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European Hazelnut and Almond Genetic Resources: Safeguard and Traditional Uses

Loretta Bacchetta * and Barbara Di Giovanni

Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Via Anguillarese No. 301, Rome 00123, Italy; E-Mail: barbara.digiovanni@enea.it

* Author to whom correspondence should be addressed; E-Mail: loretta.bacchetta@enea.it; Tel.: +39-06-3048-3405; Fax: +39-06-3048-6044.

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Abstract: The extensive worldwide interest in plant genetic resources regarding the opportunities offered by their use is clearly described by the objectives set out in both the Convention on Biological Biodiversity (CDB) and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA). This article presents the European AGRI GEN RES SAFENUT project, including its methods and results, as an example of a resourceful strategy for reorganizing and sharing hazelnut and almond genetic resources. The project emphasizes how crucial it is to preserve not only genetic resources *per se*, but also the unique cultural value of the traditional and historical uses of hazelnut and almond genetic resources, which people have conserved and, in some cases, enhanced.

Keywords: SAFENUT database; traditional knowledge; local cultivars; accessions; benefit sharing

1. Introduction

The Convention of Biological Diversity (CBD) [1] was established in 1993 as a legal instrument for accomplishing the objectives of biodiversity conservation, sustainable use of the conserved germplasm and the fair and equitable sharing of the benefits derived from the utilization of genetic resources. In particular, the CBD encourages its Contracting Parties to share the benefits arising from the commercialization of products based on genetic resources while protecting their traditional crop-related knowledge. Each Contracting Party is encouraged to: develop general measures for

conservation and sustainable use into relevant cross-sectoral plans (Article 6); organize *in situ* and *ex situ* conservation (Articles 8 and 9); and preserve, respect and maintain “knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity” (Article 8(j)). Nevertheless, access to genetic resources (Article 15) and the equitable sharing of benefits are among the most contentious issues in the CBD negotiations.

In the last quarter of the 20th century, a progressive re-evaluation of natural resources was undertaken in most countries worldwide. The International Regime on Access and Benefit Sharing [2] stressed the importance of defining the rules to properly use genetic resources and their associated traditional knowledge with the aim of supporting sustainable agriculture and food security. The implementation of Article 6 of the CBD [1] is a standing priority item on the agenda of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) [3], with a view to promoting an integrated approach to the sustainable use of Plant Genetic Resources for Food and Agriculture among Contracting Parties. Therefore, at its Third Session, the Governing Body “reiterated the fundamental importance of promoting the implementation of Article 6 in order for Contracting Parties to enhance their capacity to utilize plant genetic resources for the enhancement of agricultural production through plant breeding, including the utilization of modern tools, traditional varieties and the participation of farmers” [4].

Furthermore, at its Fourth Session, the Governing Body requested “to convene a stakeholders’ consultation, preferably by electronic means, to gather information in order to devise and elaborate elements of a work programme, in collaboration with relevant international organizations and key actors engaged in sustainable use of plant genetic resources for food and agriculture” [5].

On these premises, the European SAFENUT Action (according to [6]) is a strategy for re-organizing and sharing, in a more efficient manner, hazelnut (*Corylus avellana*) and almond (*Prunus dulci*) genetic resources by upgrading the knowledge regarding their value as well as the precious cultural meaning related to traditional and historical uses by the people who conserved and, in some cases, enhanced them [7]. These two Mediterranean species—which are commodities of considerable economic importance in Europe—are particularly interesting since their utilization is strongly intertwined with human civilization [8].

2. Description of the SAFENUT AGRI GEN RES Action

The SAFENUT project benefits from the participation of eleven research institutes in six European Partner Countries (Italy, Spain, Portugal, France, Slovenia, Greece) and from the involvement of some of the major hazelnut and almond producers and researchers, who are directly engaged in breeding activities and conservation of genetic resources.

The management of the SAFENUT Action has been organized as follows. The first activity is aimed at increasing the knowledge of the hazelnut plant material existing in *ex situ* and *in situ* collections, held by the Partner Countries. In order to recover and safeguard the maximum useful genetic diversity, a survey was carried out in different European areas on endangered cultivars and ecotypes that are conserved *on-farm*. As part of this survey, the characterization of selected accessions, with particular attention to nutritional and nutraceutical aspects, was undertaken to identify germplasm

that meets the demand of consumers—who are interested in high-quality food products—favoring new agro-industrial opportunities. The availability of reliable data on biochemical and molecular traits allows researchers to define suitable uses of nut products, as required by industries and consumers. This information is also very useful for breeding programs. Moreover, actions are needed in order to increase the public's awareness on protection of genetic resources and to provide an overview of the existing biodiversity throughout Europe. The historical memory of the local and traditional uses of old varieties, usually belonging to the older farmers, needs to be recorded and transferred to younger generations, otherwise it will be lost forever. Hence, the knowledge and safeguard of traditional agricultural practices, land uses, structure of orchards and organizations might be useful information in support of new sustainable agro-industrial applications. Furthermore, retaining and enhancing local agricultural practices may contribute to the conservation and protection of soil and biodiversity resources and to retaining the landscape structure. The establishment of a widely accessible web-based system (the SAFENUT database [9]) represents a tool for monitoring the management of Mediterranean hazelnut and almond genetic resources and their location, including traditional and ecological information associated with the crop.

In addition to the above, this paper also describes the SAFENUT Action results with a focus on the possible resulting benefits and stakeholders' involvement.

3. Main Results and Benefit Sharing

3.1. Rationalization of Almond and Hazelnut Genetic Resources for Better Conservation and Use

Following initial research, one of the first outcomes of the project was a complete list of the available germplasm: 209 accessions and 58 selections of hazelnuts from 13 collections, and a list of 180 almond cultivars was released by four Partner Countries, with spelling amendments. In general, the lack of nursery activities or certified material for propagation in new orchards as well as the large number of varieties increased the chance of mistake, or caused some confusion among local populations [10]. The consequence of this scenario is a waste of human and financial resources for conservation, along with duplication of useless materials. In this regard, 305 hazelnut and 240 almond samples were evaluated by DNA analysis throughout the three project years, with the aim of verifying the identity of the plants kept in European collections as well as of those rescued. The following step for re-organization and better conservation of genetic resources was their long-term storage in a DNA bank located in Spain, in order to collect more than 200 almond cultivars.

In order to get morphological evaluations of the germplasm consistent across Parties, specific descriptors were clearly defined. Overall, during the three-year Action, 110 accessions of the two species were evaluated for their fatty acid profiles, tocopherols, phenolic compounds and mineral and protein contents [11,12]. Seven reference hazelnut cultivars were identified and monitored each year to investigate the environmental effects on the biochemical properties of those nuts. About 90% of the world hazelnuts are shelled and sold as kernels, while the remaining 10% is sold in-shell for fresh consumption. The food industry, the primary user of kernels, has precise requirements as to their morphological, chemical and physical characteristics, besides the need for absence of imperfections. Moreover, there has been a remarkable increase in the number of consumers who require high-quality

food products for dietary, health, organoleptic or environmentally-friendly reasons [13,14]. This effort should facilitate and promote the utilization of germplasm, thus favoring further agro-industrial applications, for instance in the cosmetic field.

Based on this information, the multivariate analysis of the entire data set allows the development of core collections. Designing a core collection involves an appropriate use of diversity and offers breeders an opportunity to work with a manageable number of accessions that have been evaluated on traits of economic importance [15,16].

3.2. The Social-Economic Impact of the Recovered Traditional Germplasm Conserved “On-Farm”

The recovery and improvement of new cultivars—which implies the enlargement of the germplasm base and of the available useful genes—may offer new economic possibilities for local markets in addition to potential industrial applications. During the three years of the SAFENUT Action, several *on-farm* hazelnut ecotypes and endangered almond cultivars were recovered and evaluated. Moreover, the exploitation of “ecotypes” presently with restricted distribution and low penetrance, which are usually well adapted to the local conditions, is an instrument that fosters cultural diversification by preserving the greatest genetic variability [17]. Nut tree germplasm may be conserved *on-farm* to ensure perpetuation of traditional crop varieties within the traditional agricultural system, where the farmer is one of the participants who creates and maintains the present diversity, as underlined by the International Treaty on Plant and Genetic Resources for Food and Agriculture. In particular, organic and other farmers, who use methods that do not heavily rely on fertilizers and pesticides, require selected crops for their specific growing conditions. During the SAFENUT project, a survey was carried out in Italy, Slovenia, Spain and Greece in order to recover the *on-farm* endangered germplasm: 88 hazelnut and 122 almond accessions, confirmed by DNA analysis, were selected and evaluated.

The SAFENUT Action examined the issues to be faced during the promotion of cultivation as well as the use of local germplasm and the benefits from sharing it as an alternative to the use of the main widespread and well-known cultivars. The first main consideration concerns the evaluation of plant material (*in situ* evaluation and multi-location analysis). An *in situ* evaluation was carried out throughout the period of the Action, using the primary morphological descriptors which were developed within the project itself. Depending on the selection period, each accession was evaluated for one or two years, and more specific information still is to be collected after about five years of evaluation to better understand the germplasm behavior. For a reliable assessment of the traits of economic importance, multi-location experimental trials are also recommended. As for the hazelnut, IRTA in Spain is the most important Centre for morphological evaluation (DHE: Distinctness, Homogeneity, and Stability) at European level. The reference almond collection in Cataluña was able to integrate old endangered cultivars that are still being identified and recovered. The co-operation with local commercial nurseries is crucial for the propagation of interesting plant material on a large scale. In the case of fruit-crops, the process from the selection of new accessions to morphological, molecular and biochemical evaluation and propagation takes no less than 10 years. Another important step is the registration of the new cultivars at official institutes. The new cultivars will be officially recognized once registered in either a list of varieties or a list of patents at both the national and European levels. A new variety can also be considered for a patent. For the safeguard and patenting of

new varieties there are European rules that must be respected; the Community Plant Variety Office (CPVO) in Angers, France, is the organization responsible for plant patents in the EU [18]. However, there are different ranges of costs to bear patenting or registration, according to the procedures at the national or European level, including patent fees and experimental trials costs. In Italy, there is a national network for tree-fruits, but the situation has not yet been updated in the Italian Ministry of Agricultural Policies. The Italian registration can be freely carried out at regional level through the Regional Agencies for Development and Innovation in Agriculture. In Spain, the official register of plant varieties is located at the Ministry of the Environment, Rural and Maritime Affairs.

In several Partner Countries of the SAFENUT project, namely Italy, Greece, Slovenia, and Portugal, the lack of a referent plant nursery implies that some crucial issues are not adequately dealt with, such as the propagation of unidentified cultivars or the dissemination of diseases. In Italy, hazelnut orchards are traditionally propagated by growers. They generally select the most vigorous plants by using their own rooted suckers. For instance, the plague of *Xanthomonas syringae epv avellanae* caused the death of thousands of hazelnut trees in central Italy due to the above-mentioned self propagation and exchange among growers [19]. The information dissemination on the importance of recovering old cultivars, as delivered through the SAFENUT Action, has helped to raise growers' awareness and interest in cultivating crops with a high traditional value despite a less immediate profit. This is a crucial concept, particularly when referred to the almond market, which now consists largely of non-traditional Californian cultivars characterized by their large fruit-size but reduced flavor and nutritional value if compared to local cultivars [20,21]. Therefore, during the SAFENUT Action, some French almond growers accepted to re-introduce 18 traditional old endangered almond cultivars in new orchards. The last aspect concerns the incentives given to growers with respect to the conservation of genetic resources at the national and European levels. Besides the European measures on recovering and protecting endangered nuts, their registration and inclusion in the Rural Regional Plans implies financial support for growers, who choose to use them for new orchards instead of more profitable, non-indigenous, commercial cultivars.

3.3. Sharing of Information: The SAFENUT Database

Sharing information on Plant Genetic Resources (PGR) is imperative for planning and implementing activities related to their conservation, sustainable use and benefit sharing. The need for developing, maintaining and exchanging such information is specifically recognized in the Convention of Biological Diversity (Articles 7d and 17), and in the Global Plan of Action (Food and Agriculture Organization of the United Nations—FAO [22]). Furthermore, this concept is highlighted in the EC AGRI GEN RES program [23]. The IT developments made PGR information management through databases very important at the national, regional and global levels, and used standard descriptors for its effective exchange [24]. The SAFENUT database (available at [9]) was organized in order to provide users with multi-trait data based on germplasm evaluation records, by means of on-line search-queries. The information currently accessible is as follows: specific descriptors and passport data—as suggested by EPGR Biodiversity International—of 58 hazelnut and 248 almond accessions; photos of accessions; biochemical contents of the nuts (including fatty acids, vitamin E, protein, phenolics, minerals); and molecular data (SSR markers). The database structure and its content are

consistent with those of other international databases, such as the *Prunus* database [25]. In order to facilitate its utilization, web-pages are dynamically interfaced with the database. This approach ensures that the information from the database is up-to-date. When exploring the inventory, the drill-down concept is utilized so that when users find information of possible interest they can query the database for additional details.

3.4. The Importance of Traditional Knowledge Associated with Genetic Resources

The CBD places great emphasis on the increased awareness on the value of traditional knowledge associated with biological resources. In particular, the Nagoya Protocol [26] provides a legally binding framework which regulates access to genetic resources, although it does not provide for the disclosure of origin of associated traditional knowledge [27]. In Europe, this is a particularly important issue that takes into account the high number of products as related to traditions and uses. In this framework, the SAFENUT Action aims at safeguarding the traditional memory for the cultural heritage of future generations. Actually, the recovery of local uses has profound implications, which can be useful for new agro-industrial applications. The purpose of this approach is building a strong link between genetic resources and the eco-geographical areas they belong to. Furthermore, the recovery of traditional knowledge was achieved by different approaches: 2097 questionnaires were elaborated from high school students and their parents, interviewed in all the Partner Countries; a survey on the festivals related to the two Mediterranean species was carried out and published [28]. Questionnaires were addressed to farmers so as to provide them with the opportunity of comparing problems, as well as technical practices, and to record knowledge of the biodiversity present at European level. Keeping faithful to this philosophy, different ways of promoting the recovered endangered varieties were also examined in the different Partner Countries by analyzing the crucial aspects across regions, necessary for a common way to success. In particular, this followed the European recommendations on the European Strategy and Action plan towards a sustainable bio-based economy by 2020. The knowledge-based approach of the SAFENUT project shifted from the classic top-down “knowledge-transfer” approach into a “knowledge-exchange” approach. This method recognizes the importance of traditional knowledge that encompasses different types of expertise and enhances local capabilities in order to foster dialogue and engage active discussion with business and societal communities.

4. Conclusions

The study, evaluation, characterization, assessment and enlargement of the germplasm diversity represented in *ex situ* and *in situ* collections are significant to plant breeders for crop improvement and to multiple stakeholders for efficient use and effective management of plant genetic resources.

The morphological, molecular, biochemical characterization of hazelnut and almond European accessions enhance the value and potential utilization of the germplasm, thus making it available at the pan-European and international levels [29]. Furthermore, the characterization of the core collections with emphasis on the nuts’ nutraceutical properties may create new economic opportunities and contribute to a more suitable use of the clones held in the collection. Among the nuts, hazelnut and almond are two commodities of high economic importance. They also hold a significant and interesting social value as they are closely intertwined with traditions and local products strongly

linked with the people who use and, at the same time, safeguard them. Hence, it goes without saying that the SAFENUT database is a useful tool for freely sharing information at the national and international levels, and it represents an excellent opportunity for the preservation of genetic resources. The activity is based on a knowledge-exchange concept as a co-operative effort for increasing information and expertise, which are useful when trying to obtain a sustainable production chain. The sharing of high-quality PGR information is a crucial input when deciding on the utilization of current resources in order to reduce duplication of effort and provide a common vision for future direction.

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Conflict of Interest

The authors declare no conflict of interest.

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