilal in the high Atlas Mountains (Central Morocco), and the valleys of Saïs and Tadla (Central Morocco). A total of 41 local genotypes from different zones of each region were selected because of the general status of the plant (vigour, ramification, foliar density and appearance), physical quality of kernel, late blooming and appreciation of their kernel by the local population. These genotypes were marked and fruits were collected in summer (7-10 August) at maturity, when the fruit mesocarp was fully dried and split along the fruit suture and peduncle abscission was complete. During two consecutive years (2009-2010), a sample of 50 fruits was collected randomly around the canopy from the marked plants.

Nut thickness and width were measured at the midpoint of the length, perpendicular to each other, considering width the larger dimension. Length, width, and thickness were measured with a precision of 0.01 mm in all nuts with a digital caliper. After measurements, nuts were cracked to obtain the kernel and determine the shelling percentage by weight using an electronic balance. Length, width, and thickness were similarly measured in all kernels. These variables allowed for the determination of the sphericity index (geometric diameter/length) of fruit and kernel, which is used to define their shape (Aydin, 2003). Kernel weight/nut weight is commonly used to describe shell hardness (Kester and Asay, 1975). The traits and their definition are summarized in Table 1.

Statistical Analysis. All statistical analyses were performed with the SAS program (SAS, 2000). A Principal Component Analysis (PCA) was applied to describe the pattern of almond diversity. In PCA, intercorrelation among variables (component) was removed, thus reducing the number of variables by linear combination of correlated characters into principal orthogonal axes (PC1, PC2, PCn) which are not correlated (Philippeau, 1986). The maximal amount of variance in the dataset and its direction are often explained by the first PC. Each PC is defined by a vector known as the eigenvector of the variance-covariance matrix. PCA is used to establish correlations between variables and to visualize the relationships of individuals in two or three dimensional graphs.

Table 1. Pomological traits analysed, units and abbreviations.

Trait	Unit	Abbreviation
Nut traits		
Nut weight	g	*PA*
Nut length	mm	*LA*
Nut width	mm	*LRA*
Nut thickness	mm	*EPA*
Nut width/nut length		*R1*
Shell weight	g	*Pq*
Nut sphericity	%	*Øn*
Nut geometric mean diameter (mm)	mm	*DpN*
Kernel traits		
Kernel weight	g	*PN*
Kernel length	mm	*LN*
Kernel width	mm	*LRN*
Kernel thickness	mm	*EPN*
Kernel length/kernel width		*R2*
Kernel sphericity	%	*Øk*
Kernel geometric mean diameter (mm)	mm	*Dpk*
Shelling percentage	%	Rdt

RESULTS AND DISCUSSION

Nut quality. In-shell fruit weight varied between 1.15 and 7.39 g (Table 2). Fifteen genotypes had fruit weight lower than 3 grams, 12 genotypes between 3 and 4 grams, and 20 genotypes between 4 and 7 g (Table 2). Thus, almost all selected genotypes present small in-shell fruit and, consequently, small kernel size because of their correlation (Kester *et al*., 1977), as it happens with most local Moroccan genotypes (Lansari *et al*., 1994).

Shell traits are very important for kernel protection during manipulation and processing. Almond shells are generally characterized by their hardness, shell-seal integrity, and shelling percentage. Shell hardness is inversely related to shelling percentage, and whereas it does not directly influence kernel quality, hard shells can reduce the proportion of nut meats recovered after shelling if adequate equipment is not utilized (Socias i Company *et al*., 2008). Shelling percentage in these genotypes ranged between 15.6 and 63.67% (Table 2), with 68% of the genotypes with very hard shell (10 to 30% of shelling percentage), 19% with hard shell (30 to 50%) and only 12% with soft shells (50 to 70%). Thus, almost all local almond selections produce hard to very hard shells, showing that with this kernel protection the nuts can be stored for a long time if not exposed to sunlight because those intact hard shells protect kernels from both insect damage and deterioration from molds (Schirra, 1997).

Pre-harvest and post-harvest damage is more common in soft shell cultivars because soft shells may provide an entry point for insects and fungi (Gradziel and Martínez-Gómez, 2002). Insect larvae, such as navel orange worm, *Amyelois transitella* (Rice *et al*., 1996), may cause early-season damage because can penetrate more easily the developing soft shell, reducing kernel quality (Crane and Summers, 1971). The separation of shell fragments from shelled nuts is however more difficult with hard-shell cultivars because of the similarities in density between the kernel and shell fragments (Schirra, 1997). Consequently, distinct industries have developed based on the shell types in different growing regions. In the Mediterranean region, most cultivars are hard-shelled and the processing plants are designed for

Table 2. Mean values of the physical nut and kernel trait of each genotype.

Genotype	Region	PA	Pq	LA	LRA	EPA	R1	DpN	Øn	PN	LN	LrN	EPSN	R2	Dpk	Øk	Rdt
AK1		4.96	3.76	33.90	22.66	17.08	0.67	22.85	67.41	1.20	22.84	13.74	7.65	0.60	13.05	57.11	24.17
AK10		2.75	2.16	25.04	18.02	13.22	0.72	17.62	70.37	0.59	17.81	10.53	6.55	0.59	10.46	58.72	21.28
AK11		3.32	2.63	19.25	23.56	17.06	1.22	19.20	99.72	0.69	17.57	11.30	8.79	0.64	11.74	66.83	20.77
AK12		2.65	2.03	24.11	20.73	14.02	0.86	18.58	77.06	0.62	16.82	11.40	6.50	0.68	10.51	62.48	23.47
AK13		3.37	2.43	19.77	23.96	16.77	1.21	19.37	97.95	0.94	23.19	12.65	6.49	0.55	12.08	52.11	27.79
AK14		4.79	3.83	29.89	23.67	16.56	0.79	22.02	73.65	0.95	21.15	13.77	7.04	0.65	12.39	58.56	19.91
AK2	Aknoul	4.19	3.11	36.72	24.00	14.14	0.65	22.46	61.19	1.09	25.08	13.44	7.34	0.54	13.18	52.56	25.92
AK3		5.01	3.86	34.54	23.32	17.20	0.68	23.27	67.36	1.16	24.75	14.01	7.40	0.57	13.34	53.89	23.05
AK4		7.34	6.19	40.58	24.91	17.09	0.61	25.02	61.66	1.15	26.95	12.64	7.39	0.47	13.25	49.16	15.66
AK5		6.99	5.53	37.75	26.87	19.61	0.71	26.21	69.45	1.46	24.68	15.15	7.53	0.61	13.75	55.71	20.94
AK6		3.76	3.19	22.44	24.22	16.39	1.08	20.11	89.62	0.57	17.09	11.72	6.39	0.69	10.60	62.03	15.05
AK7		4.56	3.54	32.87	22.47	14.99	0.68	21.60	65.73	1.02	23.59	12.91	7.00	0.55	12.55	53.19	22.27
AK8		3.51	2.62	31.20	18.97	13.47	0.61	19.39	62.15	0.88	22.43	12.00	6.70	0.53	11.87	52.93	25.21
AK9		3.40	2.62	31.62	21.66	12.53	0.69	19.86	62.83	0.78	20.00	13.06	5.57	0.65	11.06	55.27	22.86
AZ1		3.05	2.23	28.59	21.96	13.91	0.77	19.98	69.89	0.81	20.84	12.51	6.91	0.60	11.87	56.93	26.70
AZ2		3.82	3.02	32.16	21.87	13.37	0.68	20.48	63.68	0.80	22.73	13.65	5.62	0.60	11.74	51.64	20.93
AZ3		4.61	3.65	35.62	22.76	15.82	0.64	22.68	63.67	0.96	25.69	13.35	5.99	0.52	12.39	48.25	20.78
AZ4		5.01	3.99	31.20	23.51	17.49	0.75	22.68	72.71	1.01	21.50	13.57	7.76	0.63	12.80	59.53	20.19
AZ5	Azilal	4.61	3.69	31.95	23.59	15.40	0.74	21.94	68.69	0.93	20.14	13.52	6.52	0.67	11.81	58.62	20.10
AZ6		4.35	3.20	36.13	24.42	14.30	0.68	22.56	62.44	1.15	22.85	13.67	7.55	0.60	12.97	56.76	26.44
AZ7		4.29	3.34	29.49	21.54	16.19	0.73	21.09	71.50	0.95	21.81	12.92	7.18	0.59	12.33	56.54	22.06
AZ8		4.46	3.47	35.89	24.30	14.24	0.68	22.44	62.53	0.99	24.25	13.54	5.95	0.56	12.19	50.25	22.11
AZ9		3.37	2.64	29.19	20.81	13.12	0.71	19.39	66.41	0.73	23.94	12.04	5.49	0.50	11.37	47.50	21.74
BM1		4.76	3.78	34.19	23.02	15.30	0.67	22.21	64.97	0.99	24.14	13.30	6.91	0.55	12.71	52.65	20.68
BM2		1.93	1.36	22.77	17.30	11.48	0.76	16.08	70.63	0.57	17.71	10.60	6.41	0.60	10.39	58.66	29.68
BM3	Bnimellal	1.91	1.37	20.38	18.13	12.05	0.89	16.00	78.49	0.54	15.02	11.23	6.34	0.75	9.99	66.50	28.42
BM4		2.26	1.64	25.88	17.79	12.05	0.69	17.20	66.47	0.61	18.27	10.78	6.52	0.59	10.61	58.10	27.21
BM5		3.52	2.73	26.18	24.37	14.67	0.93	20.44	78.07	0.79	18.60	13.12	6.73	0.71	11.51	61.86	22.38
H1		6.52	5.05	40.37	26.99	18.56	0.67	26.36	65.29	1.47	26.89	15.36	7.01	0.57	13.88	51.62	22.51
H10		2.31	1.11	29.27	19.83	15.15	0.68	20.03	68.43	1.20	22.90	13.78	8.53	0.60	13.55	59.15	51.78
H2		4.03	2.95	33.84	23.68	15.26	0.70	22.33	65.97	1.08	24.33	13.93	6.87	0.57	12.91	53.08	26.82
H3		3.35	1.66	41.24	25.42	14.74	0.62	24.12	58.48	1.69	27.41	16.39	7.78	0.60	14.77	53.88	50.34
H4		1.63	0.77	31.09	17.24	12.35	0.55	18.23	58.65	0.86	22.19	10.64	6.87	0.48	11.46	51.66	52.79
H5	Al hoceima	4.94	3.69	37.61	23.89	16.90	0.64	23.98	63.76	1.25	27.62	14.05	6.81	0.51	13.46	48.75	25.25
H6		1.83	0.99	33.86	20.45	13.49	0.60	20.43	60.32	0.84	22.11	11.87	6.76	0.54	11.81	53.41	46.10
H7		3.79	2.64	35.95	22.12	17.16	0.62	23.15	64.39	1.15	24.36	12.79	7.82	0.53	13.11	53.83	30.47
H8		1.77	0.64	34.37	21.46	13.71	0.62	20.97	61.01	1.13	24.38	14.01	7.43	0.57	13.29	54.49	63.79
H9		2.46	1.17	33.82	23.23	14.60	0.69	21.86	64.63	1.29	23.18	14.25	7.21	0.61	13.01	56.13	52.38
Sf1		1.15	0.61	20.21	15.90	12.24	0.79	15.35	75.98	0.54	15.37	10.46	7.90	0.68	10.57	68.81	47.11
Sf2		2.00	1.07	29.38	20.42	14.91	0.70	20.14	68.55	0.93	21.88	12.71	7.61	0.58	12.51	57.19	46.34
Sf3		1.80	0.89	28.60	20.00	13.77	0.70	19.31	67.53	0.90	21.33	12.61	7.32	0.59	12.22	57.31	50.80
Sf4	Sfasif	2.15	1.22	26.15	20.52	15.51	0.78	19.66	75.20	0.93	19.23	13.28	8.73	0.69	12.73	66.20	43.11
Sf5		2.99	1.93	34.41	22.57	14.13	0.66	21.54	62.61	1.06	24.62	14.10	7.05	0.57	13.13	53.34	35.57
Sf6		3.62	2.47	30.97	22.26	15.06	0.72	21.15	68.29	1.15	24.29	13.29	7.70	0.55	13.20	54.35	31.80
Sf7		4.48	2.64	40.70	27.19	16.85	0.67	25.66	63.05	1.85	29.03	17.67	7.12	0.61	14.98	51.61	41.21

Abbreviations are defined in Table 1.

cracking these types (Socias i Company *et al.*, 2008). Thus, the processing plants to be adopted by the Moroccan industries must be adapted to hard shells. Consequently, hard-shell and soft-shell almonds must be separated by the growers and the industry in order to avoid kernel breakage during the mechanical shelling and increase the product value. Nut shape also affects mechanical shelling because the sheller must be adjusted to nut size and shape. Almond nuts are frequently marketed in Morocco as a mixture of different sizes and shapes, increasing the percentage of broken kernels at shelling. Nut shape was determined according to the IPGRI guidelines and by the sphericity index (Tables 2, 3). Nuts were narrow for 46% of the genotypes, ovate to round for 28%, and oblong for 27%.

Kernel Quality. The kernel is the edible part of the nut and is considered an important food crop, with a high nutritional value.

Table 3. Qualitative nut and kernel traits of each genotype.

Genotype	Nut shape	Shell hardness	Kernel shape colour	Tegument the kernel	Shrivelling of (%)	Double kernel pubescence	Tegument taste	Kernel
AK1	Medium	Very hard	Cordate	Dark	Wrinkled	48	High	Sweet
AK10	Very small	Very hard	Round	Dark	Wrinkled	56	High	Intermediate
AK11	Very small	Very hard	Round	Intermediate	Slightly wrinkled	60	Extremely high	Sweet
AK12	Very small	Very hard	Round	Dark	Slightly wrinkled	20	Extremely high	Sweet
AK13	Small	Hard	Cordate	Dark	Slightly wrinkled	16	Extremely high	Sweet
AK14	Small	Very hard	Cordate	Intermediate	Slightly wrinkled	8	High	Sweet
AK2	Small	Very hard	Cordate	Light	Intermediate	44	Intermediate	Intermediate
AK3	Medium	Very hard	Cordate	Intermediate	Slightly wrinkled	48	Intermediate	Intermediate
AK4	Medium	Very hard	Cordate large	Light	Slightly wrinkled	64	Low	Sweet
AK5	Large	Very hard	Cordate	Dark	Slightly wrinkled	48	Low	Sweet
AK6	Very small	Very hard	Round	Dark	Slightly wrinkled	56	Intermediate	Sweet
AK7	Small	Very hard	Cordate	Dark	Wrinkled	68	Low	Sweet
AK8	Very small	Very hard	Cordate	Dark	Wrinkled	52	Intermediate	Sweet
AK9	Very small	Very hard	Cordate	Dark	Intermediate	36	Intermediate	Sweet
AZ1	Very small	Very hard	Cordate	Dark	Wrinkled	44	Intermediate	Sweet
AZ2	Very small	Very hard	Oblong	Intermediate	Intermediate	32	Intermediate	Sweet
AZ3	Small	Very hard	Oblong	Dark	Intermediate	20	High	Sweet
AZ4	Small	Very hard	Round	Dark	Slightly wrinkled	48	High	Sweet
AZ5	Small	Very hard	Cordate	Intermediate	Slightly wrinkled	56	Intermediate	Sweet
AZ6	Medium	Very hard	Cordate	Intermediate	Slightly wrinkled	44	Low	Sweet
AZ7	Small	Very hard	Cordate	Dark	Slightly wrinkled	32	High	Sweet
AZ8	Small	Very hard	Oblong	Dark	Slightly wrinkled	20	Intermediate	Sweet
AZ9	Very small	Very hard	Oblong	Dark	Intermediate	40	Intermediate	Sweet
BM1	Small	Very hard	Cordate	Dark	Wrinkled	28	Extremely high	Intermediate
BM2	Very small	Hard	Round	Extremly dark	Wrinkled	44	Extremely high	Intermediate
BM3	Very small	Hard	Round	Extremly dark	Wrinkled	40	Extremely high	Sweet
BM4	Very small	Hard	Round	Dark	Intermediate	4	High	Sweet
BM5	Very small	Very hard	Round	Dark	Intermediate	44	High	Sweet
H1	Large	Very hard	Cordate large	Light	Wrinkled	44	High	Sweet
H10	Medium	Soft	Cordate	Dark	Slightly wrinkled	16	Extremely high	Sweet
H2	Small	Very hard	Cordate	Intermediate	Slightly wrinkled	32	Intermediate	Sweet
H3	Large	Soft	Cordate large	Intermediate	Wrinkled	24	Intermediate	Sweet
H4	Very small	Soft	Cordate	Light	Intermediate	44	Low	Sweet
H5	Medium	Very hard	Oblong	Dark	Wrinkled	20	High	Sweet
H6	Very small	Soft	Cordate	Intermediate	Slightly wrinkled	36	High	Intermediate
H7	Medium	Hard	Cordate	Dark	Slightly wrinkled	44	Intermediate	Intermediate
H8	Medium	Soft	Cordate	Intermediate	Intermediate	60	Intermediate	Sweet
H9	Medium	Soft	Cordate	Intermediate	Slightly wrinkled	72	Intermediate	Sweet
Sf1	Very small	Soft	Round	Dark	Wrinkled	40	Extremely high	Sweet
Sf2	Small	Soft	Cordate	Dark	Wrinkled	32	Extremely high	Sweet
Sf3	Very small	Soft	Cordate	Dark	Wrinkled	44	Extremely high	Intermediate
Sf4	Small	Soft	Round	Extremly dark	Wrinkled	48	High	Sweet
Sf5	Small	Soft	Cordate	Extremly dark	Wrinkled	28	High	Sweet
Sf6	Medium	Hard	Cordate	Dark	Intermediate	40	Extremely high	Sweet
Sf7	Large	Soft	Oblong	Dark	Intermediate	44	High	Sweet

It may be consumed raw or cooked, blanched or unblanched, combined and/or mixed with other nuts. It can also be transformed to be incorporated into other products or to produce marzipan and nougat (Schirra, 1997). Each one of the end uses of almond depends on the different physical traits and the chemical composition of the kernel (Socias i Company *et al*., 2008). Kernel size is commercially important, as larger sizes generally confer greater value (Socias i Company *et al*., 2008), because size may imply kernel use (Cavaletto *et al*., 1985). Kernel size depends on kernel weight, ranging in the genotypes studied from 0.54 to 1.85 g (Table 2), being classified (Gülcan, 1985) as very small in 37.8% (less than 0.9 g), small in 31% (0.9 to 1.1 grams), medium in 22% (1.1 to 1.4 grams), and large in 8% (1.4 to 1.8 grams). Almost all local almond populations produce small kernels. Not only smaller kernels may reduce yields for a given fruit load, but are also less valued and paid. Dry matter accumulation in almond kernels takes place in late summer, when the evaporative demand is at its maximum and other growth processes are very much reduced (Kester *et al*., 1996). Kernel dry weight may be reduced by severe drought conditions or even with moderate water stress during late summer (Girona *et al*., 2005). The small fruit of these selections may be explained by the fact that they are grown under arid and drought conditions. Medium to large kernels are desirable for most end uses, and small kernels are only appreciated for specialized uses, such as inclusion in chocolate bars, such as 'Felisia', with an average weight of 0.85 g (Socias i Company and Felipe, 1999) or 'Milow' of 0.82 g (Kester and Gradziel, 1996).

Kernel shape is a determining trait for some specialized uses, as longer, more oblong kernels are often desirable for sliced or slivered products since these kernels produce a more uniform sliced product (Schirra, 1997). Kernel shapes are most easily distinguished by the extent and uniformity of length/width ratio (L/W) (Kester *et al.*, 1980), without paying much attention to thickness (T) (Socias i Company *et al.*, 2008). According to almond descriptors (Gülcan, 1985), 4.4% of the genotypes produce narrow kernels (W/L from 0.43 to 0.49), 26.6% medium kernels (W/L from 0.50 to 0.56), 46.7% broad kernels (W/L from 0.57 to 0.63), and 22.2% very broad kernels (W/L ≥ 0.64). Kernel length, and to a lesser degree kernel width, is largely predetermined by the size of the seed cavity during early fruit development, whereas kernel thickness is more dependent on final seed fill, which is more vulnerable to late-season environmental stresses such as drought and diseases (Kester and Gradziel, 1996). Thus, Valverde *et al.* (2006) reported that under non-irrigated conditions 'Guara' produced kernels of greater mass (M), length (L), and width (W), whilst under irrigation kernels were thicker and more spherical. Kernel thickness in these genotypes ranged from 5.49 to 8.79 mm (Table 2). According to almond descriptors (Gülcan, 1985), 11.1% of the genotypes had very thin kernels (< 6mm), 36.6% thin kernels (from 6 to 6.9 mm), 46.7% medium kernels (from 7 to 7.9 mm), and 7.7% thick kernels (from 8 to 8.9 mm). Thus, almost all Moroccan almond seedlings produce kernels from very thin to medium, probably due to late-season environmental stresses such as drought and diseases.

About 35% of the genotypes produced kernels with pronounced wrinkle (Table 3). This trait is not desirable for direct consumption because consumers prefer smooth and uniform kernels without pronounced wrinkle (Cavalleto *et al.*, 1985). A high wrinkling degree is also reflected on the surface of blanched kernels, creating an undesirable appearance. Slight wrinkling, however, may be important in salted and flavoured nuts because these kernels may hold more seasoning on their increased surface area (Cavalleto *et al.*, 1985). In relation to the seed coat colour and texture, 90% of these genotypes showed a tegument with intermediate to dark color and more than 90% a rough surface texture (Table 3). Seed coats of light color and smooth surface are preferred (Socias i Company *et al.*, 2008). However, a rough "pubescence" facilitates a more uniform coating of processed almond kernels with salts and other flavorings, but it also may confer a "papery" mouth-feel. A greater pubescence is associated with darker seed coat colour and is less desirable for nuts consumed raw (Socias i Company *et al.*, 2008). Thus, fruits of these genotypes could be consumed blanched or they must be isolated during the sorting process to be destined to other uses than to direct consumption.

Double kernels were produced by all these genotypes with percentages ranging from 3% to 64% (Table 3). In some SE areas, almond populations showed higher percentages of double kernels, sometimes attaining 100%, because this trait has been selected by local growers (Lansari *et al.*, 1994). Double kernels occur when two seeds are present within the nut and result from the fertilization and development of both ovules normally present in the ovary. Several physiological and climatic causes have been suggested to favour this trait, but none has been clearly documented. Low temperatures before blooming (Egea and Burgos, 1994) or at blooming time (Spiegel-Roy and Kochba, 1974) have been mentioned as promoting higher percentages of double kernels. The earliest-blooming flowers seem to be the ones that produce the largest number of double kernels (Socias i Company and Felipe, 1994). All the studied genotypes are early-blooming (Table 3), which could explain the high percentages of double kernels. This trait is considered to be negative, lowering crop value (Kester *et al.*, 1980), since the simultaneous development of both kernels usually results in deformed nuts, which makes the processes of shelling, size selection, and blanching difficult (Socias i Company *et al.*, 2008). Double kernels are misshapen and therefore unsuitable for use as salted nuts or for slicing. Although a small percentage can be tolerated, significant amounts are undesirable. Thus, to improve the commercial values of the local almond cultivars, the growers must harvest the genotypes with high percentages of double kernels separately.

Diversity analysis. Statistical methods such as principal component analysis and cluster analysis are useful tools for studying the genetic diversity and have been applied to fruit species such as almond (Lansari *et al.*, 1994) and peach (Nikolić *et al.*, 2010). Consequently, PC analysis was applied to the average data of both years (Table 2). The best model with the minimum number of dimensions explaining the data structure was selected by the exclusion rule, based on the amount of residual variability to be tolerated, retaining a sufficient number of PCs capable of explaining a percentage of variance > 80%. With this rule, the first two PCs were enough because they described 87.38% of the sample variability. The contribution of each PC to the total variance is shown in Table 4. Kernel weight, length, width, sphericity index, length/width ratio and in-shell fruit length were primarily responsible for the separation on the PC1. The second component is represented by in-shell weight and width, shell weight and shelling percentage and the third component is represented by nut and kernel thickness and geometric diameter, nut sphericity index and length/width ratio.

When means were plotted on the two principal axes (Fig. 1), the almond population of al Hoceima had a high positive value on PC1. This showed the highest values for kernel weight, length and width, and the lowest values for sphericity index and length/width ratio (Tables 5, 6). In contrast, the population of Bnimellal had a high negative value on the first component (Fig. 1),

Figure 1. Position of the first two principal components (PC) scores of the physical almond kernel of the five Moroccan populations.

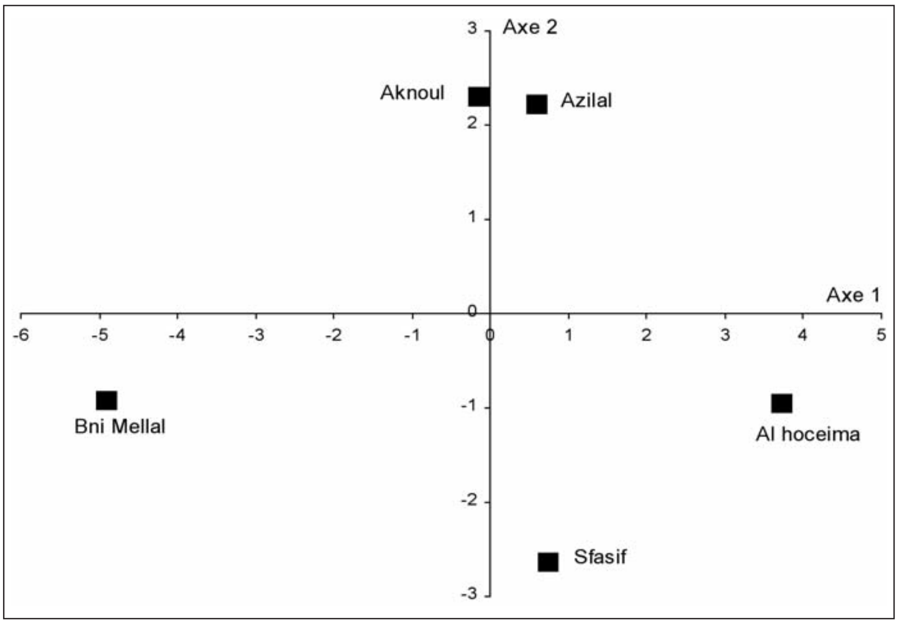


Table 4. Eigenvectors of the 3 principal components axes from PCA analysis of the Moroccan almond seedlings.

Variable	Axe1	Axe2	Axe3
Nut weight (g)	0.06	0.45	0.07
Nut length (mm)	**0.31**	0.06	-0.20
Nut width (mm)	0.24	**0.31**	0.09
Nut thickness (mm)	0.25	0.21	0.36
Shell weight (g)	-0.01	**0.46**	0.05
Kernel weight (g)	**0.31**	-0.11	0.06
Kernel length (mm)	**0.32**	0.02	-0.07
Kernel width (mm)	**0.31**	-0.07	0.00
Kernel thickness (mm)	0.19	-0.29	0.44
Nut width/nut length	-0.29	0.11	**0.31**
Kernel length/kernel width	**-0.30**	-0.13	0.11
Nut sphericity. %	-0.27	0.15	0.37
Kernel sphericity. %	**-0.28**	-0.14	0.27
Shelling percentage (%)	0.18	**-0.38**	0.01
Kernel geometric mean diameter (mm)	0.19	-0.29	0.42
Nut geometric mean diameter (mm)	0.25	0.22	0.33

Table 5. Means of nut traits of each population.

Region	PA	Pq	LA	LRA	EPA	DpN
Aknoul	4.3±1.37	3.4±1.17	29.9±6.56	22.7±2.25	15.7±1.94	2.5±0.10
Azilal	4.2±0.60	3.2±0.52	32.2±2.81	22.7±1.21	14.8±1.36	2.4±0.07
BniMellal	2.8±1.11	2.2±0.95	25.8±4.67	20.1±2.96	13.1±1.56	2.3±0.09
Al-Hoceima	3.2±1.59	2.1±1.47	35.1±3.77	22.4±2.84	15.1±1.88	2.4±0.10
Sfasif	2.6±1.16	1.5±0.80	30.1±6.43	21.2±3.40	14.6±1.45	2.4±0.08

Abbreviations are defined in Table 1.

Table 6. Means of kernel traits of each population.

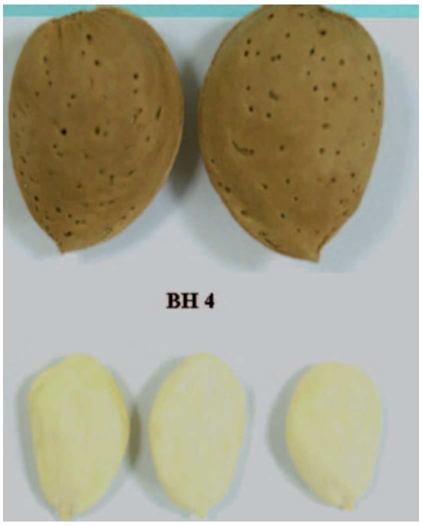
Region	PN	LN	LRN	EPSN	Dpk	Rdt
Aknoul	0.93±0.26	21.7±3.22	12.7±1.21	7.1±0.73	1.9±0.07	22.1±3.4
Azilal	0.92±0.12	22.6±1.67	13.2±0.55	6.5±0.79	1.8±0.08	22.3±2.3
BniMellal	0.70±0.17	18.7±2.98	11.8±1.17	6.5±0.21	1.8±0.02	25.6±3.5
Al-Hoceima	1.20±0.25	24.5±2.09	13.7±1.63	7.3±0.58	1.9±0.05	42.2±14.5
Sfasif	1.05±0.40	22.6±4.34	13.4±2.18	7.6±0.57	1.9±0.05	42.2±6.7

Abbreviations are defined in Table 1.

Insect damages on almond kernels. North of Morocco.

indicating that this population showed the lowest values for kernel weight, length and width, and the highest values for sphericity index and length/width ratio (Tables 5,6). On the second component, these populations had slightly negative values showing an intermediate to high value of shelling percentage and low values of in-shell fruit and shell weight and in-shell fruit width (Tables 5,6). On the third component, both populations had a slightly negative value showing intermediate to low values of the variables explaining this component (Table 4). The almond population of Azilal, the second most important local population after Al Hoceima, had a positive value on PC1 and PC2, showing intermediate values for kernel weight, length and width, and low values for sphericity index, length/width ratio, and shelling percentage, and high values of in-shell fruit weight and width and shell weight (Tables 5 and 6). On PC3, these populations showed a thin nut and kernel and medium to narrow nut. The Sfasif population had slightly positive values on PC1 and PC2 (Fig. 1), characterized by intermediate values of the variables explaining this component (Table 4), however on PC2 showed the highest value of shelling percentage and the lowest values of the in-shell and shell weight (Tables 5, 6). The almond population of Aknoul is characterized by intermediate to low values of the variables explaining the first component, and very low values of shelling percentage and very high values of in-shell fruit and shell weight on the PC2. On the third axe this population showed thicker nuts and kernels and broad nuts (Table 4). These results showed that the nuts produced in Aknoul and Azilal are the heaviest, of 4.33 and 4.17 grams, respectively, and those produced in Al Hoceima the largest, 35 mm (Tables 5 and 6). The kernels produced in Al Hoceima and Sfasif are the heaviest (1.20 and 1.05 grams, respectively) and largest (24.25 and 22.65 mm, respectively) than those produced in the other regions (Table 5, 6). Furthermore, the shell of the populations of Al Hoceima and Sfasif is less hardy than that of the other populations (Table 5, 6).

The present analysis enabled the definition of the genetic structure of the almond seedling populations in Morocco using physical nut and kernel parameters in order to prospect for the regions with interesting populations. The objective was the identification and selection of the best genotypes to be incorporated as parents into almond breeding programmes in Morocco in order to select new cultivars with good agronomical traits, medium blooming date, self-compatibility and tolerance to drought stress.



Nut and kernel of selected almond tree.
North of Morocco.

CONCLUSION

The present study focused on evaluating physical nut and kernel traits of the Moroccan almond seedlings from a qualitative point of view in order to better define the possible end uses of the resulting kernels and the best machinery required to process the crop industrially. The present results show that the kernels produced by local almond seedlings are of low quality, because of their low kernel weight, seed coat darkness, high percentage of double kernels, and wrinkled kernels. These negative traits reduce the marketable value of this production because they do not meet the physical quality standards required by the market (Socias i Company *et al.*, 2008). However, the chemical composition of these kernels was of very high quality (Kodad *et al.*, 2011), suggesting others post-harvest utilizations, such as marzipan, almond flour and oil. These industrial products could increase the marketable value of these local populations, thus increasing producers' income. The differences between the various Moroccan almond populations suggest the possibility of selecting the best regions for each product and the identification of the best genotypes for their possible incorporation as parents in almond breeding programmes.

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THE HUNGARIAN WALNUT INDUSTRY

Walnut (*Juglans regia* L.) is the most important shell fruit species in Hungary. Its production has a long term tradition countrywide. There is a walnut population in Northeast Hungary which probably used to be native to the Carpathian basin (Terpó, 1976).

Based on results of the last data collection fulfilled in 2001, the total surface area of Hungarian walnut orchards is 3,200 ha (Anonymous, 2002a). After the year 2001 there are only surface estimations for walnut orchards. According to these estimations there might be about 4,500-5,000 ha of walnut orchards in the country. There are many small farmers, which means that around 50% of Hungarian walnut orchards are smaller than 0.5 ha, and that the ratio of large farms (equal or larger than 10 ha) is just 6% (Anonymous, 2002b). The most important walnut growing regions are Somogy and Szabolcs-Szatmar counties (Figure 1). Szabolcs-Szatmar county raises 30% of the total production and Somogy county's production ratio is 10% (Anomymous, 2002a).

The Hungarian climatic conditions are suitable for walnut production, but growers prefer low hills instead of totally flat fruit growing sites to ensure safe climatic conditions for the orchard. A safe fruit growing site guarantees a safe production, because the leafing-out of the approved varieties starts around 15th to 20th April. Therefore, late spring frosts may damage young shoots.

Based on the above-mentioned reasons, Hungary is on the Northern border of the safe walnut growing area. Therefore, before establishing an orchard, it is compulsory to have the chosen fruit growing site evaluated. The Research Institute for Fruit growing and Ornamentals Budapest-Érd has the right to do this activity. The aim of the evaluation process is to select the best sites for walnut growing and to avoid the establishment of a walnut orchard in unsuitable climatic conditions. The evaluation process involves a site visit, where location, climatic conditions, and the exposure of the chosen site are checked, and a discussion is held on the results of soil analysis. The Research Institute has a so-called Hungarian Fruit Site Cataster database, where data are available on all sites suitable for walnut growing (this database contains sites for every fruit species).

Walnut consumption peak takes place before Christmas. Walnut strudel is a traditional Christmas sweet which cannot be missed on a Hungarian family's Christmas table. In other periods of the year, walnut consumption is low. However, the Hungarian-bred walnut varieties fit well in health-related nutritive diets, because their phythochemical content is higher compared to other walnut varieties (Bujdoso *et al.*, 2010). Average yearly walnut consumption is around 0.5 to 0.7 kg per year per capita (Kállay *et al.,* 2000) which is very low and below the European average.

Hungarian growers only use trees grafted on common walnut (*Juglans regia* L.) as planting material to establish a new orchard: it is not allowed to plant seedlings. Two year old non-feathered grafted trees, with a height of at least 1.5 m, are the standard planting material. The Hungarian nurseries use bench hand grafting during winter time as a propagation method.

Hungarian growers prefer to select Hungarian walnut varieties bred by Prof. Dr. P. Szentivanyi. He used genotypes of a Carpathian race (a local population) in his landscape selection and this population was crossed with 'Pedro' variety in his cross breeding work. Three landscape selected varieties ('Alsoszentivani 117', 'Milotai 10' and 'Tiszacsecsi 83') as well as five hybrid varieties ('Alsoszentivani 117' x 'Pedro': 'Bonifac', 'Alsoszentivani kesei', 'Milotai 10' x 'Pedro': 'Milotai botermo', 'Milotai kesei', 'Milotai intenzív') are on the National Variety List, and are made available for growers (Fig. 2).

Generally, growers prefer landscape selected walnut varieties because their ripening time is the earliest on the Northern hemisphere, their fruit size is larger than 32 mm (Ø), their shell and kernel colour is light and their kernel may be yellowish or light brown.

In the case of hybrid varieties, growers confirmed that hybrid varieties achieved higher yield than landscape selected varieties, as their terminal and lateral buds also yield. 'Milotai kesei', 'Bonifac' and 'Alsoszentivani kesei' have a late leafing-out time, which means that these varieties can leaf out around early May, right after late spring frosts. Therefore they can guarantee safe walnut productions. Their fruit

Figure 1. Distribution of walnut orchards by counties in Hungary.

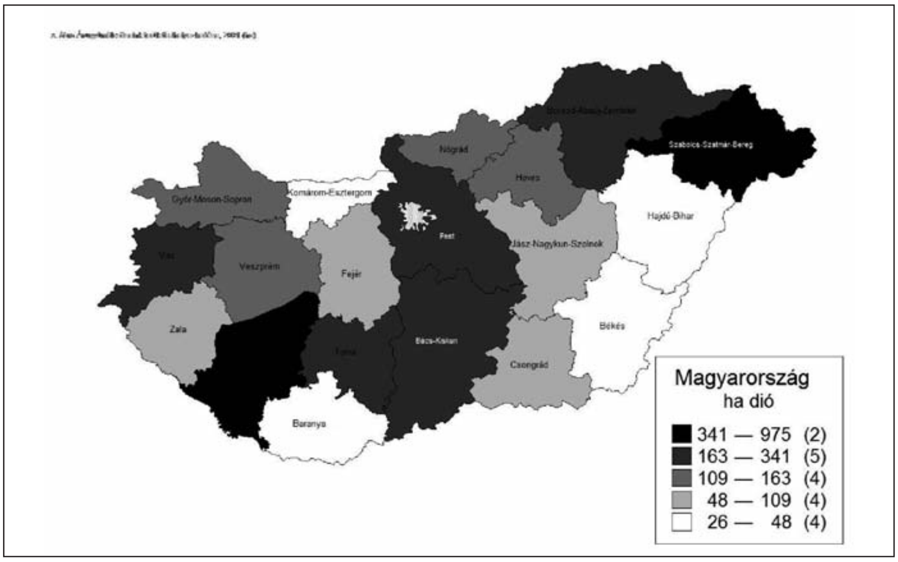
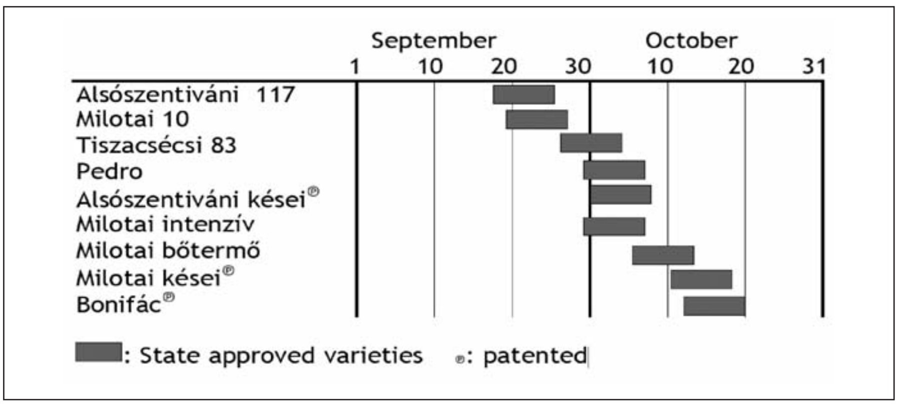


Figure 2. Ripening time of Hungarian bred walnut varieties that are on the Hungarian National List.



quality is excellent. Therefore nuts reach an average Ø of 32 mm.

Some scientific papers show results on higher sensitivity of novel bred walnut varieties. The novel Hungarian bred walnut varieties are also a bit more sensitive to *Xaj* compared to standard varieties (Rozsnyay 2006, Rozsnyay-Szügyi, 2009). Growers agree that they have to spray the novel bred varieties a couple of times more, but they obtain higher yields using hybrid instead of landscape selected varieties.

'Alsoszentivani 117' and 'Milotai 10' are the most important and largely planted varieties. 'Alsoszentivani 117' has the earliest ripening time and therefore is very popular. 'Milotai 10' has the best shell and kernel quality and therefore is highly appreciated by growers. Usage of novel bred walnut varieties was started in the last decade.

When establishing a new walnut orchard, growers plant double tree rows on a one hectare orchard to obtain first yields as high as possible. Tree thinning is made at the 13th to 20th leafing out after planting, when canopies get really close to each other.

Today, irrigation is an important issue in walnut production, as average yearly precipitation (500 to 700 mm yearly) is not enough. Hungarian growers do not irrigate walnut orchards, but they are considering it. In order to achieve stable productions and good fruit quality, the Hungarian walnut orchards must be irrigated in the future. There is enough water available and growers have the right to use it.

The most important disease is *Xaj* (*Xanthomonas arbicola pv. juglandis*), which can cause great damage, mainly on novel bred hybrid varieties' fruits and leaves. The most sensitive variety is 'Milotai intenzív', while the less sensitive are 'Milotai kései', 'Alsoszentivani kesei' and 'Bonifac'. Phoma/Phomopsis is spreading in Hungarian walnut orchards (Vajna – Rozsnyay, 2005).

At present, the walnut husk fly (*Rhagoletis complete* Cresson) has not been isolated yet in Hungary. The most important pest is the codling moth (*Cydia pomonella* L.).

The Research Institute for Fruit growing and Ornamentals, Budapest-Erd, has made numerous innovations in the field of mechanization since the 1970s. Therefore, it is common to see the most suitable machines in the walnut orchards and processing plants. As mechanization also includes post-harvest technology, Dr. Andor has pieced together a special line which contains a husk removal machine, a washing and a drying machine, a sizer, as well as a manipulation line and/or cracking adapter. There are 14 processing plants in the country, which capacity covers the whole Hungarian walnut processing capacity.

It is not easy to decide on the best way growers may sell their products. Walnut products can be commercialized in shelled or kernel form. Hungarian growers prefer shelled walnuts, because Hungarian bred walnut varieties ripe first on the Northern Hemisphere and their fruit size is larger than the competitor's varieties. Also, their shell colour and surface are excellent.

Unfortunately, Hungary has no field advisor system supported by the State. The Ministry of Rural Development used to stimulate the establishment of new walnut orchards. Today, growers or co-operatives have the possibility to apply for developing projects in agreement with the EU policy.

Thus, the Hungarian walnut industry is increasing year after year, due to a good and stable market situation. In order to increase the success of the Hungarian walnut industry, a Walnut Association will be founded by Industry members in the near future, with the hope that Hungary may stabilize its current success in the future.

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KERNEL QUALITY IN A LOCAL WALNUT *(JUGLANS REGIA)* POPULATION GROWN UNDER DIFFERENT ECOLOGICAL CONDITIONS IN MOROCCO

INTRODUCTION

Persian or English walnut (*Juglans regia* L.) is native to the mountain ranges of Central Asia (Leslie and McGranahan, 1998). It is a traditional fruit crop in North Africa and its first introduction into the Maghreb is attributed to the Romans (Germain, 1992). Walnut covers an area of 7,600 ha in Morocco, being considered by local farmers and populations as a forestry fruit tree. Walnuts are found in mountainous and remote areas between 800 and 1,800 m above sea level and under different environments (Lansari *et al*., 1999). Its nuts are easily stored and transported over long distances. Thus, the walnut tree can be found in humid and warm Mountains (north of Morocco), semi-arid and cooler Mountains (high Atlas Mountains) and arid regions in the southeast of Morocco. More than half of the trees are seedlings resulting from the prevailing form of propagation known by farmers, since grafting is unusual. The genetic variability of Moroccan walnut groups, defined as "populations" or "geographic provenances" and named by sampling site, was investigated using morphological traits (Kodad, 2000; Lansari *et al*., 2001). The results of these studies showed that the genetic variability of the local Moroccan walnut populations is assumed to be very large. Morocco, as well as other countries with forestry resources, is paying great attention in protecting seedling stands as valuable tools for biodiversity conservation, and as a source of high quality plant material. Moreover, the selection of productive and drought tolerant genotypes with high kernel quality could be essential for the conservation of walnut in different producer regions of Morocco. Taking into account the climate change scenarios from drought and heat stress, low rainfall and increase of biotic stresses, the selection of the seed source may be crucial for the success of future plantations (Hemery, 2008). Moreover, Callaham (1994) reported that the provenance research provides an excellent basis for the selection of seed sources and refers to the geographical origin of seeds or trees. In fact, several studies reported that the physical fruit traits (McGranaham and Leslie, 1990) and chemical kernel profile (Amaral *et al*., 2003; Crews *et al*., 2005; Martinez *et al*., 2006) depend on the genotypes, with a strong effect of the environmental conditions. The present study aims at the evaluation of genetic diversity and genotype

Walnut population in High Atlas Mountain in Morocco.

performance of the local walnut seedlings from different Moroccan eco-geographical provenances.

MATERIAL AND METHODS

Plant material. This study was carried out with walnut genotypes from four different regions rich in genetic resources: Bni Mtir in the Middle-East of the Atlas Mountains, Imlile and Oukaimeden in the high Atlas Mountains (Central-Southern Morocco), Midelt situated in the high valley of Moulouya in Central-Eastern Morocco, and Er-Rich in South-Eastern Morocco. A total of 25 local genotypes from different zones of each region were selected because of the general status of the plant (vigour, foliar density and appearance), a lateral fructification, and kernel physical quality appreciated by the local population. These genotypes were unique seedlings; therefore each genotype was a single tree. These genotypes were marked and fruits were collected in winter in 2010. The nuts were collected when the fruit mesocarp had split and peduncle abscission was complete. After cracking, the kernels were soaked in liquid nitrogen and then ground using an electrical grinder (IKA, Janke & Kunkel, Germany) to obtain fine flour.

Physical fruit traits. Nut thickness and width were measured at the midpoint of the length, perpendicular to each other, considering width the larger dimension. Length, width, and thickness were measured with a precision of 0.01 mm in all nuts with a digital caliper. After measurements, nuts were cracked to obtain the kernel and determine the shelling percentage by weight using an electronic balance. Length, width, and thickness were similarly measured in all nuts.

Kernel chemical determination. Oil was extracted from 5 grams of ground walnut kernel using a fat extractor Soxtec during 5 hours and using hexane as a solvent (AOCS Ce 2-66 modified). The oil content was expressed as the difference in weight of the dried kernel samples before and after extraction. The protein content was obtained indirectly by determining the total N content obtained by the Kjeldahl method (AOAC, 1995) and multiplying by nitrogen-protein conversion factor (Kc =6.25) (% Protein = Kc * % Total nitrogen).

Statistical analysis. All statistical analyses were performed with the SAS program. Analysis of variance was performed with a two random factors design. The factor genotype was hierarchical to the factor population because the trees were not repeated between sites. To draw a general conclusion from the four walnut locations, the population was considered as a random effect (Steel and Torrie, 1960). The Principal Component Analysis (PCA) was applied to describe the pattern of walnut diversity.

Table 1. Analysis of variance of physical traits and oil and protein contents of Moroccan walnut seedlings.

Variable	d.l	Mean squares	*F*-Value	*P*
Nut weight				
Population	4	86.09	221.34	<.0001
Genotype(population)	21	27.83	71.55	<.0001
Error	365	0.38		
Kernel weight				
Population	4	3.96	249.82	<.0001
Genotype(population)	21	0.72	45.64	<.0001
Error	365	1.015		
Shell weight				
Population	4	70.75	172.93	<.0001
Genotype(population)	21	22.75	55.62	<.0001
Error	365	0.41		
Kernel weight/Nut weight				
Population	4	0.32	194.44	<.0001
Genotype(population)	21	0.08	48.50	<.0001
Error	365	0.001		
Oil content				
Population	4	77.11	37.27	<.0001
Genotype(population)	20	34.99	16.91	<.0001
Error	25	2.06		
Protein content				
Population	4	25.59	24.06	<.0001
Genotype(population)	20	6.62	6.23	<.0001
Error	25	1.06		

RESULTS AND DISCUSSION

Genotype and location variability. The analysis of variance was carried out on some nut and kernel traits considered as important quality parameters in walnut. This analysis showed high variability between genotypes for nut and kernel weight, shell hardness, kernel ratio, protein and oil content (Table 1). The range of variability for oil content was between 51.59 and 69.91%, and between 9.21% and 13.77% for protein content (Table 2). The protein content agreed with previous reports (Amaral *et al.*, 2003), as well as

Table 2. Mean value of oil content, protein content and physical trait of nut and kernel of Moroccan walnut seedlings.

Genotype	Protein content (%DM)	Oil content (%DM)	Nut length (mm)	Nut width (mm)	Nut thickness (mm)	Nut weight(g)	Shell thickness (mm)	Kernel weight(g)	Partition weight(g)	Shell weight(g)	Kernel ratio
AM2	11.22	68.47	40.60	32.30	31.10	13.80	1.80	5.01	0.40	8.40	0.36
AM3	9.58	68.66	38.20	31.40	31.00	11.60	1.50	5.10	0.40	6.10	0.44
AM4	10.20	55.09	35.50	29.80	30.70	6.60	1.20	1.70	0.20	4.70	0.26
ZH1	9.62	61.94	36.10	31.50	31.50	10.70	1.30	4.30	0.30	6.10	0.40
ZH2	11.01	62.39	34.80	32.10	30.30	10.50	1.30	4.50	0.20	5.80	0.43
ZH3	11.63	58.74	34.70	32.10	31.30	11.70	1.50	4.60	0.20	6.90	0.39
Er-Rich	10.71	62.55	36.65	31.53	30.98	10.82	1.43	4.20	0.28	6.33	0.38
BM1	11.02	68.08	35.40	26.80	27.40	7.80	1.10	3.70	0.20	3.90	0.47
BM2	12.03	62.36	35.90	28.10	27.50	6.70	1.10	2.20	0.20	4.30	0.33
BM3	12.22	65.23	35.90	29.40	30.30	9.10	1.30	3.60	0.20	5.30	0.40
BM4	10.59	62.82	34.40	29.29	28.90	8.80	1.30	4.10	0.20	4.50	0.47
Bni Mtir	11.47	64.62	35.40	28.40	28.53	8.10	1.20	3.40	0.20	4.50	0.42
IM10	11.16	65.81	38.40	32.90	35.40	14.90	1.70	5.80	0.30	8.80	0.39
IM12	12.44	58.10	41.30	32.40	33.80	9.20	1.20	3.50	0.30	5.40	0.38
IM13	11.84	65.82	34.70	31.40	32.20	10.50	1.50	4.40	0.30	5.80	0.42
IM2	12.34	62.70	35.30	27.80	28.10	8.08	1.40	3.30	0.20	4.50	0.41
IM4	11.42	61.79	35.60	31.10	32.80	10.20	1.40	4.50	0.30	5.40	0.44
IM5	9.89	64.68	33.30	28.40	28.28	8.20	1.40	3.50	0.20	4.50	0.43
Imlile	11.68	63.15	36.43	30.67	31.76	10.18	1.43	4.17	0.27	5.73	0.41
O1	11.89	58.75	33.30	30.30	30.80	10.01	1.40	4.50	0.30	5.20	0.45
O2	11.90	52.34	39.20	35.90	36.40	12.80	1.60	5.10	0.30	7.40	0.40
O3	11.98	65.62	39.10	32.30	34.30	14.60	2.20	5.40	0.40	8.80	0.37
O5	11.08	53.97	37.90	30.70	28.90	9.60	1.50	3.70	0.20	5.70	0.39
O6	10.80	55.91	36.40	29.30	30.60	8.20	1.10	3.50	0.30	4.40	0.43
Oukaimeden	11.53	57.32	37.18	31.70	32.20	11.04	1.56	4.44	0.30	6.30	0.41
MT1	10.70	59.84	33.03	28.70	28.50	8.40	1.60	2.70	0.30	5.40	0.32
MT2	11.31	61.39	30.80	26.50	28.10	8.20	1.60	3.10	0.20	4.90	0.38
MT3	10.42	65.62	30.70	28.60	28.80	8.30	1.30	4.04	0.20	4.10	0.48
MT4	10.55	66.72	35.70	30.30	31.20	10.70	1.50	4.20	0.30	6.20	0.39
Midelt	10.74	63.39	32.56	28.53	29.15	8.90	1.50	3.51	0.25	5.15	0.39

the fat content, although the lowest value obtained was lower than any previous report (Amaral *et al.*, 2003; Bada *et al.*, 2010). The range of variability for nut weight was between 6.6 and 14.9 g; and 1.7 and 5.8 g for kernel weight; and between 25.75% and 48.19% for kernel ratio (Table 2). In general, the values for these fruit parameters are lower than those reported in other local populations of walnut (Iran: Arzani, 2008; Turkey: Aslantas, 2006; Albania: Zeneli *et al.*, 2005). The kernel weight should range from 6 to 8 g and the kernel ratio should range from 50 to 55% in promising walnut cultivars according to Akça (2009) and Nenjuhin (1971), but in the present study no genotypes satisfy these commercial criteria.

The population effect was significant for all studied traits (Table 2). For nut parameters, the Oukaimeden genotypes had the highest values of nut weight (Table 1). The lowest values for nut weight were obtained in the Er-Rcih gene pool (Table 1). For kernel weight and kernel ratio, the highest values were obtained in the Imlile and Oukaimeden gene pools (Table 1), and the lowest values in the Er-Rich gene pool (Table 1). The location and the growing conditions have been reported to affect fruit and kernel weight (Diaz *et al.*, 2005). For oil and protein content the growing conditions appear to affect these components in walnut (Amaral *et al.*, 2003; Crews *et al.*, 2005; Martinez *et al.*, 2006), where the same genotypes were tested in different locations. In our study, however, the genotypes are different in each population, showing that the geographical origin of the genotypes affects the physicochemical components of the kernels of local walnut populations, probably as a consequence of local adaptation of these genotypes. Almost all of the genotypes from humid and cooler regions (Imlile and Oukaimeden) show heavy and fat kernels (Table 2). These results could be explained in part by the differences in the growing and climatic conditions between geographical origins, as reported in shea butter, *Vitellaria paradoxa* C.F. Gaertn. (Maranz and Weisman, 2004) and almond, *Prunus amugdaus* Batsch (Kodad *et al.*, 2013). Furthermore, these results clearly show that nut and kernel weight and protein and oil content not only depend on the genotype (Amaral *et al.*, 2003; Diaz *et al.*, 2005), but also on the gene pool origin. Similar results have been reported in almond (Kodad *et al.*, 2010; 2011). The present results show a clear effect of geographical origin on the physical and chemical components of the walnut kernels placing the emphasis on selecting the promising genotypes in each cultivation area in Morocco.

Genetic diversity. Statistical methods such as principal component analysis and cluster analysis are useful tools for studying the genetic diversity and have been applied to tree nut species such as almond (Lansari *et al.*, 1994; Kodad *et al.*, 2011). The best model with the minimum number of dimensions explaining the data structure was selected by the exclusion rule, based on the amount of residual variability to be tolerated, retaining a sufficient number of PCs capable of explaining a percentage of variance > 80%. With this rule, the first three PCs were enough because they described 78.58% of the sample vari-

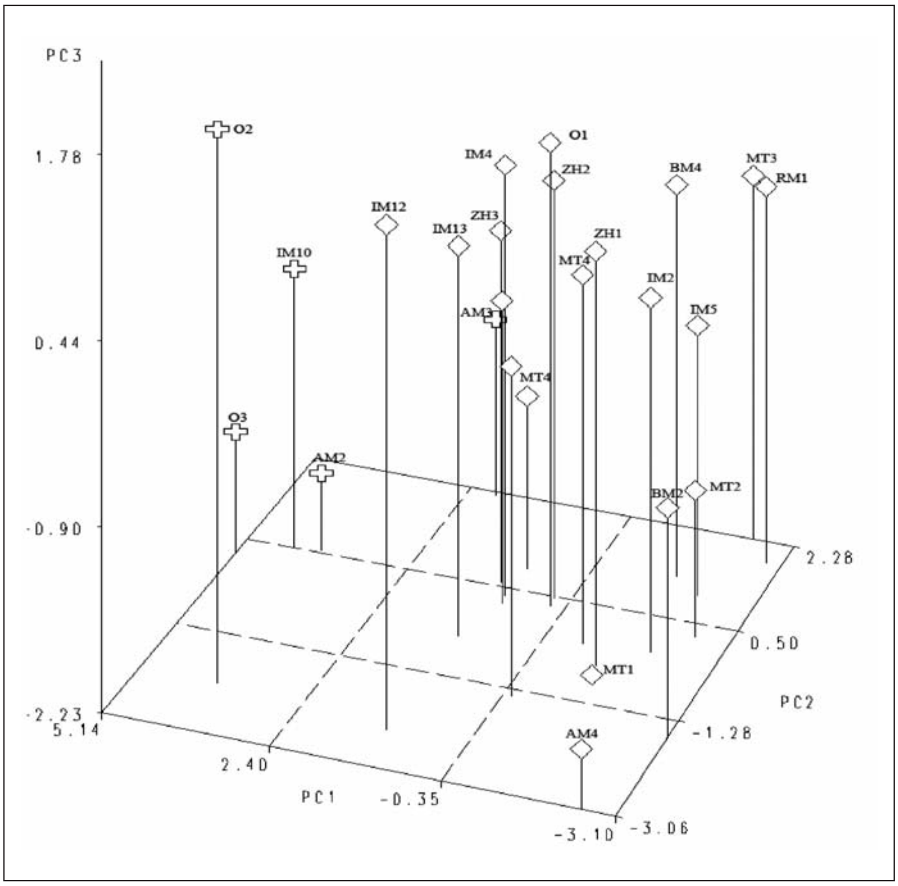
Table 3. Eigenvectors of the three principal components axes from PCA analysis of the Moroccan walnut seedlings.

Variable	Axe 1	Axe 2	Axe 3
Protein content (% DM)	0.07	-0.29	**0.37**
Oil content (%DM)	0.05	**0.58**	-0.27
Nut length (mm)	**0.29**	-0.26	0.05
Nut width (mm)	**0.36**	-0.19	0.25
Nut thickness (mm)	**0.36**	-0.18	0.23
Nut weight (g) (A)	**0.41**	0.13	-0.01
Shell thickness (mm)	**0.31**	0.09	**-0.38**
Kernel weight (g) (B)	**0.35**	0.14	0.26
Partition weight (g)	**0.32**	0.09	-0.23
Shell weight (g)	**0.40**	-0.03	-0.19
Kernel ratio (B/A)	-0.02	**0.54**	**0.61**

ability. The contribution of each PC to the total variance is shown in Table 3. Nut, kernel, shell and wall weight, and nut length and width were primarily responsible for the separation on the PC1. The second component is represented by oil content and kernel ratio and the third component is represented negatively by shell thickness and positively by kernel ratio. The present results confirm that nut and kernel physical traits are the most variable among walnut genotypes in local Moroccan seedlings (Lansari *et al.*, 2001).

When means were plotted on the three principal axes (Fig. 1), more than 56% of the genotypes showed intermediate to low nut and kernel weight and dimension and oil content (Table 2). When the analysis focused on the origin of the genotypes, it appears that genotypes from Bni Mtir (Middle-East Atlas Moutains) and genotypes from Midelt (High Valley of Moulouya) showed the lowest values for nut and kernel weight and dimensions (Fig. 1; Table 2). However, some genotypes such as BM1 from Bni Mtir and MT3 from Midelt showed high oil content. In contrast, almost all genotypes from the high Atlas Mountains showed intermediate to high values for nut and kernel weight and dimensions and fat content. These results are in accordance with those found applying analysis of variance (Table 1).

Figure 1. Position of the first three principal components (PC) scores of the physical and chemical component of the Moroccan walnut seedlings.



At individual level, the genotypes AM2 from Er-Rich (South of Morocco), IM10 from Imlile and O3 from Oukaimeden (High Atlas) had a very high positive value on PC1. This showed the highest values for kernel and nut weight, nut length and width, and the highest shell hardness (Table 2). On the second component, these genotypes had slightly positive values showing an intermediate value of kernel ration and oil content (Table 2). Regarding the third component, these genotypes had a negative value indicating that these genotypes show low values for protein content (Table 2). Genotype AM2 from Er-Rich (Southern Morocco) is very interesting because of its high positive value on PC1 and PC2 (Fig. 1), indicating its heavy nut and kernel and high fatty content (Table 2). Furthermore, genotypes IM4, IM12, O1 and O2 (High Atlas mountains) showed a high value on PC3 (Fig 1), indicating that these genotypes had very high protein content.

The results of the multidimensional analysis clearly showed that walnut grown in Morocco is characterized by the high variability of physical andchemical traits of nut and kernel. This variability could be used to select the best genotypes with adapted traits, high productivity and good kernel in each region to be propagated vegetatively as new local cultivars or to select the genotypes with high productivity and fatty kernel to be used as source seed for extending the recovery of degraded walnut forests in Morocco. Taking into account the relevance of high lipid contents as a source of carbon and energy during germination and seedling growth (Chenvard *et al.*, 1994), the genotypes IM5 from Imlile (high Atlas mountain), BM1 and BM3 from Bni Mtir (Middle-Eastern Atlas Mountain), AM3 from Er-Rich (Southern Morocco) and MT3 from Midelt (high valley of Moulouya) could be considered as seed sources for walnut propagation in each walnut productive region in Morocco as a tool to recover from forest degradation, since the choice of the seed source is considered crucial for the success of future plantations in silvicultural management (Hemery, 2008; Callaham, 1994).

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PISTACHIO RESEARCH IN TUNISIA: PAST, CURRENT AND FUTURE INVESTIGATIONS

INTRODUCTION

The cultivation of pistachio nut trees in Tunisia is probably very old. Archaeological studies bear witness to the presence of pistachio nuts during the Carthaginian period (Hurst and Stager, 1978). The need to develop pistachio culture in Tunisia increased since the Robert Willard Hodgson mission (1930-1931). Hodgson (1931) highlighted the potential economic and social gains of pistachio culture due to its adaptation to the extreme conditions of arid areas and its fruit quality. However, its expansion was very limited until the 1960s. In 1964, pistachio cultivation occupied only 30 ha mainly in the central and south part of the country. The two FAO-INRAT projects (1964-1972) greatly contributed to the extension of this crop. Many technical problems related to crop multiplication were resolved, new varieties and rootstocks were introduced and orchards were installed in different bioclimatic areas to study the behavior of local and foreign genotypes. Currently, pistachio cultivation occupies 37,000 to 43,000 ha with a total annual production of 2100 to 2700 tons (official national data, 2011; FAO, 2012). The FAO world classification of pistachio cultivation placed Tunisia in the 5th position regarding cultivated area, 9th for production and 17th for productivity (FAO, 2012). Despite the relatively large land occupation, the crop domestic productivity does not exceed 60 kg/ha on average. Tunisian pistachio research started in 1948 at the National Agronomic Research Institute of Tunis (INRAT) previously known as “Service Botanique et Agronomique de Tunis (SBAT)” and is still ongoing by different teams in a few other national research institutions such as the Olive Tree Institute (IO) and the National Agronomic Institute of Tunisia (INAT). This report overviews the main axes developed and related results.

PROPAGATION AND MICROPROPAGATION

Pistachio propagation was one of the earliest concerns of pistachio research in Tunisia. Seeding and budding techniques were studied since 1948 by Crossa-Raynaud and allowed for the production of hundreds of plants in Gafsa (south-eastern Tunisia). During the 1964-1972 years, several collections of varieties and rootstocks were installed in different areas of the country (Jacquy, 1972). Budding success rates reached 80 to 90%. The control of propagation techniques through INRAT-FAO projects in the 1960s and 1970s is the origin of the current spread of pistachio crop areas in Tunisia.

Seed germination studies focused mainly on *Pistacia* wild species and hybrids as *P. vera* seed germination is less problematic. The hardiness of the sclerotic endocarp of some genotype seeds is thought to be among the reasons for this recalcitrance to germination. Several pretreatments were tested to improve the permeability of seeds and/or to raise their dormancy: chemical scarification with sulfuric acid, imbibing seeds in sterile distilled water or a solution of gibberellic acid, the combination of these two treatments (Chelli-Chaabouni and Gouta, 2002) and cold stratification at 4°C for 2, 3 and 4 months. The effects of medium and light germination on in vitro germination were also tested.

Besides conventional propagation techniques, micropropagation techniques were investigated with the two main objectives of 1. cloning desired varieties and performing rootstocks on their own roots and, 2. possible use of biotechnological methods of conservation, assessment and plant breeding. The potential of in vitro propagation of *Pistacia vera* cv. 'Mateur' were tested through microcuttings, apex culture, caulogenesis, somatic embryogenesis and micrografting (Chatibi, 1999). Moreover, the responses of different plant materials to in vitro propagation through microcutting and apex culture techniques were studied over a period of ten years (2002-2012) at the "Institut de l'Olivier" with the aim of preserving genetic resources. Microcuttings were used from seedlings of *P. vera* and *P. atlantica* genotypes to develop optimal physical and chemical conditions for in vitro propagation (Chelli-Chaabouni, 2012). The different stages of micropropagation were studied with relative success (Fig. 1). The apex culture technique was used to test for the ability of *P. vera, P. atlantica* and *P. terebinthus* genotypes to in vitro propagation (Chelli-Chaabouni *et al.*, 2011; Chelli-Chaabouni, 2012). Explants used were taken from young and adult trees growing in the field. Only a few genotypes issued from 39- to 40-year old trees have been successfully established and proliferated.

GENETIC DIVERSITY AND PLANT BREEDING

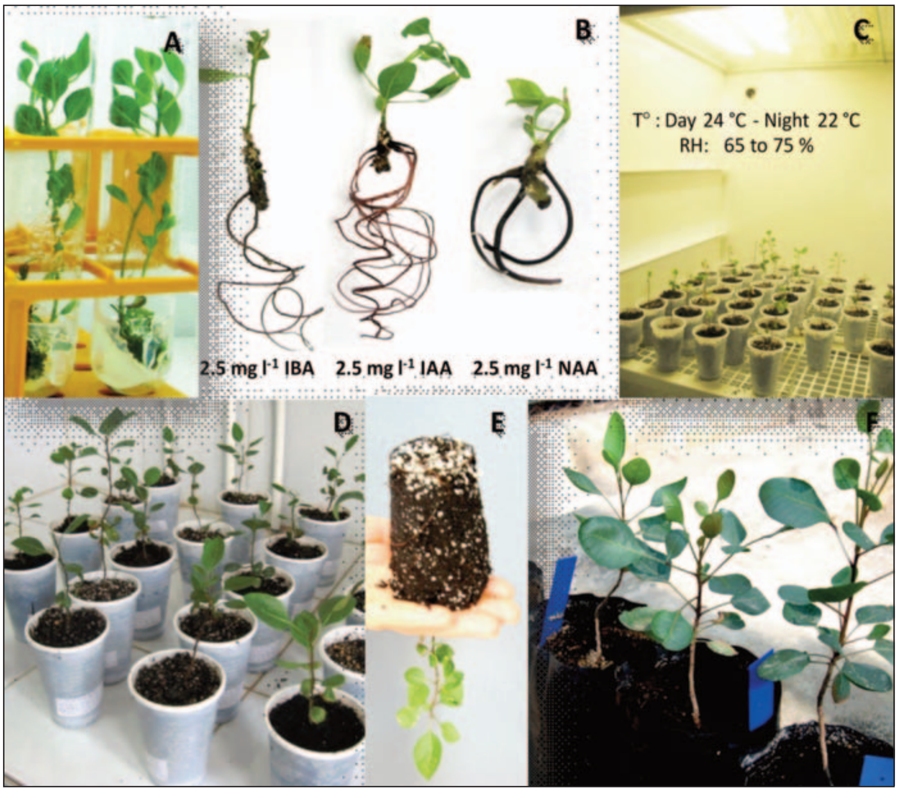
The observation and identification of high yielding varieties of pistachio (*Pistacia vera* L.) was started in 1951 by Crossa-Raynaud, research head in fruit culture at the SBAT. Few male specimens having abundant and late flowering were detected. Since the early 1960s orchard collections of local and foreign varieties were created in different bioclimatic conditions. These collections were, unfortunately, neglected after selecting the most popular Tunisian pistachio cultivar Mateur in 1974 and its two pollinators 25A and 40A in 1979. The performance of these varieties was variable across cultivation areas and did not have similar behaviors in the center and the south as in the north where they have been selected for. Since 1998, the survey of local and foreign varieties in the collection was started by a multidisciplinary team from IO and INAT institutes (Chelli-Chaabouni *et al.*, 2013a and b; Ghrab *et al.*, 2002, 2004; Zribi *et al.*, 2004; 2013). In the same way, prospecting the traditional areas of pistachio production was conducted with the aim of screening local population (Ghrab et al., 2010b) and selecting suitable ones for each cultivation area. Genetic diversity of pistachio was studied using morphological features that succeeded to identify several specimens (Ghrab *et al.*, 2012). Some biochemical traits were also investigated (Ghrab *et al.*, 2010a, Zribi *et al.*, 2006, 2011).

The genetic diversity of the wild *Pistacia atlantica* Desf. species has also been studied. Since 2002, surveys were made in Sidi Bouzid, Gafsa, and Sfax areas to collect fruits and leaves from autochthonous *P. atlantica* trees. Morphological characterization, based on IPGRI descriptors was conducted to evaluate the genetic diversity of this species. Visual observations showed great variability in the fruit color and the shape of trees, fruits, fruit clusters and leaves (Fig. 2). Only a few results of this study were published (Ghrab *et al.*, 2010b).

POLLINATION AND FRUIT SETTING

The study of pistachio flowering and pollination started in the late 1960s. It focused on the evaluation of pollen germination and female flower receptivity (Mlika, 1969). Later, different developmental stages of male and female inflorescences were defined. Histological studies and microscopic fluorescence techniques were used to follow flower differentiation and dynamic transmission of the pollen tube through the pistil. The period of receptivity of the female flowers was determined to better conduct artificial pollination (Bel Faleh, 1986). More recently, an assess-

Figure 1. Micropropagation of *P. vera* from seedlings:
A. Vitroshoot growth on DKW + 1 mg/l BA + 0.2 mg/l NAA;
B. Effect of the nature of auxin on root quality;
C. Acclimatization in controlled conditions; D. 75 days of acclimatization;
E. Root growth in pot; F. 10 months acclimatization.



ment of *P. vera* male genotypes performance was started. The aim was to select suitable pollinators for cultivated varieties grown in different areas of the country. The flowering period of 17 genotypes cultivated in the "Taous" experimental orchard of the IO was determined (Ghrab *et al.*, 2002). Some reproductive traits, such as flowering density, pollen production, reproductive bud rate, and pollen viability and germination were assessed (Chelli-Chaabouni *et al.*, 2013a and b, Ghrab *et al.*, 2002).

PERFORMANCES OF THE MAIN PISTACHIO CULTIVARS AND VULNERABILITY TO CLIMATIC CHANGES

Chilling and heat requirements of pistachio cultivars

Nut trees must fulfill chilling and heat requirements to break dormancy and flowering respectively. However, little information is available for the 'Mateur' cultivar needs. Results of a research project-carried out under laboratory conditions estimated chilling and heat requirements of this cultivar at 600 CU and 12000 GDH respectively. To validate laboratory results, a phenological dataset of a five-year monitoring period under field conditions was used (Salhi *et al.*, 2013).

Chilling trends effects on performance of pistachio trees cv. 'Mateur'

The responses of pistachio trees to variable winter chilling and annual precipitation were investigated. Yield correlated poorly with precipitation and showed a moderate alternate bearing index of 0.63 (Elloumi *et al.*, 2013a). However, flowering and nut yield of pistachio trees was a function of chill accumulation computed as chilling hours (CH), chill units (CU) or chilling portions (CP) depending on the model used, Crossa-Raynaud, Utah or Dynamic, respectively. Warm winters, with low chilling, caused erratic floral bud break, delayed flowering, sparse foliage and decreased yield. With inadequate winter chilling, chemical treatments with hydrogen cyanamide (Dormex) at 2 and 4% increased floral bud break, advanced flowering period and improved vegetative growth of pistachio trees in comparison with the untreated control (Ghrab and Ben Mimoun, 2013; Elloumi *et al.*, 2013a). Due to warm temperatures in the production area, additional research on local pistachio germplasm to select low chilling specimens is needed. A research project was initiated to evaluate a large number of local female and male cultivars and test for chilling trends.

Alternate bearing of pistachio trees cv. 'Mateur'

The most limiting factors for pistachio yield in the Tunisian pistachio growing zones are low annual precipitations and deficient cultural practices which increase alternate bearing (Ghrab *et al.*, 2004). Under these conditions, it is important to understand carbon partitioning and its relationship with the crop load to develop management strategies likely to minimize this phenomenon. Dry matter, starch and nutrient uptake of pistachio trees branches were investigated to determine the effects of fruiting on shoot growth in rain-fed conditions in an arid climate (Elloumi *et al.*, 2013b). Four treatments were applied; T0: normal alternation cycle, T1: disbudded trees for one year, T2: disbudded trees for two successive years and T3: removal of 50% of all floral buds for each year. Disbudded trees permitted an estimation of vegetative growth potential of pistachio tree cv. 'Mateur' the main cultivar in Tunisia under severe conditions. Removal of 50% of flower buds (T3) each year showed a beneficial result. It leads to an earlier and regular accumulation of dry matter and starch in the shoot. Thus, under rain-fed conditions, annual hand-pruning could be used to prevent or to minimize alternate bearing of pistachios.

ROOTSTOCK EVALUATION

Germination ability

Pistachio dioecy and heterozygocity are a source of great variability. This variability was found in the in vitro germination ability of different mother tree seeds of *P. atlantica*. Results of seed germination of 29 genotypes sampled from Meknassy and Sidi Bouzid areas over the 2004-2005 period revealed germination rates between 5 and 100% (Ghrab *et al.*, 2010b). Germination rates (days needed to reach 50% of seed germination) lower than 10 days and higher than 49 days were recorded.

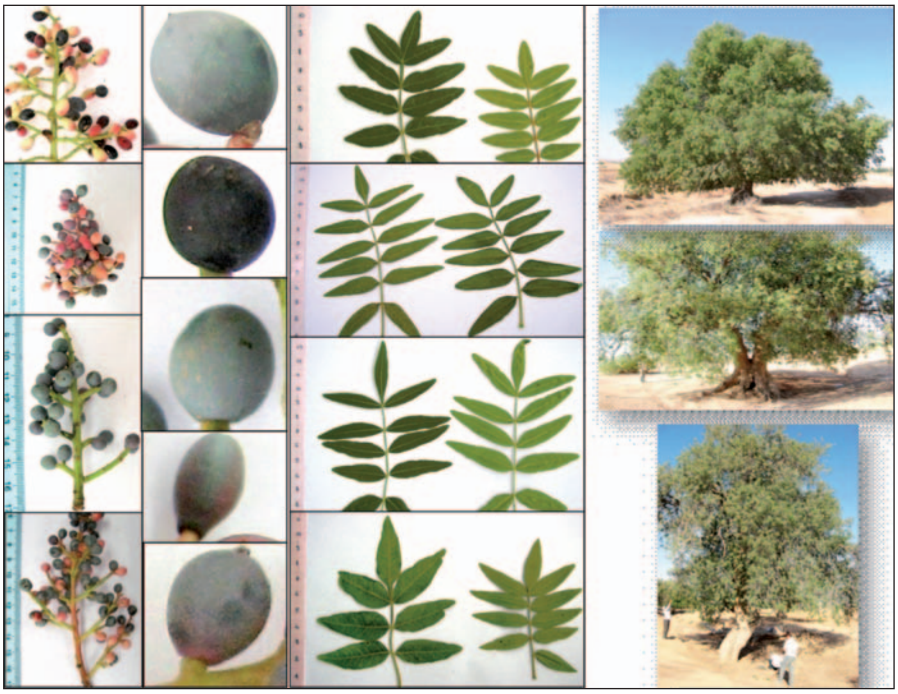
Evaluation of local and foreign *Pistacia* genotypes

Seedlings derived from local *Pistacia* genotypes and foreign selected species and hybrids [kindly provided by Dr. F.J. Vargas, (Spain), Dr. L. Ferguson (USA) and Mr. Ribera (Spain)] were installed, in 2002, in nursery conditions (30 cm in the row and 1 m between rows). The aim was to select vigorous specimens adapted to local soil and climatic conditions to be included in a rootstock breeding programme. Great inter-specific variability was recorded regarding plant vigour and survival rate. Interesting results were found and will be published soon.

Evaluation of scion/rootstock combination

The main pistachio rootstock currently used in Tunisian pistachio orchards is *P. vera* L.. The autochthonous *P. atlantica* spp. *atlantica* was previously used by ancient farmers. Despite the high vigour and longevity attributed to varieties grafted on this rootstock (Jacquy, 1973), its use was neglected probably because of the poor

Figure 2. Some aspects of genetic diversity of local *P. atlantica* genotypes.



availability of seeds and their variable germination ability. In order to contribute to the valorization of this local and endangered species, an experimental orchard was installed at "Taous" experimental station, IO institute (Sfax area), in 2002 to study the rootstock/variety combination in irrigated conditions of a semi-arid area. 'Mateur' and 'Kerman' varieties were grafted on *P. vera* and *P. atlantica* rootstocks. Since tree grafting, growth monitoring of scions and rootstocks are conducted every year during the active physiological cycle. First fruit setting was recorded after 5 years from grafting. Recently, study has begun on some mineral and physiological parameters. Preliminary results showed a higher grafting success rate on *P. atlantica* rootstock, better survival rate in these bioclimatic conditions and similar or higher variety growth on *P. atlantica* rootstock. The average yield per tree of both cultivated varieties recorded from 2008 to 2010 was higher on the *P. atlantica* rootstock. In the same context, a new experimental study will be initiated in 2014 (as a PhD thesis) to evaluate the variety/rootstock combination for a 20-year-old orchard at INRAT Mornag (north of Tunisia) experimental station in rain-fed conditions.

Assessment of local pistachio tolerance to stresses

The low diversification of pistachio rootstocks in Tunisian orchards affects crop sustainability through the low adaptation of varieties to environmental stresses. That is why special attention was paid to the development of highly performing pistachio rootstocks. The development of irrigated lands, which has often been proposed for the enhancement of productivity, unfortunately adds to the salinization of soils and the development of pathogens. To prevent the deleterious effects of this practice, research focused on two main stresses: salinity as abiotic stress and *Verticillium dahlia* disease as biotic stress.

The response of pistachio rootstocks to salinity was studied with the objective of: 1. better understanding the mechanisms adopted by the species to avoid salt toxic effects, and 2. early selecting highly performing rootstocks. Research was conducted on *P. vera* (used as the main pistachio rootstock in Tunisia) and *P. atlantica* (autochthonous and endangered species). Effects of salt at germination, seedling and adult stages and under different environmental conditions (in vitro, nursery and field conditions) were studied. Research focused on the development of an efficient method to select mother trees likely to give high rates of vigorous salt-tolerant seedlings based on seed performance at the germination stage. In vitro seed germination of 29 *P. atlantica* genotypes in the presence of 60, 120 and 180 mM of sodium chloride (NaCl) allowed genotypes with the highest salinity threshold concentration to be selected (NaCl concentration leading to 50% reduction of germination rate). Genotypes were then, classified into three classes C1, C2 and C3 from the highest to the lowest salt tolerant. To check whether an early selection at the germination stage could be an efficient indicator for salt tolerance at the seedling stage, one-year-old seedlings derived from these three classes were submitted to salt effects (0, 100 and 200 mM NaCl) in irrigation water in nursery conditions (Chelli-Chaabouni *et al.*, 2010b). Results showed great variability within and between classes. It appears from this study that *P. atlantica* salt tolerance classification at germination stage did not necessarily reflect the same behaviour at the one-year seedling stage. To enhance the knowledge about the possible mechanisms used by *Pistacia* species to cope with salt effects, Chelli-Chaabouni *et al.* (2010a) studied in vitro response of *P. vera* and *P. atlantica* seedlings to several concentrations (0 to 240 mM) of sodium chloride (NaCl). High NaCl concentrations (0; 131; 158.5 and 240 mM) were tested for 25 days while low and mild concentrations (0; 20; 40; 60 and 80 mM) were applied for 45 days. Results revealed high salt tolerance of both species. *P. atlantica*, however, showed higher performances with high survival rate, less growth reduction and more efficiency of the K-Na and Ca-Na selectivity than *P. vera*. The effect of salt in irrigation water was also studied on five-year-old cv. 'Mateur' variety in field conditions at the "Taous" experimental orchard. Three water electric conductivities were applied (1.95 dS/m; 5 dS/m and 12 dS/m). Some growth parameters were found to be stimulated by water conductivity of 5 dS/m but declined at 12 dS/m. Proline and soluble sugars increased with increasing salinity (Mehdi *et al.*, 2011).

Tunisian pistachio production in irrigated lands is threatened by soil fungi causing root rot, dieback and death of trees (Triki *et al.*, 2009). To prevent and mitigate damages that may be caused by these diseases, a research programme was recently initiated to study soil fungi of pistachio trees and select tolerant or even resistant genotypes that could be used as rootstocks. As *Verticillium dahliae* attacks have been reported to be particularly dangerous in many production countries, this fungus has been given priority attention. Six month-old seedlings derived from five *P. atlantica* genotypes and *P. vera* cv. 'Mateur' were used to test for the virulence of three isolates. Inoculation methods and disease evaluation revealed that most genotypes are moderately sensitive. One *P. atlantica* genotype exhibited, however, higher tolerance that was associated to a significant increase in total polyphenol content (Triki *et al.*, 2013). Further investigations are ongoing on other genotypes to study possible endogenous compounds responsible for *Verticillium dahliae* resistance.

VALORIZATION AND NUT QUALITY

Despite its good adaptation to the severe conditions of arid lands, pistachio has highly nutritious nuts that are rich in fats and may be used in the food, pharmaceutical and cosmetic industries. Tree nuts contain several bioactive and health promoting components that could be used. Aiming at the enhancement of cultivated and wild *Pistacia* germplasms, nut quality of *P. vera* and *P. atlantica* was studied. Preliminary investigations revealed that fat content in the fruits of *P. atlantica* varied between 40 and 48%, dominated by oleic acid (47.3 - 61%) followed by linoleic acid (17.3 - 25.7 %) and palmitic acid (16.3 – 24.8%) (Ghrab *et al.*, 2010b). Regarding *P. vera*, nut quality was initiated for cultivated local and foreign cultivars (Ghrab *et al.*, 2010a, 2010b). Promising results on oil quality of pistachio were obtained and more investigations will be oriented to bioactive and health promoting components.

NUT STORAGE AND QUALITY

The pistachio is commonly used by the food industry in products such as ice-creams, cakes and confectionery. It is usually not consumed fresh but after being stored for a variable period of time. Long storage in inappropriate conditions leads to the development of post-harvest moulds such as *Aspergillus* which produces mycotoxins, mainly aflatoxins (AFs). With the aim of evaluating the effect of the storage period on the susceptibility of the most cultivated pistachio varieties in Tunisia to the contamination by AFB1, a total of 49 samples were rapidly screened by enzyme-linked immunosorbent assay (ELISA) combined with an immunoaffinity step. Results showed that a two-year period of storage lead to the contamination of all tested varieties. Aflatoxin contents in the samples tested were mainly associated with storage duration and cultivar (Bensassi *et al.*, 2010).This work will be continued to test for a large number of pistachio cultivars and evaluate different local methods of nut processing.

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GALL-FORMING APHIDS ON *PISTACIA* IN THE MEDITERRANEAN REGION: WHAT ARE THEY?

GALL INDUCTION BY INSECTS

The intimate relationship between gall-forming insects and their host plants is attracting considerable attention among ecologists and evolutionary biologists. Numerous insects, more than 13,000 species, have the ability to transform normal plant tissues into galls. The ability to induce galls has evolved convergently among and within various insect lineages such as wasps, beetles, flies, thrips and aphids (Shorthouse and Rohfritsch, 1992). The multiple, independent origins of gall formation indicate that this phenomenon is highly adaptive. The galls serve as an "incubator" for the insects in which they may gain better nutrient supply, shelter from harsh abiotic factors and protection from natural enemies including pathogens, predators and parasitoids (Price *et al.*, 1987). Gall morphology and structural complexity are strikingly variable both across and within insect groups; however, the interactions between insects and plants are extremely specific. Usually a given insect species induces a typical gall on a specific organ of a single plant species. Unlike the case of crown galls induced by *Agrobacterium*, the mechanism of gall formation by insects is unknown. It seems, however, that the insects control gall formation and development for their own benefit. Therefore, galls are often considered the "extended phenotype" of the insect's genes.

APHID GALLS ON *PISTACIA*

Across their wide distribution in Asia, the Middle East, Africa, Europe and America, *Pistacia* spp. are accompanied by a highly specialized group of gall-forming aphids (Homoptera: Fordini) (Blackman and Eastop, 1994). The galls are usually conspicuous and vary in shape, size and color. In this paper, I will refer mainly to approximately 20 gall-forming aphid (Fordini) species found on the most common wild *Pistacia* species in Mediterranean-type habitats in Europe, the Levant and North Africa. Most species are found on *P. atlantica* and *P. terebinthus* (and its sibling species *P. palaestina*). A single well-known aphid species is found on the evergreen shrub *P. lentiscus*. The taxonomic status of the aphids on *Pistacia* species in the region is not fully clear (e.g., Brown and Blackman, 1994; Ortiz-Rivas *et al.*, 2009). No doubt, new aphid species will be found especially in remote and relatively unstudied regions in the Middle East where new species are occasionally described (Manheim, 2007; Remaudière *et al.*, 2004). The wide and disjunctive distribution of some *Pistacia* species across different habitats in the region should also promote local aphid speciation (Avrani *et al.*, 2012).

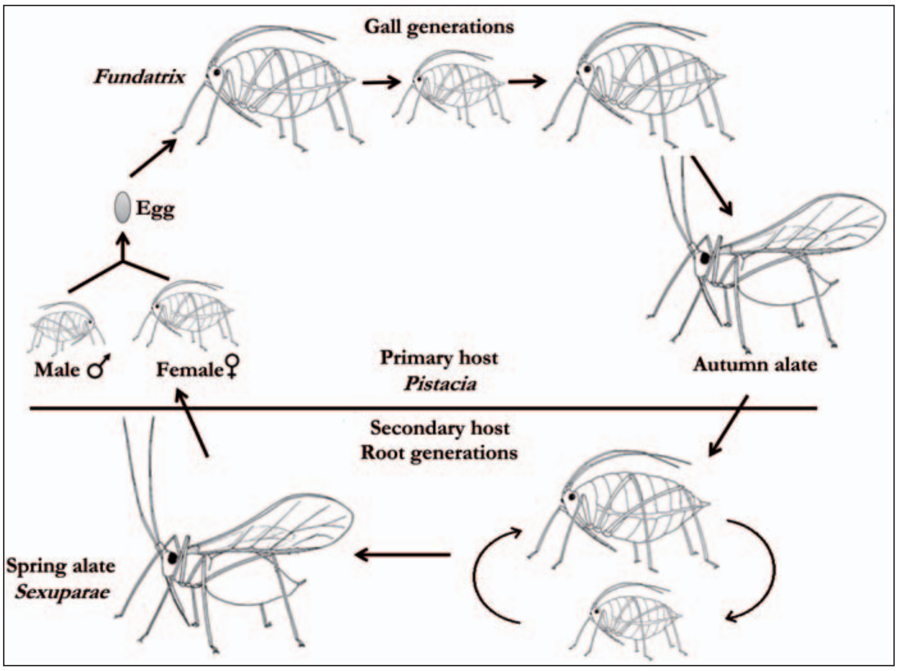
THE LIFE-CYCLE OF APHIDS

The life-cycle of these aphids (Fig. 1) is complex, and includes sexual and asexual reproduction phases and alternation between the primary host (always a *Pistacia* species) and roots of non-specific secondary hosts (Wool, 2004). Galls are only formed on the primary *Pistacia* host. Galls are induced early in the spring by first instar nymphs (fundatrices) hatching from overwintering eggs. Each fundatrix induces its own gall and at this early stage may compete or even fight for a suitable galling site (Whitham, 1979; Inbar, 1998). Within each gall, 2-3 aphid generations are produced parthenogenetically. In the fall, winged aphids disperse from the galls and their offspring develop on the roots of the secondary hosts (non-specific grasses). On the roots, the aphids are free feeders, i.e., they do not induce galls. In the following spring (April-June), another winged aphid morph, the sexuparae, develops on the roots. They will migrate back to the primary host and give birth to tiny males and females (Wool *et al.*, 1997). After mating, the fertilized eggs remain on the host and the fundatrices hatch from them one year later (two-year life-cycle). This typical life-cycle may have several modifications. Few species induce two types of galls on their *Pistacia* host: the fundatrix induces small 'temporary' galls on the leaflet midvein whereas her offspring induce a different 'final' gall on the leaflet margin. Other species (*Slavum wertheimae*) do not migrate to the secondary host, and complete their life-cycle on the *Pistacia* host in one year. Interestingly, the distribution of aphids on the secondary host is extended far beyond the distribution of their primary *Pistacia* host. Hence, the root populations of aphids may be found in Northern Europe, North America and Australia, for example, but without the sexual reproduction phase (anholocycle).

GALL TYPES

Due to their remarkable and divergent shape, size and color, most galls can be observed easily in nature (Koach and Wool, 1977). According to their general structure and location, galls may be cate-

Figure 1. Schematic illustration of the Fordini life-cycle. The life-cycle is divided between a specific aphid species-dependent *Pistacia* plant (primary host) on which the galls are induced (upper part), and non-galling, root generations (lower part) on non-specific grasses (secondary hosts). Excluding a single sexual event, all other generations are different morphologies of genetically identical parthenogenetic females. Galls are usually induced by the fundatrix that overwinter as an egg on the branches of *Pistacia*. See text for more details and some deviations from this typical two-year life-cycle (drawing by Tali Berman).



gorized into one of the following types (see Inbar *et al*., 2004; Fig. 2): a. *pea* galls, small (~5 mm long) lentil-shaped, open galls located on the midvein of the leaflets; b. *margin* galls, open, elongated galls (~20 mm long) located on the margin of the leaflet; c. *bag* galls, open galls located on the upper (adaxial) leaflet surface occupying most of the leaflet surface. The gall openings are near the leaflet midvein; d. *spherical* galls, completely sealed globular galls (volume ~4 cm^3) located on the lower (abaxial) side of the leaflet midvein; and e. *bud* galls, the largest, completely sealed galls formed by the Fordini. Although they are different in shape (banana-shaped galls of *Baizongia pistaciae* and cauliflower-shaped galls of *S. wertheimae*), they are induced similarly on the main vein of young leaflets and eventually take over the entire bud.

Some species (genus *Smynthurodes, Forda*) induce two types of galls during the spring. The fundatrix induces small pea-shaped ("temporary") galls. A few weeks later, her offspring leave the pea galls, and each one of them can potentially induce margin ("final") galls on adjacent young leaflets. Usually, the fundatrix dies within a few weeks, but the empty temporary pea galls may be seen on the tree until the leaves fall in autumn. There is a further complication in *S. betae* since some of the fundatrix's offspring may continue to reproduce and complete their development and reproduction within the pea galls. In such rare cases, the pea galls are slightly darker, larger and become harder than normal fundatrix galls (Wool and Burstein, 1991). In other genera (*Paracletus*, *Tramaforda*), the fundatrix induces only margin galls.

While the margin galls may contain between 10-100 aphids, the bag (genus *Aploneura*, *Asiphonella*), spherical (genus *Geoica*, *Rectinasus*) and bud galls may contain hundreds to thousands of individuals, respectively. Phylogenetic analysis indicates that the primitive gall was probably the simple, open pea type that supports only a few aphids. The open margin and bag galls developed next, followed by the bigger spherical galls, ending with the large bud galls that can support thousands of aphids each. The evolution of the Fordini was therefore from small and simple galls to large and complex ones, associated with the stronger ability of the aphids to manipulate their host plant and induce stronger sinks for assimilates (Inbar *et al*., 2004). Similar trends were detected in other gall-forming aphid groups (e.g., Zhang and Qiao, 2007). Different gall types that are induced on different plant organs (bud, leaflet midrib or margin) may reduce interspecific competition between aphids for suitable galling sites in the spring (Inbar and Wool, 1995).

GALL DENSITY AND DISTRIBUTION

Gall-forming insects have very close relationships with their host plants. The galling process involves intimate crosstalk between the plant and the insect genotypes. The aphids are obligated to a specific host plant species, organ and tissue. Landing of the sexuparae on the right *Pistacia* species or on a susceptible individual plant is critical.

Gall density varies considerably among individual plants within the same *Pistacia* species. Some are heavily infested every year while others remain constantly gall-free (e.g., Wool, 1990). Such intraspecific differences can be seen among plants on larger ecological scales or between plants that grow a few meters apart (Wool, 1990). The abundance of each galling species on an individual plant depends on the location of the secondary host plants, the ability of the sexuparae to locate their primary host, the survival of the sexual generations and the eggs, and the ability of the fundatrix to induce galls. The latter is highly influenced by the susceptibility of the plant (genetic or phenotypic traits) to gall formation. The synchronization between fundatrix hatching time and the availability of young leaves that are suitable for gall induction is clearly crucial (e.g., Burstein and Wool, 1993). A controlled experimental approach is needed to reveal the mechanism(s) responsible for the common intraspecific variation in gall density.

It has been shown that aphids may be a useful tool for *Pistacia* taxonomy and systematics. The European species *P. terebinthus* has similar aphid fauna to that of its sibling species *P. palaestina*, which is common in the Levant. As far as the aphids are concerned, they are the same host plant. Natural hybrids of *Pistacia* species are quite common (e.g., Kafkas and Perl-Treves, 2001). Trees that according to leaf morphology are presumably hybrids of *P. atlantica* X *P. palaestina* are scattered in Mediterranean-type habitats in Israel. We often observe galls on these trees that are associated with both plants (Koach and Wool, 1977; Inbar, 2008). Interestingly, *P. saporta*, a hybrid between *P. lentiscus* and *P. terebinthus* (and *P. palaestina*) that belongs to different sections, is resistant to all gall-forming aphids. In commercial pistachios, we may easily identify the rootstock by the typical galls that develop on the leaves of the suckers (unpublished observations). The Fordini, therefore, may assist with *Pistacia* taxonomy and systematics at all levels (Inbar, 2008).

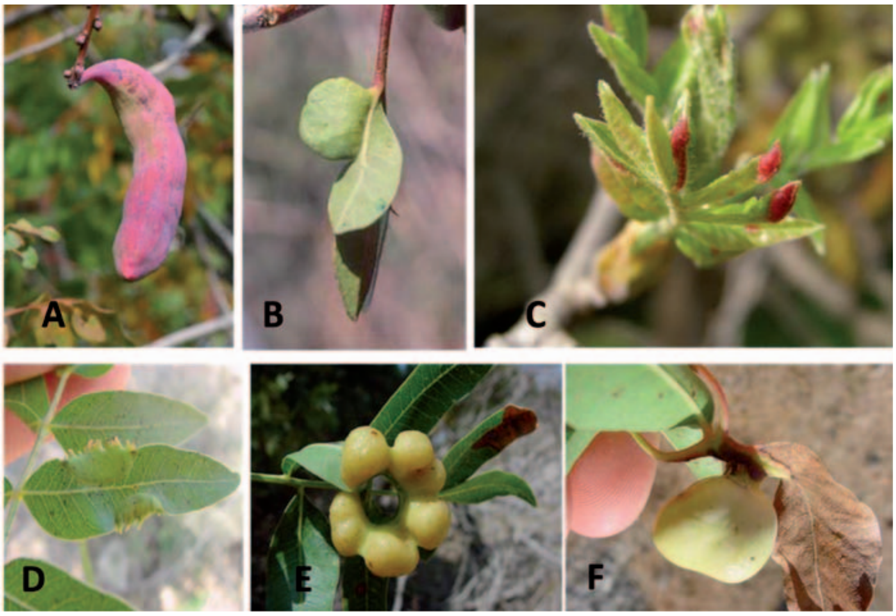
IMPACT ON HOST PLANT

The Fordini galls are characterized by extensive and complex histological modifications of the plant tissue. The anatomical modifications of normal plant tissue during gall induction and maintenance are associated with the aphid's development, and provide better access to the phloem elements and defense from natural enemies (Wool *et al.*, 1999; Álvarez *et al*., 2009; Álvarez, 2012.). The histological modifications, especially of the small galls (pea and margin types), are usually restricted to galled tissue only (Álvarez *et al*., 2009). The large bud galls, however, may have much greater effects on the lower branches (Aloni *et al*., 1989). The aphids are phloem feeders and the galls act as a physiological sink for assimilates. The pea and margin galls drew assimilates from the galled leaflet, while the bag and spherical galls may draw assimilates from the entire galled leaf or neighboring leaves on the same shoot. The latter gall may cause early leaflet senescence (Inbar *et al*., 1995; Inbar *et al*., 2004). The effect of gall-forming aphids on the plants is rather limited and usually restricted to the galled organ. An exception is the bud gall induced by the *B. pistaciae*. During the year of gall formation, there is neither elongation nor branching beyond the position of this gall. In the following years, galled branches produced more lateral shoots (branching) than ungalled branches as a result of apical dominancy removal. Consequently, galled branches carried more leaves and tended to gain more biomass than ungalled branches but the fruit set remained the same. Hence, repeated heavy infestation by *B. pistaciae* may promote bush-like architecture in *P. palaestina* and *P. terebinthus* (Kurzfeld-Zexer *et al*., 2010). Martinez (2008) reported that the bud galls induced by *S. wertheimae* tend to stop the development of the shoots of *P. atlantica*. He suggested that the effect of aphids (galls) is more complicated than simple physical destruction. Since most gall-forming aphids have rather limited impact on the plant, they are not considered as important pests in commercial pistachio orchards (Mehrnejad, 2001).

FUTURE RESEARCH DIRECTIONS

The intimate and complex relationships between gall-forming aphids and their

Fig. 2. Examples of common aphid (Fordini) galls that can be found on wild Pistacia plants in the Mediterranean region. A. Fully mature (summer) gall induced by *Baizongia pistaciae* on the terminal buds of *Pistacia palaestina* and *Pistacia terebinthus.* The galls are often red and may reach the size of a banana. B. Bag galls induced by *Aploneura lentisci.* This is the only aphid species that induces galls on the evergreen shrub *Pistacia lentiscus.* C. "Temporary" pea galls induced the fundatrix of *Smynthurodes betae* on the young leaflets of Pistacia atlantica. Note that these galls can be seen before the leaves are completely unfolded. D. Margin galls induced by the aphid *Tramaforda wooli* (on *Pistacia atlantica*). E. Margin galls induced by *Forda riccobonii* on the leaflets of *Pistacia atlantica.* These are the final galls of the species as the fundatrix induces a pea type gall similar to C. F. A spherical gall induced by *Geoica* spp on the leaflets' midrib of *Pistacia palaestina* and *Pistacia terebinthus.* During the summer (picture taken on August) the gall may cause an early senescence of the galled leaflet.



Pistacia host plants across a wide geographic range may be useful for basic- and practical-oriented research. The system provides a convenient arena for studying ecological and coevolutionary processes between insects and plants. From the practical point of view, the Fordini (as described above) can add novel insights to our understanding of the problematic taxonomy and systematics of *Pistacia* (Inbar, 2008). It is well known that *Pistacia* spp contain various beneficial metabolites (see Golan-Goldhirsh, 2009) that have, for example, proven antioxidant capacity, and antimicrobial and anti-inflammatory activity (e.g., Giner-Larza *et al.*, 2001; Alma *et al.*, 2004; Assimopoulou and Papageorgiou, 2005; Barra *et al.*, 2007; Gardeli *et al.*, 2008; Gourine *et al.*, 2010). Compared with intact leaves, the galls are loaded with high amounts of specialized metabolites such as terpenes, tannins and other active compounds (Caputo *et al.*, 1979; Inbar *et al.*, 2003; Flamini *et al.*, 2004; Gerchman and Inbar, 2011; Rostás *et al.*, 2013). Hence, the galling system may help us understand the production, biochemistry and active properties of these valuable compounds.

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I dedicate this paper to Prof David Wool who recently celebrated his 80th birthday. David "infected" me with the enthusiasm and curiosity about gall-forming aphids. It was a privilege to be his student and later on his colleague.

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NOTES AND NEWS

RETIREMENT OF PROF. DR. A. İLHAMI KÖKSAL

Prof. Köksal was born in Ordu in the Black Sea Region of Turkey in 1944. After graduating in 1967, he was appointed as Assistant in the Department of Horticulture, Faculty of Agriculture at Ankara University. He pursued Ph.D. degree at Hannover Technical University in Germany and studied the physiology of rootstock-cultivar relationships between 1969 - 1973 After, returning to Ankara University he continued to work on tree fruit physiology especially between rootstocks and cultivars, and plant hormones. He was promoted to Associate Professor in 1977 after completing the “Associate Professorship Thesis” on “Research on changes of GA and ABA-like chemicals between some apple - pear rootstocks and important cultivars grafted onto them”. Later, Prof. Köksal’s research focus shifted to postharvest physiology and storage of tree fruits, especially pome fruits in the early 1980s, which would be his main research interest until his retirement and for which he has been known as a fruit postharvest and storage physiology expert in Turkey. He was promoted to full professor in 1988. After retirement of the late Prof.Dr. Mahmut Ayfer who was honored with the Golden Tree Nut Award by INC, Prof. Köksal took over the Liaison Officer position for the Hazelnut Sub Network within the Inter-Regional Cooperative Research Network on Nuts, FAO-CIHEAM in 1994, and served until his retirement. At the same time, his research area expanded to storage and cultural problems of tree nut crops especially on hazelnuts and pistachios. Since then he has been a leader of several research

Picture of Prof. Dr. A. İlhami Köksal.

projects. He has also developed close connections with the hazelnut processing industry in Turkey. This was not difficult because his home town is in the middle of a hazelnut growing and processing area, and some of his relatives have been engaged in hazelnut growing and trade. In 1995 he went to the USA as a visiting scientist to observe Oregon's hazelnut industry.

Prof. Köksal organized the "4th International Congress on Hazelnut" in Ordu, Turkey in 1996 as convener and he was one of the co-editors of the proceedings. Later, he authored the "Inventory of Hazelnut Research Germplasm and References" in 2000. He served as Hazelnut Reporter for Turkey in the Specialized Section on Standardization of Dry and Dried Produce, ECE, United Nations in 1993 and was elected as a member of the Scientific Committee for the International Nut Council (INC) in 1998.

Being an academic, he gave lectures and supervised several M.Sc. and Ph.D. students, attended several national and international symposia and congresses. He has published more than 100 research articles and books. He knows German (very well) and English. He has also been involved in administration, as Associate Dean for the Faculty of Agriculture, Ankara University between 1988-1991 and Founder-Dean for the Faculty of Forestry at the same university from 1995 to 2007. Prof. Köksal retired on 30th December 2010 at the age of 67. However, he has been keeping his ties with colleagues in the department where he has spent 47 years of his life as a student, researcher, lecturer and administrator.

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PRESENTATION OF THE NEW HAZELNUT'S LIAISON OFFICER

Veli Erdogan is a professor, scientist and lecturer at Ankara University, Faculty of Agriculture, Department of Horticulture, in

Dr. Veli Erdogan.

Ankara (Turkey). He received his PhD degree on Genetic Relationships among Hazelnut Species in 1999, in the Department of Horticulture, in Oregon State University (Oregon, USA). His expertise is in Fruit Science, especially tree nut species: hazelnut, walnut, pistachio and almond. He has published more than 40 scientific or technical papers or book chapters, mostly about the hazelnut. Prof. Erdogan is a member of the International Society for Horticultural Science (ISHS) and of the Turkish Society for Horticultural Science. In April 2014, he assumed the role of Hazelnut Liaison Officer in the FAO/CIHEAM Inter-regional Research Network on Nuts, to replace Prof. Koksal. The NUCIS editors wish him luck in his new role.

NEW CHAIRMAN OF THE ISHS ALMOND WORKING GROUP

During the ISHS Business Meeting held at the VI International Symposium on Almonds and Pistachios (Murcia, Spain, 27-31 May 2013), the chairman of the ISHS Almond Working Group, Dr. Rafel Socias i Company, relinquished his post. Dr. Socias i Company has held this chairmanship since the International Horticultural Congress of Brussels in August 1998 and suggested Dr. Thomas M. Gradziel as new chairman, which was unanimously approved by the audience.

Dr. Socias i Company has been an almond breeder at the CITA de Aragón (Spain) and retired on 30 December 2013, although he continues his activities as editor, meeting convener and research leader. Dr. Gradziel is a well known researcher of the University of California at Davis, where he started his almond activities with Dr. Dale E. Kester.

NEW CHAIRMAN OF THE ISHS WALNUT WORKING GROUP

During the ISHS 7th International Walnut Symposium (Fenyang City, Shanxi Province, China, 27-31 July 2013), the new chairman of the ISHS walnut working group was elected. The Convener of this symposium, Dr. Jianbao Tian, Director of the International Cooperation Department from the Shanxi Academy of Agricultural Sciences, China, was elected to be the Chairman of the ISHS Working Group on Walnuts by a vote, substituting the previous chairwoman Gale McGranahan.

NEW PROJECTS

The Forestry Institute (INFOR) by the University of Valparaiso, are running (Dec. 2012 to Nov. 2015) the project "Development of Management Techniques for Producing Stone Pine (*Pinus pinea* L.), an attractive option for Commerce in Chile", funded by FONDEF-CONICYT in collaboration with public and private sector. This initiative proposes to develop a technology, production and industrial package to promote the production of pine nuts in the country and trade in the local and international market. (For more information contact Verónica Loewe Muñoz, from Chile: vloewe@infor.cl)

A new European project on nuts, has been initiated in 2013: "BIOFOS. Micro-ring resonator-based biophotonic system for food analysis". FP7-ICT-611528 (2013-16). The main goal is to develop a portable device to detect mycotoxins in nuts and milk, pesticides in oils, antibiotics and lactose in milk. Under coordination of ICCS/NTUA (Greece). In this project 10 partners from 6 European Countries are involved. (For more information contact Ioanna Zergioti, from Greece: zergioti@central.ntua.gr).

CONGRESSES AND MEETINGS

8th International Congress on Hazelnut.

THE 8TH INTERNATIONAL CONGRESS ON HAZELNUT

The 8th International Congress on Hazelnut took place in the city of Temuco, in the Araucania region of Southern Chile, from 19 to 21 of March 2012. The congress was organized by the "Instituto de Investigaciones Agropecuarias" (INIA) together with ISHS, and supported by public institutions such as "Fundación para la Innovación Agraria" (FIA), as well as by private and local companies.

The large number of participants (189) came from diverse and distant countries (Argentina, Australia, Canada, Chile, China, Croatia, France, Italy, Spain, Turkey and USA), indicating the great interest and importance of the meeting.

Eight sessions were programmed and on the last day of the Congress a technical tour was carried out, visiting different hazelnut orchards.

The session "Germplasm and Genetic Improvement" was moderated by S.A. Mehlenbacher (Oregon State University, Corvallis, USA) and 9 oral and 5 poster communications were presented. The session "Biology and Physiology" was moderated by Roberto Botta (Università degli Studi di Torino, Grugliasco, Italy) and 4 oral and 2 poster communications were presented. The session "Propagation and Rootstocks" was moderated by Valerio Cristofori (Università degli Studi della Tuscia, Viterbo, Italy) and 5 oral and 3 poster communications were presented. The session "Orchard Management" was moderated by Mercè Rovira (IRTA, Spain) and 7 oral and 7 poster communications were presented. The Session "Pests and Diseases" was moderated by Sebahat Ozman Sullivan (Ondokuz Mayis University, Samsun, Turkey) and 8 oral and 2 poster communications were presented. The session "Postharvest, Quality, Health benefits" was moderated by Jeff Olsen (Oregon State University, Corvallis, USA) and 5 oral and 1 poster communications were presented. The session "Industry, marketing and economics" was moderated by Fengxiang Dong (China) and 2 oral and 2 poster communications were presented. The session "Miscellaneous" was moderated by Celal Tuncer (Ondokuz Mayis University, Samsun, Turkey) and 3 oral communications were presented.

The scientific and agronomical communications, the round table and the technical tours (focused mainly on technological innovation), provided an immense opportunity to comment on and discuss the state of the art and further development of the hazelnut industry in Chile.

Miguel Ellena and
Pablo Grau
Scientific Secretariat


8th International Congress on Hazelnut - Visit to a hazelnut orchard.

Participants - VI International Symposium on Almonds and Pistachios.

SIXTH INTERNATIONAL SYMPOSIUM ON ALMONDS AND PISTACHIOS

The VI International Symposium on Almonds and Pistachios took place from 27 to 31 May 2013, at the headquarters of CajaMurcia in Murcia (Spain). The event was organized by the Department of Plant Breeding at CEBAS-CSIC (Spanish National Research Council) under the auspices of the International Society for Horticultural Science (ISHS). This international symposium which is held every four years brings together the world's leading experts on these two crops. The previous symposia were held in Agrigento, Italy (1993), California, USA (1997), Zaragoza, Spain (2001), Tehran, Iran (2005) and Sanliurfa, Turkey (2009).

The symposium was attended by more than 100 researchers from 14 countries (Algeria, Australia, Denmark, Egypt, Spain, United States, France, Iran, Israel, Italy, Morocco, Serbia, Tunisia and Turkey). It consisted of seven thematic sessions with oral presentations and posters. The sessions were moderated by internationally renowned researchers in each of the topics.

The opening lecture was given by Mr. Francisco Vargas (IRTA, Spain), who spoke of the great impact research had had in recent years on the modernization of almond and pistachio crops in the Mediterranean basin.

The session "Plant Breeding" was moderated by Dr. Thomas Gradziel (University of California, Davis, USA) who highlighted the current influence of new improved cultivars on world production, and the utility of molecular markers in breeding programmes.

The session "Biology and Physiology" (moderated by Dr. Raquel Sánchez-Pérez, University of Copenhagen, Denmark) dealt with the impact of proper pollination on fruit set, the problems arising from flower incompatibility, and the impact of fulfilling chilling requirements for abundant flowering and production. Besides, some works were presented on "in vitro" multiplication and on the molecular basis for the sweetness or bitterness of the seed, a character of great importance for the almond.

Dr. Mehrnejad (IPRI, Iran) moderated the session "Crop Protection". He reviewed pests and diseases affecting almonds and pistachios as well as the different strategies to control them.

The session "Food Technology" (moderated by Dr. Agustí Romero from IRTA, Spain) analysed the chemical and nutritional characteristics of almonds and pistachios in relation to their industrial uses and highlighted the beneficial health properties of these commodities. Furthermore, new molecular techniques to determine the traceability of the nuts in processed products such as nougat were presented.

Dr. Ak (University of Harran, Turkey) moderated the session "Varietal Behaviour", in which the performance of cultivars and rootstocks of both species in different environmental conditions and cultures was discussed, highlighting the wealth of plant genetic resources existing in these species.

The session "Orchard Management" was moderated by Mrs. Louise Ferguson (University of California, Davis, USA) who highlighted the enormous importance of optimal crop management for farm profitability. New issues were the plantation of high density almond orchards, the different irrigation strategies for yield, the mechanization of pruning and the application of chemicals to improve fruit set.

Inauguration of the VI International Symposium on Almonds and Pistachios. From left to right: Mr. Rafael Socías i Company, ISHS representative, Mrs. Isabel Martínez, Councillor of Economy, Town hall of Murcia, Mr. Antonio Cerdá, Counsellor of Agriculture, Region of Murcia, Mr. Juan José Alarcón, Director of CEBAS-CSIC, and Mr. Federico Dicenta, Symposium Convener, CEBAS-CSIC.

Fried almonds and nougat made with 'Antoñeta', almond cultivar from CEBAS-CSIC.

Finally, the session "Economy and Markets," moderated by Mr. Christopher Joyce (Almond Board of Australia), highlighted the most recent world production trends and the increasing demand for these products, which promise more profitable prices for farmers in the years to come.

During the symposium the GREMPA (*Groupe de Recherches et d'Etudes pour l'Amandier Méditerranéennes et le Pistachier*), a research group bringing together researchers working in these two species in the Mediterranean basin, held their 15th meeting. It was moderated by Dr. Mercè Rovira (IRTA, Spain) and Mr. Antonio López-Francos from CIHEAM. During this meeting researchers responsible for the different institutions presented a summary of their current work.

The last day was devoted to a technical visit, during which the participants visited an almond orchard in the Region of Murcia, displaying the recent almond cultivars released by CEBAS-CSIC. Dr. Federico Dicenta explained the main characteristics of almond cultivation in Spain, under rainfed and irrigated conditions. Participants visited a 80 ha solid orchard, where the high productivity of the self-compatible almond cultivar 'Antoñeta' of CEBAS-CSIC was observed. The owner of the property offered a delicious appetizer to participants with regional products, including fried almonds and nougat made by local craftsmen with his 'Antoñeta' almonds. Afterwards, participants visited the facilities of the Cooperativa Agraria de Totana (COATO). The president of the cooperative, Mr. José Luis Hernández, explained the functioning of the cooperative highlighting its commitment to high quality organic products, including almond prominently. Later, the participants visited the facilities of the cooperative and the Bioshop offeringa large variety of products from the cooperative partners. The day ended with a lunch at the port city of Cartagena and a cultural visit to the town, including the Roman baths and theatre.

At the end of the Symposium the ISHS Business meeting was held, chaired by the ISHS representative Dr. Rafael Socías i Company. During this event, participants agreed to organize the next symposium in Australia in 2017, led by Dr. Michelle Wirthensohn from the University of Adelaide.

Federico Dicenta

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Fried almonds and nougat made with 'Antoñeta', almond cultivar from CEBAS-CSIC.

The hall of the opening, 7th International Walnut Symposium ceremony.

THE 7TH INTERNATIONAL WALNUT SYMPOSIUM

The 7th Walnut Symposium(IWS) was successfully held in Fenyang City, Shanxi Province, China from 20 to 23 July, 2013 under the auspices of the International Society for Horticultural Science (ISHS). The IWS was hosted by the International Society for Horticultural Science, the Chinese Society for Horticultural Science, the Shanxi Academy of Agricultural Sciences, the Forestry Department of Shanxi Province and the People's Government of Lvliang City, Shanxi Province. The Organizers were the Pomology Institute, Shanxi Academy of Agricultural Sciences, the People's Government of Fenyang City, Shanxi Province.

The theme of the Symposium was "**Health Ecology Green Share**", with the slogan "**More walnut more health**".

The 7th IWS provided an opportunity for scientists involved in research, expansion, production, processing and market promotion of the walnut to share experiences with colleagues from around the world. The activities of the four-day programme included the opening ceremony, invited lectures, oral presentations and poster presentations in different sessions, exhibition of walnut products, germplasm resource and cultural techniques, technical visits and city tour, as well as a closing ceremony.

The symposium opening ceremony was held on the morning of 20 July, 2013, in the Fenyang walnut trading centre. More than 1000 participants took part in the ceremony, including government officers, symposium delegates and exhibition delegates. After the opening ceremony, over 61,700 persons visited the walnut exhibition , including walnut products, seedlings, furniture, etc., representing more than 100 enterprises – both domestic and overseas.

On the afternoon of 20 July, 2013, a technical visit was held in the Fenzhou Yuyuan company, to a walnut demonstration orchard and walnut visit platform.

Over all 200 delegates attended the 7th walnut symposium in Fenyang, Shanxi Province, China.

During the two day academic meeting, 207 participants from 19 countries presented and discussed 105 abstracts and 50 papers related to walnut breeding and genetics, germplasm resources, rootstocks and propagation, orchard management techniques, pruning and training, soil, fertilization and irrigation, plant protection, biotechnology, processing and nutrition, etc. Two guest lecturers and 40 speakers presented their studies in all the categories. Besides poster and oral sessions, two workshops were held, chaired by Dr. Damiano Avanzato, with participants from different countries and talks

A moment of the ceremony.

Welcome speech by Dr. Damiano Avanzato, ISHS representative.

Delegates at the opening ceremony.

Nursery and Nuts exhibition.

Walnut germplasm exhibition.

Walnut round table.

Local traditional performance.

Dr. Avanzato presenting the medal to the convener, Prof. Janbao TIAN.

were delivered about walnut rootstocks and related issues in the walnut industry in different countries. During the four days of the symposium, over 70 Chinese walnut germplasm resources were also exhibited.

In the afternoon of 22 July, all participants visited the Fenjiu company, Wenfeng Tower landscape and watched the local traditional performance held by the local government.

At the symposium closing ceremony, Dr. Damiano Avanzato presented the ISHS organization, history and current situation. The Convener of this symposium, Dr. Jianbao Tian, Director of the International Cooperation Department from the Shanxi Academy of Agricultural Sciences, China, was elected to be the Chairman of the ISHS Working Group on Walnuts by a vote in competition with American and Iranian candidates. Meanwhile, Chile and Iran competed to host the 8th IWS in 2017 and the ISHS delegates chose Chile.

The China walnut industry will remember the 7th IWS forever. Its success is the result of the intensive and constant cooperation between the ISHS representative and the Chinese organizers over the last years. Most of the participants spoke highly of the 7th IWS, and Dr. Damiano Avanzato, Chairman of the ISHS Commission on Nuts and Mediterranean Climate Fruits, commented that of all the similar academic events of ISHS he had chaired or participated in at during his ISHS mandate, the 7th IWS was the most successful and impressive.

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REPORT ON THE II EUROPEAN CONGRESS ON CHESTNUT

(9-12 October 2013 - Debrecen, Baia Mare, Modry Kamen)

The II European Congress on Chestnut was held from 9 to 12 October 2013 in three neighbouring countries (Hungary, Romania and Slovakia) of the Central-European region. The congress was organized by the Institute of Plant Protection at Debrecen University (Hungary), Institute of Forest Ecology SAV Zvolen (Slovakia) and Fruit Research Station of University of Craiova (Romania) under the auspices of the International Society for Horticultural Science (ISHS). This international symposium, which is held every four years, brings together the World's leading experts on this valuable tree species. The 1st European Congress on Chestnut was held in Cuneo, Italy, in 2009.

The Symposium was attended by more than 100 researchers from 24 different countries (Australia, Austria, Azerbaijan, Brazil, Bulgaria, China, Croatia, France, Greece, Hungary, India, Italy, Japan, Portugal, Romania, Slovakia, South Korea, Slovenia, Spain, Switzerland, Taiwan, Turkey, and USA). The scientific programme of the congress consisted of six thematic sessions with oral presentations and posters. Presentations were held at the Hotel Aquaticum Debrecen (Hungary). Sessions were moderated by internationally renowned researchers in each of the topics.

The Symposium provided scientists, professionals and students with an opportunity to present their latest findings and discuss their current work in the area of basic and applied aspects of chestnut cultivation and production. The meeting promoted the exchange of ideas and international cooperation and collaboration among researchers and other people involved in the chestnut industry around the world. The Co-Conveners of the Symposium were Dr. László Radócz (Hungary), Dr. Milan Bolvansky (Slovakia) and Dr. Mihai Botu (Romania).

The pre-conference presentation was delivered by Prof. Ümit Serdar (University of Samsun, Turkey) who will be the organizer of the VI International Chestnut Symposium in 2016. He presented nice pictures of the Turkish chestnut industry and the venue for the future Symposium.

All oral presentations were distributed in an introductory plenary session and 5 parallel thematic sessions: Plant Pathology, Tree Physiology, Breeding and Selection, Entomology, Forestry and Orchard Management.

PLENARY SESSION

The plenary session was moderated by Dr. Chira Danut (Forest Research Institute in Brasov, Romania). Prof. Giancarlo Bounous (University of Torino, Italy) presented a paper about the perspectives of chestnut industry in Europe and all over the world. He was followed by Dr. Mark L. Double (University of West Virginia Morgantown, USA) who summarized the most interesting papers of the V International Chestnut Congress, which was organized in Shepherdstown, USA in 2012. Dr. George Melika (Food Safety Chain Office Budapest Hungary) highlighted the current situation of chestnut gall wasp and its impact on the local chestnut populations in the Carpathian basin. He was followed by Dr. Daniel Rigling (Swiss Federal Research Institute Birmensdorf, Switzerland) who analysed chestnut blight fungus and its hypovirus in Europe. Dr. Stephanos Diamandis (Forest Research Institute Thessaloniki, Greece) demonstrated the effectiveness of mass application of hypovirulent fungal strains against chestnut blight fungus on a nationwide scale. The last speaker of this session was Dr. Damiano Avanzato, chair of the ISHS Section of Nuts and Mediterranean Climate Fruits, who focused on the present activity of ISHS and conferred ISHS awards to the organizers.

A trip to Baia Mare city (Maramures County, Romania) was organized during the second part of the first day, where 5 million year old fossils of chestnut leaves were discovered. A visit to the surrounding sweet chestnut forest took place along with a guided tour to the historical centre of the town. The evening was hosted by the mayor of Baia Mare and prefect of Maramures with music and a lovely display of artwork in the foyer by local students with a theme of "Save the chestnut trees!" A fantastic banquet was held in the evening where the local foresters were acknowledged for providing excellent support for the symposium. It was a feast including roasted chestnuts and a delicious chestnut dessert. After dinner, there was a great amount of socializing and dancing with excellent music being provided by a live band playing a mix of Romanian folk songs.

SESSION I: PLANT PATHOLOGY

The session entitled "Plant Pathology" (moderated by Dr. Stephanos Diamandis and Dr. Daniel Rigling) dealt with the impact of treatments on chestnut trees to control blight fungus in Australia, Hungary, Slovakia, Portugal, Michigan State of USA, South Korea and Romania. In addition, work was also presented on management of chestnut ink disease in Spain and susceptibility to blight fungus of some local chestnut cultivars in Turkey.

SESSION II: TREE PHYSIOLOGY

Dr. Roberto Botta (University of Torino, Italy) moderated the session on "Tree Physiology". The presentations in this session analysed the chemical and nutritional characteristics of chestnut wood phenols as well as photosystem activity of the *Castanea sativa* trees under drought and highlighted conditions and phytochemical sources for herbal preparations. They highlighted the cloning of a new simple sequence repeat and its application in phylogenetic analysis among *Castanea* species. Furthermore, architectural development of young chestnut trees as affected by different propagation method was also presented.

SESSION III: BREEDING AND SELECTION

The session entitled "Breeding and Selection" (moderated by Dr. Giancarlo Bounous, University of Torino, Italy) dealt with the genetic diversity and gene conservation of sweet chestnut in Portugal, Italy and Croatia. Improvement of the pellicle peelability in Japanese chestnut breeding programme was also presented. In addition, work was highlighted on chestnut fruit sites in Hungary and Hungarian bred chestnut varieties.

SESSION IV: ENTOMOLOGY

Dr. George Melika (Food Safety Chain Office, Budapest, Hungary) and Dr. Miklós Tóth (Plant Protection Research Institute of HAS, Budapest, Hungary) moderated

Participants - II European Congress on Chestnut.

this session. Dr. Melika reviewed the European distribution of chestnut pest gall wasp (*Dryocosmus kuriphilus*) affecting chestnuts, as well as the different strategies to control it. Papers were also presented on the potential of biological control of chestnut gall wasp by its native parasitoids in different European countries. Dr. Tóth presented a paper about new, ecologically harmless methods for monitoring the chestnut tortrix (*Cydia splendana*).

SESSION V: FORESTRY AND ORCHARD MANAGEMENT

The session on "Forestry and Orchard Management" was moderated by Dr. Mihai Botu (Horticultural Research Institute of University of Craiova, Romania) and Dr. Milan Bolvansky (Institute of Forest Ecology SAS Zvolen, Slovakia). In this session 13 contributions were presented. Dr. Botu highlighted the importance of a new cultivar named 'Romval' and a new rootstock for sweet chestnut named 'Casval'. New issues included thinning operations of coppice chestnut woods, the impact of different irrigation strategies in Northeast-Portugal, the sweet chestnut supply chain of in South-Tyrol and the effect of grazing by native pigs on the vegetation of chestnut coppice.

Presentations of the second part of the session were varied and in some cases on non-traditional topics. For instance, Dr. Carmen Santamaria Linaza from Spain presented results on how to increase the added value of old chestnut groves by promoting fruiting of the very prized ectomycorrhizal fungus named *Amanita cesarea*. The use of DNA markers in the selection of genotypes of *Castanea crenata* with easy-pealing pellicle trait was presented by Dr. Sogo Nishio from Japan. Dr. Maria Fernanda Penteado de Castro from Brazil pointed out that only in some genotypes of *Castanea crenata* was a lower level of fungi infection of the kernels and shells observed in the samples collected from the tree than in the samples collected from the soil. In most trees, no difference in fungi infection of fruits was observed between both harvesting methods. The next topic presented by Dr. Milan Bolvanský, Slovakia, dealt also with fungus attacking chestnuts, particularly that one causing leaf spot. Significantly lower extent of leaf spot was observed in *C. crenata* seedlings and *C. sativa* × *C. crenata* grafts than in *C. sativa* × *C. crenata* seedlings and *C. sativa* seedlings. Dr. Roberto Botta, Italy, emphasized a complex approach to the evaluation of chestnut germplasm in Italy with the aim of both saving local cultivars and providing growers with selected plant material able to yield high quality nuts.

POSTER SESSION

This session was moderated by Dr. Ursula Heiniger (Swiss Federal Research Institute for Forest Snow and Landscape Research, Birmensdorf, Switzerland). 33 poster papers were presented there showing results from very different fields of research on cultivation and production of sweet chestnut. Nearly half of the posters dealt with diseases and pests, most of them with chestnut blight fungus and gall wasp. Other topics such as tree physiology, silviculture, chestnut cultivation including mycorrhizal fungi, biological properties as well as morphological and genetic variability of nuts were presented by 3 to 5 papers.

During the Symposium, the ISHS business meeting was held, chaired by the

ISHS representative Dr. Damiano Avanzato. At the meeting, participants agreed to hold the next European Congress on Chestnut in Bellinzona (Switzerland) in 2018, organized by Dr. Marco Conedera from the Swiss Federal Research Institute for Forest Snow and Landscape Research.

In the evening, the gala dinner was held at the dining hall of the Agricultural Faculty of the University of Debrecen. The evening banquet provided fun and informal atmosphere and brought together researchers, chestnut producers and processors. The evening included a tasting of Hungarian Palinka and other Hungarian wines, music by a local band and dances. The meal included chestnut dishes and there were 3 groups of musicians for entertainment. A group of Hungarian folk dancers was spellbinding. The shepherd stick dance was incredible and the women's costumes mesmerising. As usual, the dinner also provided opportunities for networking across the international chestnut community.

The last day (12 October) was devoted to a second field visit. On Saturday morning the participants visited chestnut forests in the Region of Danube-Bend (Nagymaros, Hungary). To reach the first location, Nagymaros in Northern Hungary, nearly 300 km away, it was necessary to pass from Debrecen. The morning programme was hosted by the mayor of Nagymaros town and local foresters. The lunch was served at the terrace of the restaurant Maros with a spectacular view over the Danube River and Visegrad hill and castle.

The distance from Nagymaros to the second location, Modrý Kameň in South-Slovakia was less than 80 km. There was a gala welcome of participants by the Modrý Kameň town mayor took place in the ceremony hall of the local manor house and castle. Afterwards the participants were invited to visit the Museum of puppet cultures and toys, which is highly specialized and the only one of its kind in Slovakia. It was amazing to learn that the smallest town of Slovakia has the largest population of European chestnut in Slovakia. Century old chestnut trees grow on several sites but most of them are heavily damaged by chestnut blight. Participants, guided by co-convener Milan Bolvanský, visited an old chestnut orchard near the castle where trees damaged by chestnut blight were, as early as 20 years ago, treated with hypovirulent strains of *Cryphonectria parasitica*. Many cankers healed but no successive natural spread of hypovirulence was observed. The field trip was concluded by an official dinner in a restaurant in the near district town Velky Krtis. The dinner was opened by a local folk music and dance group made up of women dressed in local ethnic costumes. After dinner, regional brands of wine produced by a local wine-company were served. At the end three conveners of the congress expressed their thanks to all participants for attending the congress and withstanding its demanding programme, which was held in three neighbouring, Central-European countries.

Finally a new chairman of ISHS Chestnut working group, Dr. Ümit Serdar, valued this congress positively and invited participants to attend the VI International Congress on Chestnut in Samsung, Turkey in 2016.

More information and a free copy of the Book of Abstracts can be obtained from the leader of Organizing Committee:

Dr. Laszlo Radocz
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138. Boszormenyi str.
H-4032 Debrecen, Hungary
e-mail: radocz@agr.unideb.hu
www.chestnutdebrecen.eu

Nut exhibition at the II European Congress on Chestnut.

TO BE HELD:

Almond and Pistachio

XVI GREMPA Meeting
Date: May 2015
Place: Meknès (Morocco)
Convener: Ossama Kodad, Department of Pomology, National School of Agriculture Meknès (Morocco)
E-Mail: osama.kodad@yahoo.es

Stone Pine

Meeting on the Stone Pine
Date: 2015
Place: Portugal

Chestnut

VI ISHS Chestnut Symposium
Date: September 20-30, 2016
Place: Atakum, Samsun (Turkey)
Convener: Prof. Dr. Ünit Serdar, Ondokuz Mayis University, Faculty of Agriculture, Horticultural Department. 55139 Samsun (Turkey)
E-mail: userdar@omu.edu.tr
Tel: (90) 362 312 19 19 / (90) 362 457 60 34

Hazelnut

IX ISHS Congress on the Hazelnut
Date: August 15-19, 2017
Place: Atakum, Samsun (Turkey)
Convener: Prof. Dr. Celal Tuncer, Ondokuz Mayis University, Faculty of Agriculture, Department of Plant Protection. 55139 Samsun (Turkey)
E-mail: celalt@omu.edu.tr
Tel: (90) 362 312 19 19 / (90) 362 457 60 34

Almond and Pistachio

VII ISHS Symposium on Almonds and Pistachios
Date: 2017
Place: Adelaida, South Australia
Convener: Michelle Wirthensohn. School of Agriculture, Food & Wine Plant Research Centre, Waite Campus, The University of Adelaide (Australia)
Tel: +61 8 8313 6653
E-mail: michelle.wirthensohn@adelaide.edu.au

Walnut

VIII ISHS Walnut Symposium
Date: 2017
Place: Chile
Convener: Dr. Juan Luís Vial , Chile Nut Industry

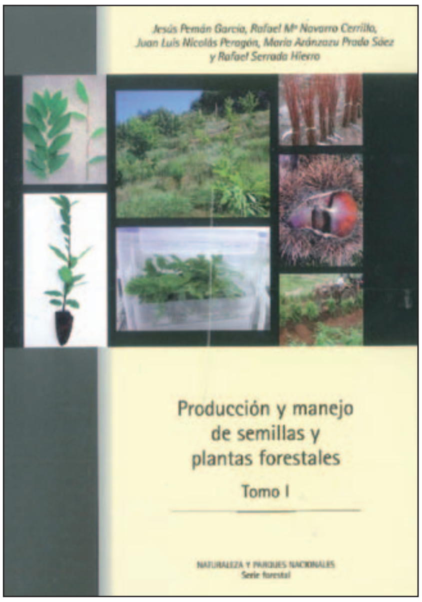
Chestnut

III European Congress on Chestnut
Date: 2018
Place: Bellinzona (Switzerland)
Convener: Dr. Marco Conedera. Swiss Federal Research Institute for Forest, Snow and Lanscape Research

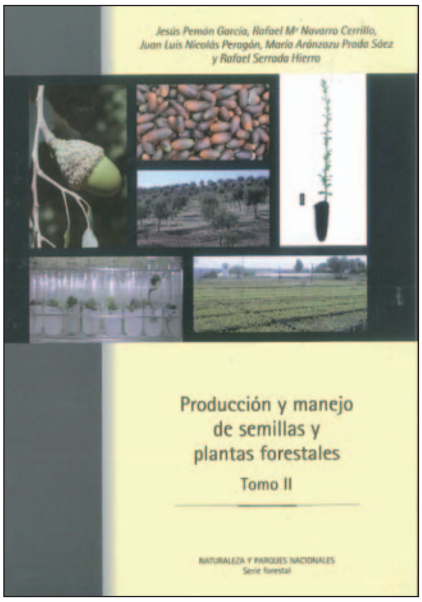
NEW BOOKS

Criterios orientadores para la admisión de materiales base del género *Juglans*. Requisitos Técnicos (in Spanish). Aletà, N.; Vilanova, A. Ministerio de Medio Ambiente Y Medio Rural y Marino, Madrid (Spain), 39p, 2011.

This is the guideline for the process of registration of the Forest Basic Material of *Juglans* spp., applying the current Spanish legislation. It includes technical criteria and protocols that should be considered for the production of different kinds of Forest Reproductive Materials.

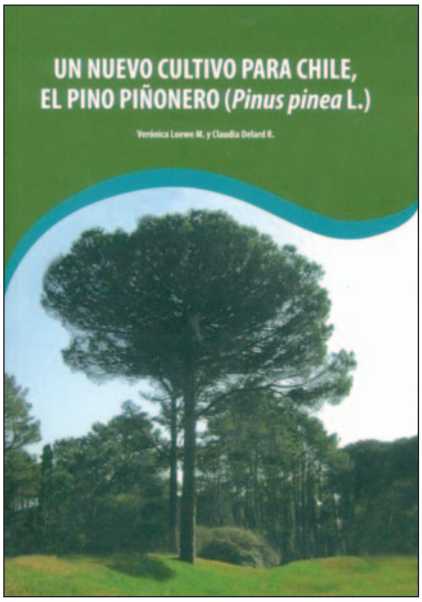


Producción y manejo de semillas y plantas forestales (Tomo I y Tomo II) (in Spanish). Pemán, J.; Navarro, R.M.; Nicolás, J.L.; Prada, M. A.; Serrada, R.



Naturaleza y Parques Nacionales, Serie forestal. Organismo Autónomo Parques Nacionales, Ministerio de Agricultura, Alimentación y Medio Ambiente. 2012.

Over 100 woody species are described in this book of two volumes. It includes some species of edible nuts such as *Castanea sativa* Mill., *Ceratonia siliqua* L., *Corylus avellana* L., *Juglans* spp and *Pinus pinea,* and the two *Pistacia* growing naturally in the Iberian Peninsula*: Pistacia lentiscus* L. and *Pistacia terebinthus* L. Distribution and ecological characteristics, reproductive biology, nursery management and production of forest reproductive materials; and potential uses in reforestation or afforestation are broadly described.



Un nuevo cultivo para Chile, el pino piñonero (*Pinus pinea* L.) (in Spanish). Published by INFOR (Forestry Institute) – INNOVA from Chile. Edited by Loewe and Delard. 2012

We present this new book on the Stone pine, published in Spanish by INFOR (Forestry Institute)-INNOVA from Chile, whose title is "A new crop for Chile, the stone pine (*Pinus pinea* L.)", by editors Loewe and Delard.

In 364 pages this text contains the main indications for those interested in planting and cultivating Mediterranean pine to produce pine nuts, known as *pinoli*, the most expensive nut in the world market. It is divided into five chapters, with attractive illustrations.

The first chapter is devoted to the species description, including historical aspects, distribution, ecological requirements, reproductive and genetic aspects, and finally sanitary issues.

The second chapter is devoted to the pinion, detailing its characteristics, uses, preparation, performance, and national and international markets.

The third chapter is devoted to wood, presenting information on its characteristics, uses and markets, and growth and productivity.

The fourth chapter focuses on plantations and orchards, and contains aspects related to the production of plants and clones (grafted plants), and presents in great detail how to establish and manage plantations and specialized orchards established with grafted plants, including the limited information available in the world.

Finally, the fifth chapter discusses in great detail the development potential of the crop in Chile, including potential production areas, social impact analysis of its cultivation, and an economic analysis of stone pine culture in Chile.

The book ends with conclusions and an extensive bibliography.

It is recommended for those interested in the species and in pine nut production with a reading knowledge of Spanish.

For purchase contact Pilar Leiva at pilar.leiva@infor.cl

La regeneración natural de *Pinus pinea* L. y *Pinus pinaster* Ait. en los arenales de la Meseta Castellana (in Spanish). Gordo, J.; Calama, R.; Pardos, M.; Bravo, F.; Montero, G., (eds.). IUGFS UVa-INIA, Palencia. ISBN 978-84-615-9823-6. 2012

This publication (in Spanish) is an outcome of the Scientific Meeting on "Natural regeneration of *Pinus pinea* L. and *Pinus pinaster* Ait. in the sand plains of the Castilian Meseta" held in 2010 in Valladolid, organised by the Thematic Network on Sustainable Forestry and Forest Management (SELVIRED), the Research Institute of Sustainable Forest Management (University of Valladolid-INIA) and the Regional Government Junta de Castilla y León. The book offers information about biology, management and research lines in natural regeneration of Mediterranean pines in a singular environment, the huge sandy plains and inland dunes of Northern Castile known as Tierra de Pinares the land of Pine Forests.

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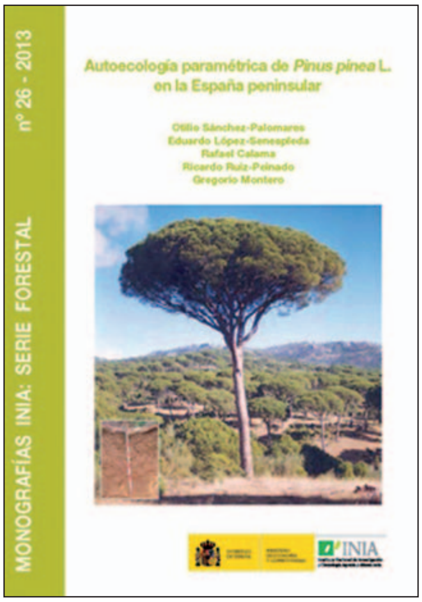

Autoecología paramétrica de *Pinus pinea* L. en la España peninsular (in Spanish). Sánchez Palomares, O.; López-Senespleda, E.; Calama, R.; Ruiz-Peinado, R.; Montero, G. Monografía INIA Serie Forestal 26. INIA, Madrid. ISBN: 978-84-7498-561-0. 2013.

The stone pine (*Pinus pinea* L.) is a typical Mediterranean tree covering more than 700,000 ha from the Iberian Peninsula to

Syria and Lebanon. The largest area of stone pine is in Spain where it and covers 475,000 ha. The relevance of the species for the Mediterranean area is one of the main reasons that justifies this research for a deeper understanding of its ecological requirements. Methodology of autecology studies for Spanish forest species is based on the environmental envelope concept, defining the physiographic, climatic and edaphic habitats. The main soil types for stone pine are regosols, arenosols and luvisols under Mediterranean climate conditions. When compared to other studied species, stone pine has a low textural valency. The potential distribution of stone pine was defined by projecting the current habitat in Spain, differing four hierarchical classes. According to this study, optimal area for stone pine might cover over seven million hectares in Spain. Significant correlations of site index with ecological parameters are given.

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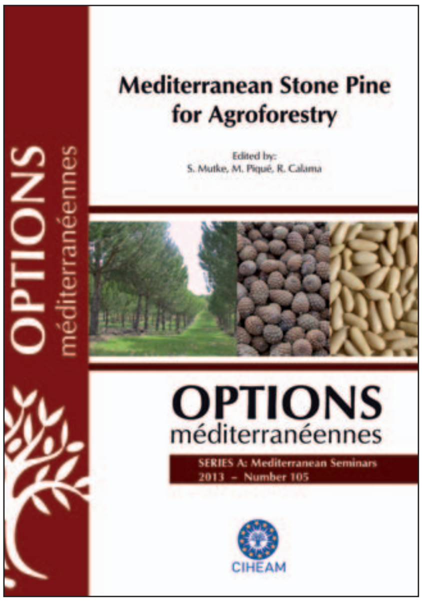

Mediterranean stone pine for agroforestry. Mutke S.; Piqué M.; Calama R. (eds), Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 105. Zaragoza: CIHEAM / FAO / INIA / IRTA / CESEFOR / CTFC. 2013, 140 p.

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 collected mainly from natural forests in the Mediterranean countries, and only recently has the crop taken the first steps to domestication as an attractive alternative on rainfed farmland in Mediterranean climate areas, with plantations yielding more pine nuts than the natural forests and contributing to rural development and employment of local communities. The species performs well on poor soils and needs little husbandry, it is affected by few pests or diseases and withstands adverse climatic conditions such as drought and extreme or late frosts. It is light-demanding and hence has potential as a crop in agro forestry systems in Mediterranean climate zones around the world.

This publication contains 14 of the contributions presented at the AGROPINE 2011 Meeting, held from 17 to 19 November 2011 in Valladolid (Spain). The Meeting aimed at bringing together the main research groups and potential users in order to gather the current knowledge on Mediterranean stone pine as a nut crop and to analyse its potential and current challenges. The presentations and debates were structured into two scientific sessions dealing with management of stone pine for cone production and on genetic improvement, selection and breeding of this species, and was closed by a round-table discussion on the challenges and opportunities of the pine nut industry and markets. Thirty nine scientists, and forest and industry managers, coming from Lebanon, Portugal, Spain, Tunisia and Turkey participated in the meeting, which will hopefully be the first of a series of meetings and activities of the newly restored FAO-CIHEAM Sub-network on Mediterranean Stone Pine

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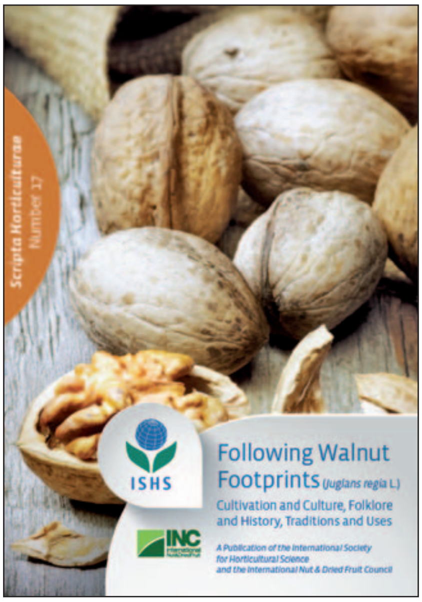
http://om.ciheam.org/option.php?IDOM=1010



Following Walnut Footsprints (*Juglans regia* L.). Cultivation and Culture, Folklore and history, Traditions and Uses. Avanzato, D. Scripta Horticulturae, 17. ISHS-INC. SSN 1813-9205. 2014, 448p.

This edition on the Walnut is the fifth in the *Scripta Horticulturae* series "Following Footprints", after the previously published volumes on the Almond, Pistachio, Chestnut and Olive.

"Following Walnut Footprints" revisits 58 walnut growing countries, in particular Afghanistan, Albania, Algeria, Argentina, Armenia, Australia, Azerbaijan, Bulgaria, Canada, Chile, China, Czech Republic, Denmark, Egypt, France, Georgia, Germany, Great Britain, Greece, Hungary, India, Iran, Italy, Japan, Kazakhstan, Kyrgyzstan, DPR Korea, South Korea, Lebanon, Macedonia, Mexico, Moldova, Montenegro, Morocco, Nepal, the Netherlands, New Zealand, Nigeria, Norway, Pakistan, Poland, Portugal, Romania, Serbia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Tajikistan, Tunisia, Turkey, Turkmenistan, Ukraine, Uruguay, USA, and Uzbekistan. 120 specialists from all over the world have collaborated with this book.

The members of the Editorial Board were: *Damiano Avanzato* (Chair of ISHS Section Nuts and Mediterranean Climate Fruits for the period 2006-2014), who took care of the contacts with Caucasian and Asian countries and *Gale McGranahan* (University of California, USA) who liaised with the English-speaking countries and the Commonwealth, *Kourosh Vahdati* (University of Tehran, Iran) who coordinated with the Middle East and Muslim countries, *Botu Mihai* (University of Craiova, Romania) who coordinated with the countries of Central and Eastern Europe, *Iannamico Luis* (Instituto Nacional de Tecnología Agropecuaria Rio Negro, Argentina) who coordinated with the South American and Spanish speaking countries and *Jozef Van Assche* (Executive Director of the International Society for Horticultural Science, Belgium) who coordinated with the countries of northern Europe. The work started in November 2012 and was completed in December 2013.

This book reports the status of the walnut industry country by country. Information is given on the geographical distribution of the species of *Juglans*, its historical origin and its introduction into different countries. It also presents Persian walnut cultivation techniques and information on native varieties, as well as commercial data.

The walnut is one of the most important nut species from an economic and botanical point of view, and in many countries it has a rich cultural heritage. Today the walnut is grown in over 60 countries around the globe, and is harvested from both cultivated orchards and wild populations. Modern production techniques have resulted in the cultivation of selected varieties; modern machinery is now responsible for much of the processing (de-hulling, cleaning, grading, storage, packaging); and the range of processed products has been expanded. All of these factors have extended the period for consumption of walnuts. In the past, the highest demand for walnuts occurred during the Christmas period, but nowadays nut consumption is constantly extending into other times of the year. The USA dominates the international market for standardized walnutsand together with France, was the first country to cultivate selected walnut trees. There are now many countries that are equipped to produce quality nuts, including Chile, Argentina and Australia, and countries such as Turkey, Iran, Spain, Italy, Romania and Hungary. China has the highest walnut production in the world, in terms of area cultivated and quantity of nuts produced. Their industry is mainly based on saplings, the product of which is greatly affected by nut variability. However, efforts are underway to encourage the planting of walnut orchards with locally selected cultivars or with foreign cultivars that are commercially recognized for their high value, e.g., 'Chandler'.

The authors of this book were requested to include descriptions of traditional uses of walnut, both of the fruit itself, and also of the plant. The result has been a collection of data that relates to the original uses of walnut wood (e.g., cabinet making and handcrafts), leaves (e.g., medicinal use), husks (e.g., extraction of dye), shells (e.g., domestic heating and the cleaning of jewelry), and kernels (direct consumption and in the preparation of sophisticated sauces). Even the membrane that divides the valves of the kernel has been used as "confetti" decoration! In many cases, the authors report on the use of walnut in culinary recipes and reveal how it has sparked the imagination of mankind throughout history and in modern times. The authors have made significant efforts to collect data, as evidenced by more than 800 references that accompany the various chapters.

In publishing this volume, the International Society for Horticultural Science (ISHS) has made a significant contribution to the exchange of information between developed and developing countries, confirming the vocation of the organization to promote international cooperation between scientists from around the world.

As Chair of the ISHS Section Nuts and Mediterranean Climate Fruits from 2006 until 2014, I thank all those who have collaborated on this volume and hope that similar initiatives will be launched in the future for other fruit species. The next challenge will be the preparation of a volume "Following Hazelnut Footprints".

Il Castagno. Risorsa multifunzionale in Italia en el mondo (in Italian). Bounous, G., 2014.

This book is a tool for researchers, teachers and students and a solid manual for technicians, chestnut growers and hobbyists. It devotes ample space to agronomic technics, propagation, pests and diseases, management, and maintenance and recovery of old chestnuts. Aspects of the collection and use of fruit and wood are also discussed, as well as silvicultural management and landscape values.

Written by Prof. Giancarlo Bounous, Liaison Officer of the Working Group Chestnut of the FAO-CIHEAM Inter-Regional oOn Cooperative Research Network and Nuts. Chairman of the Working Group on Chestnuts of ISHS (International Society for Horticultural Science), (2014).

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