

Coordination of genebank activities between different national collections of berry genetic resources in Europe in the frame of ECPGR

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Abstract

Cultivated strawberries (*Fragaria* L.), raspberries (*Rubus* L.), and several other berries belong to the *Rosaceae*. *Fragaria* as well as *Rubus* are comprised of a highly heterozygous series with a range of ploidy levels. Blackcurrants, red currants and gooseberry belong to the *Saxifragaceae*, whereas blueberry (*Vaccinium* L.) crops belong to the *Ericaceae*. Domestication, breeding, and the transition from small-scale production to intensive production in specialized farms have resulted in a reduction of both morphological and genetic diversity. Therefore, retaining the variability available today to limit the decrease of the genetic base is important. Most of the temperate fruit species are genetically heterozygous and vegetatively propagated. In Europe, collections of berry genetic resources are maintained in the field as active plantations where the accessions are available for characterization, evaluation, and distribution. Backups for the plant material are needed to provide security in case of a disease or an environmental disaster. A long-term coordinated work with extending collaborative actions of berry genetic resources on the European level is necessary. In March 2019, the new Berries Working group was established under the umbrella of the European Cooperative Programme for Plant Genetic Resources (<http://www.ecpgr.cgiar.org/working-groups/berries/>). At present, 85 members from 22 European countries have accepted collaboration within this working group. The main goal of the working group is to coordinate the activities between the national collections based on a continuous long-term network cooperation. This includes different activities for harmonizing and enhancement of management of existing ex situ collections of berry genetic resources. The European Search Catalogue for Plant Genetic Resources will be used for the documentation.

Keywords: characterization, ECPGR, *Fragaria*, fruit genetic resources, preservation, *Rubus*, *Vaccinium*

INTRODUCTION

The conservation and use of plant genetic resources is an evolving scientific discipline with an important technical, socio-economic and political concern over the past 50 years (Engels, 2004). The ratification of the Convention on Biological Diversity (CBD) in 1992 has led to considerable awareness about the importance of conserving biodiversity, its sustainable use and the need for equitable benefit-sharing arrangements. Several countries have strengthened efforts for the conservation and sustainable use of plant genetic resources (PGR) based on the CBD and the Global Plan of Action for the Conservation and Sustainable Use of PGR for Food and Agriculture (<http://www.fao.org/home/en/>). Consequently, biodiversity is now an important global issue. The Global Plan provides a coherent framework for activities in the field of in situ and ex situ conservation, and for sustainable utilization of PGR.

In Europe, the ex situ and in situ conservation of PGR is facilitated by the European Cooperative Programme for Plant Genetic Resources (ECPGR). This organization was founded in 1980, based on recommendations from the United Nations Development Programme, the

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Food and Agriculture Organization of the United Nations, and the Genebank Committee of the European Association for Research on Plant Breeding (<http://www.ecpgr.cgiar.org/>). The long-term goal of the ECPGR is to facilitate the effective long-term ex situ and in situ conservation of plant genetic resources and to promote their characterization, evaluation, and encourage their exchange and sustainable use. The ECPGR is a voluntary association of individuals with a common goal and the willingness to contribute within the limits of their capabilities and those of their organization to joint activities. The ECPGR is financed by the participating countries. Members of the Working Groups (WGs) and other scientists from participating countries follow an accepted work program with their own resources as in-kind contributions to the program.

Currently, ECPGR operates through 20 crop specific WGs and three thematic WGs. The focus of their collaborative actions has been on the documentation of the collections conserved in European countries. The ex situ collections are available online through the European Internet Search Catalogue (EURISCO), which is a compilation of national European inventories (<http://eurisco.ipk-gatersleben.de>). In recent years, ECPGR has made efforts towards establishing a European genebank integrated system (AEGIS; <https://www.ecpgr.cgiar.org/aegis>), which is an initiative to improve coordination and share the responsibilities of the conservation, management, and access of and to genetic resources in Europe (Engels and Maggioni, 2011). Countries and institutions selected to be part of the European Collection will adhere to the AEGIS programme and assume long-term conservation responsibilities for AEGIS accessions (Maggioni and Engels, 2014). This approach offers great potential to harmonize and improve the quality of germplasm collection management and their use.

For fruit genetic resources, the ECPGR *Prunus* WG was established in 1983 as one of the initial six working groups. In 1995, the *Malus/Pyrus* WG was founded. In the past years, a number of joint projects were realized (Benedikova and Giovannini, 2013; Evans et al., 2009) and species-specific databases were created (<http://www.bordeaux.inra.fr/euprunusdb/index.html>; <http://www.nationalfruitcollection.org.uk/ecpgr.php>). While coordinated and successful work has been carried out over many years for the tree fruit species under the two above-mentioned ECPGR groups, this possibility did not exist for the berry fruit genetic resources. This paper describes the establishment and first activities of the Berries WG.

BERRY GENETIC RESOURCES

In botanical terminology, a berry is a simple fruit with seeds and pulp produced from the ovary of a single flower, in which the complete pericarp is still juicy or at least fleshy when ripe (Kiger and Porter, 2001). Traditionally and in everyday language, the term has different meanings and is usually used for small, sweet fruits, and the berry fruit. Berries under both definitions include blueberries, cranberries, lingonberries, and the fruits of many other members of the heather family, as well as gooseberries (*Ribes* L.), goji berries (*Lycium* L.) and elderberries (*Sambucus* L.) The fruits of currants (*Ribes* L.), such as blackcurrants, red currants and white currants, are botanical berries, even though their most commonly used names do not include the word “berry”. On the other hand, several different kinds of fruit commonly called berries are not botanical berries. Blackberries, raspberries, and strawberries are aggregate fruit; they contain seeds from different ovaries of a single flower.

The cultivated strawberries, raspberries, and several other berries belong to the *Rosaceae* family, and the *Rosoideae* sub-family. *Fragaria*, as well as *Rubus* are comprised of a highly heterozygous series with a range of ploidy levels. The number of species is particularly high for *Rubus* (>500). Blackcurrants (*Ribes nigrum* L.), red currants (*Ribes rubrum* L.) and gooseberry (*Ribes uva-crispa* L.), belong to the *Saxifragaceae* family; whereas some other berry crops belong to other families such as *Actinidiaceae*, *Annonaceae*, *Berberidaceae*, *Caprifoliaceae*, *Eleagnaceae*, *Ericaceae*, *Moraceae*, *Rosaceae*, *Schisandraceae*, *Solanaceae*, or *Vitaceae*. Because a large number of plant species belong to berry fruit genetic resources, the activities of the Berry WG will be diverse, and prioritization will take into account the economic importance of the crop.

Strawberry (*Fragaria*) is economically the most important berry crop with a harvest area of 104,328 ha and total production of 1,271,750 t in 2018 in the EU (FAOSTAT, 2020).

Strawberry is particularly well represented, due to its widespread production across all EU countries. This fruit was chosen to be on the Annex 1 list of the International Treaty on Plant Genetic Resources for Food and Agriculture (<http://www.fao.org/plant-treaty/en/>). Alongside the important role of strawberry in the EU market, the production of other berries, especially red raspberry and blueberry, are increasing rapidly. Raspberry (*Rubus*) (41,328 ha and 229,240 t in 2018) as well as blueberry (19,170 ha and 114,735 t in 2018) are becoming increasingly important in the EU with an expansion of cultivation in response to high market demand. For most of these cultivated species, domestication has resulted in a reduction of both morphological and genetic diversity, with modern cultivars being genetically similar. Therefore, keeping the variability available today to limit the decrease of the genetic basis of berry genetic resources is important.

Most of the temperate fruit species are genetically heterozygous and vegetatively propagated. Unique heterozygotic individuals, which have been identified and selected for their special combination of genetic attributes and which cannot be regenerated by seed, are the focus of breeding and commercial fruit production. Collections of berry genetic resources are maintained in the field as active collections where the accessions are available for comprehensive characterization, evaluation, and distribution. However, several factors such as exposure to pests and diseases as well as abiotic hazards limit the efficiency of active collections and threaten their security. Field genebanks require considerable input in the form of land, labour, management and materials, and therefore, their capacity to ensure the maintenance of the diversity present in a species is limited.

For *Fragaria*, the field plantings have some special disadvantages, such as a regular careful monitoring to avoid contaminations by runners from different accessions, and the natural spread viruses through insect vectors. These plants require periodic replanting. The same problems exist in the other berry fruit species (*Rubus*, *Ribes* and *Vaccinium*). The turnover is much shorter for strawberry (2 or 1 year for some institutions) than for raspberry (5-8 years). For this reason, the collections are subject to permanent changes.

Ideally, the berry germplasm has to be stored as potted plants under insect-proof screens with an active integrated pest management program to reduce the risk of virus infection. Backups for the plant material in active collections are needed to provide security in case of a disease or environmental disaster. A safety backup collection comprises accessions of an active collection at different locations, i.e., maintained at a second site as a field collection, in greenhouses, or held as in vitro cultures in the laboratory as short- and medium-term storage or cryopreservation as long-term storage.

COLLECTIONS OF THE CULTIVATED STRAWBERRY AND OTHER BERRIES IN EUROPE

During an earlier European AIR project in the years 1994 and 1995, a first inventory of strawberry was created with 900 cultivars of the main European collections (Roudeillac and Boxus, 1997). In 1998, the European COST action 836 “Integrated research in berries” was initiated to coordinate the scientific activities in 22 partner countries (Geibel and Roudeillac, 2000). A first overview of the responsible working groups for genetic resources has shown that the collections of the participating institutes have been changed significantly within these few years. At the end of the COST action 836, the database included entries of 1,056 strawberry cultivars from 20 collections. Nearly half of the listed cultivars are grown only at one site and at least six important old cultivars still appear lost. Therefore, 108 important cultivars were selected as the core mainly for historical reasons.

An improvement of the European cooperation regarding the genebank activities was reached with the EU project AGRI GEN RES 036 “European small berry genetic resources” (2007-2011). The objective of the EU GENBERRY project was to ensure that agricultural biodiversity of berries, strawberry and red raspberry is preserved and characterized for further breeding programs. This project was based on the notion of networking, considering that maximum benefit can only be reached by coordinating competences on techniques of cultivation, phenotypic description, molecular biology, as well as evaluation for health value compounds and plant disease resistance. This project involved ten partners located in eight European countries (France, Italy, Germany, Great Britain, Lithuania, Poland, Romania and

Spain; <http://www.bordeaux.inra.fr/eustrawberrydb/>; Sasnauskas et al., 2014).

For edible currants and gooseberry, the RIBESCO project (2007-2011) was initiated with the aim to establish cooperation between national collections in different countries in order to find the most valuable part of each collection and organise a decentralised core-collection for safe and recognised conservation (Karhu et al., 2012). This project involved nine partners located in eight European countries within the Baltic Sea Region (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden). During the project, the existing European Central *Ribes/Rubus* Database under construction at the Vilnius University, Lithuania was utilised and updated (<http://www.ribes-rubus.gf.vu.lt/download.htm>).

Based on these two projects, the main objective of the subsequent EUBerry project (2011-2014) was to provide the necessary knowledge and tools to facilitate development of high quality, consumer-desirable fresh berry fruits of high nutritional quality optimal for human health at a competitive cost (<https://www.euberry.univpm.it/Project>). In addition, the project aimed at developing and validating sets of tools to improve competitiveness of European berry production and consumer accessibility to berry fruits. One deliverable was the data mining of existing characterisation data.

The aim of GoodBerry project (2016-2020) was to use novel approaches for genetic improvement of berries in different environments, which are absent in current breeding programs caused by the genetic complexity of these species and the complex plant-environment interaction and particular management practices. Seven European countries, China and Chile are involved (<https://goodberry-eu.eu/>).

The disadvantages of the above mentioned projects are 1) only a limited number of countries could be involved, 2) the time frame was limited and 3) the topic “genetic resources” covers only a very limited part of what is needed. However, due to changes of persons responsible of European genetic resources, the lack of money and phytosanitary problems, genetic resources works are endangered today. A long-term coordinated work with extended collaborative actions of berry genetic resources on the European level is necessary.

BERRIES WG – A NEW MEMBER OF THE ECPGR

Many partners of the above-mentioned European projects support the idea to build a regular coordination framework to improve the status of berry genetic resources conservation, characterization, evaluation and use in Europe. In March 2019, the new Berries WG was established under the umbrella of the ECPGR (<http://www.ecpgr.cgiar.org/working-groups/berries/>). At present, 85 members from 22 European countries have accepted to collaborate within this working group (Figure 1).

Monika Höfer from the Julius Kühn-Institute (JKI), Institute of Breeding Research on Fruit Crops in Dresden-Pillnitz, Germany was nominated as the chair of this WG. The main goal of the working group is to coordinate activities between the national collections based on a continuous long-term network cooperation. The general objectives of the ECPGR for the newly founded WG will be adapted according to the state of the art. In particular, the tasks listed below, which focus on preservation, characterization/evaluation, documentation and use are priorities of the WG:

- Inventory of existing genetic resources in berries;
- Development of an effective conservation strategy for berry genetic resources – rationalisation of conservation in ex situ collections (manual);
- Obtain information about the status of safety-duplication in all collections and long-term facilities. Partners will be encouraged to make plans for safety-duplication through organization of material exchange;
- Elaboration of passport descriptor lists and characterization protocols to improve standardization/harmonization and to develop primary and secondary descriptors;
- Characterization of genotypes using molecular markers, identification of health nutritional compounds and plant disease evaluation;
- Re-actualisation of the core collections obtained from the former projects and establishment of a core collection for all berry species;
- Development of criteria for acceptance to candidates to implement AEGIS collection of

- each berry species;
- Use the EURISCO catalogue as common documentation platform by providing passport and characterization information of actively conserved European diversity in berry species;
 - Facilitate the use of berry genetic resources by breeders and other possible users.

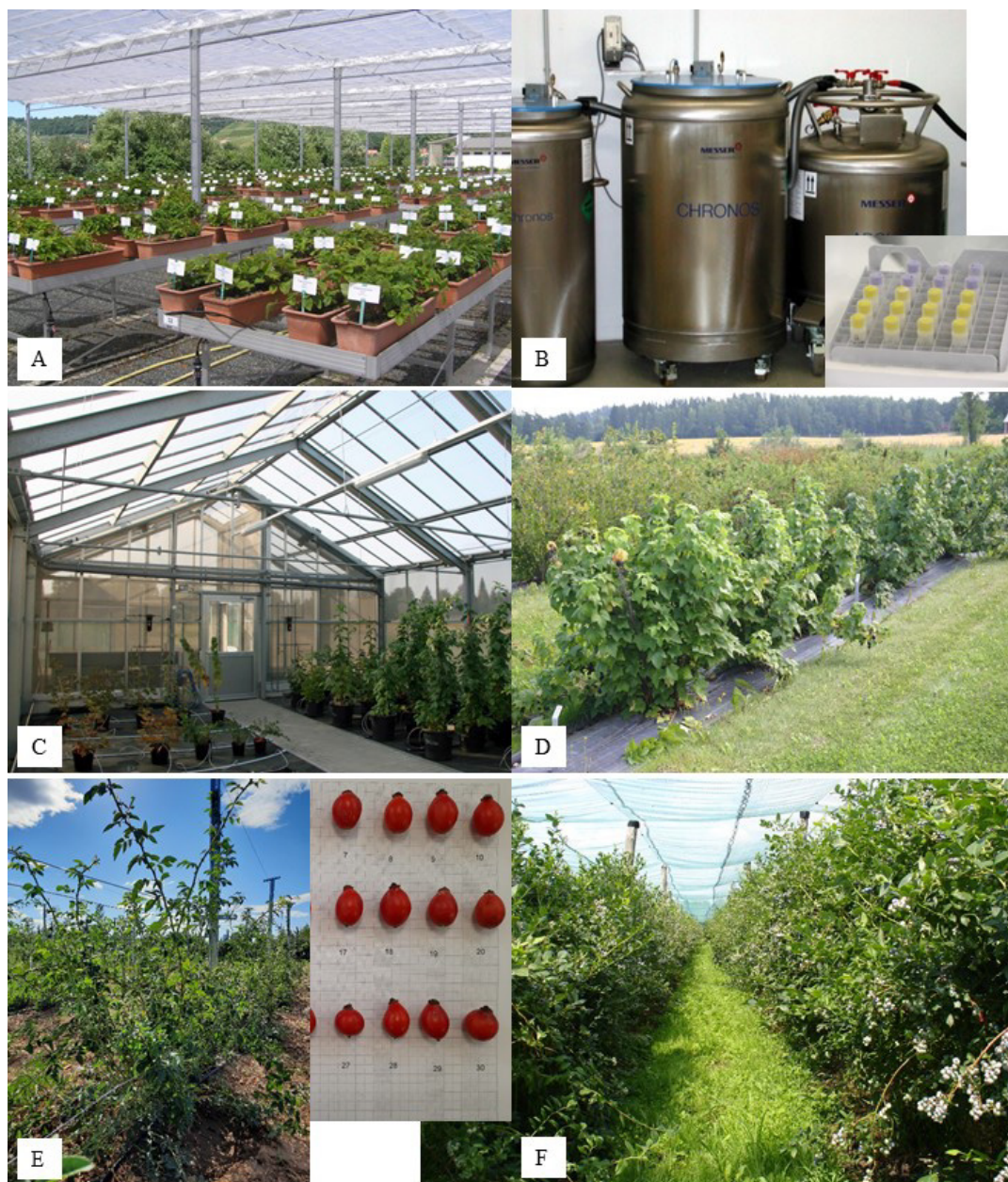


Figure 1. Preservation of berry genetic resources in Europe: A) JKI, Germany: potted plants of the ex situ strawberry collection; B) JKI: facility for cryopreservation; C) Federal Plant Variety Office, Germany: insect-protected screen house for raspberries, photo: BSA Wurzen; D) Natural Resources Institute Finland: field collection of blackcurrant, photo: Luke; E) Hellenic Agricultural Organization Demeter, Greece: dog rose collection, photo: Demeter; F) Agricultural Institute of Slovenia: field collection of blueberries, photo: Agricultural Institute of Slovenia.

The implementation of these objectives are dependent on the results of previous projects (described above). Furthermore, international standards like the Strawberry descriptors of IBPGR (Clamot et al., 1986), the Genebank Standards for Plant Genetic Resources for Food and Agriculture (FAO, 2014), the FAO/Bioversity Multi-Crop Passport Descriptor (Alercia et al., 2015) and the descriptors of Union Internationale pour la Protection des Obtentions Végétales (UPOV, <http://www.upov.int/portal/index.html.en>) for the different berry species, will be taken into account.

The first common activity of the ECPGR WG on Berries was a meeting held January 14-15, 2020, in Dresden, Germany, organized in collaboration with the JKI and sponsored by the German Federal Ministry of Food and Agriculture. Participants from 17 countries reported on the status of berries' genetic resources in their collections. The group agreed to start its activity with an inventory of all the existing berry germplasm that is maintained in Europe.

Subsequently, a project proposal titled 'Collaborative action for updating the documenting about berry genetic resources in Europe' was submitted in the Fourth Call for proposals under the ECPGR Activity Grant Scheme (Phase X). With the implementation of the project, the varieties/cultivars of the berry genetic resources will be recorded in the participating European countries. The data will be harmonized, qualitatively evaluated and made available for inclusion to the respective National Focal Points for EURISCO. Secondly, a first draught of crop-specific technical guidelines for genebank management (Manuals) of berry genetic resources will be written. The outcomes of the aforementioned outlines will provide the basis for the future work of the Berries WG. Following the inventory of the preserved berry genetic resources of the European countries, we will initiate further projects, which will focus on phenotypic and molecular characterisation aimed at identifying unique accessions for inclusion in AEGIS in the future.

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