

Data management and development of documentation system for plant genetic resources in Bulgaria

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Abstract

During the period 2007-2021 the fund of the National Genebank in the Institute of Plant Genetic Resources – Sadovo is enriched with 12.454 accessions. 6.571 accessions are acquired through expeditions, conducted by national and international projects. A great diversity of cereal, grain legume and vegetable local varieties from home gardens and crop wild relatives from natural habitats are collected. There are 4.628 accessions, introduced from foreign genebanks or botanical gardens by international free exchange. 1.255 advanced cultivars and lines from breeding institutes in Bulgaria are preserved. The main purpose of data management is to identify the accession in the process of conservation, study, reproduction, free exchange and sustainable use of germplasm collections. The electronic register includes the following passport information: taxonomy, catalogue number, acquisition date and source, country of origin, donor, collecting site, ecology-geographical characterization, biological status, and type of storage, according to FAO/Biodiversity descriptor. The standard allows Bulgarian *ex situ* collection to be published on the European Search Catalogue for Plant Genetic Resources EURISCO. National Inventory includes passport data of 69.768 accessions. From 2020 intelligent documentation system with specialized software, functional ontologies for free access to plant genetic resources for all stakeholders and assured security of records through blockchain technologies are being developed. This work is supported by Bulgarian National Science Fund under the project BGPlantNet “Establishment of National Information Network GenBank – Plant genetic resources”, and the obtained results will be applied in the National Research Program “Smart Crop Production”.

Key words: plant diversity; passport descriptor; electronic register; European collaboration; EURISCO standard; free access

INTRODUCTION

Maintaining plant genetic diversity through seeds of cultivated species and their wild relatives at national, regional and international levels, and promoting access to and equitable sharing of benefits arising from the use of these resources and associated traditional knowledge is one of the objectives for sustainable development of FAO (<https://www.fao.org/sustainable-development-goals/indicators/251a/en/>).

Plant genetic resources are cultivated and wild forms, local populations, old, forgotten and improved varieties, carriers of a functional unit of heredity and possessing real or potential value for science and practice (ITPGRFA, 2009; Mattana et al., 2021). The main goal of their collection is the creation of well-documented, preserved and studied collections that represent the widest possible diversity of the gene pool (Engels & Visser, 2008; Engels & Ebert, 2021).

Due to its specific geographical location, diverse relief and climatic features, our country is distinguished by a rich botanical diversity, which has been used for millennia in traditional Bulgarian cuisine and medicine. With its role as a national coordinator of plant genetic resources, IPGR-Sadovo follows international documents establishing obligations such as conducting measures for public awareness of the importance of plant genetic resources, cooperating with European partners to conduct scientific research for transfer of new technologies, contributing to information exchange and increasing access and use of the gene pool (Penchev, 2022).

The Nagoya Protocol (CBD, 2011) recognizes that countries have sovereign rights over their genetic resources and provide a framework for domestic legislations on Access and Benefit-Sharing. Although the ITPGRFA's Multilateral System of Access and Benefit-Sharing provides opportunities for easier access to plant genetic resources for food and agriculture (ITPGRFA, 2009), genebanks face increasing complexity in their operation. Adding material to genebank collections has become more difficult, not only because collecting missions need to be negotiated with national and local authorities, but also because acquiring material from other collections is possible if the origin of the material is properly documented and is done in compliance with regulations (Brink & Hintum, 2020). In the framework for the new multi-stakeholder process to expand the roles of genebanks three different types of actors involved in the management of crop diversity: farmers and farmers' organizations, genebanks, and researchers are pointed (Louafi et al., 2021).

Plant genetic resources are vital to food security, nutrition, livelihoods and the resilience and adaptability of global agricultural production systems. Despite increasing efforts in recent years, much remains to be done to improve the management of these resources. Many of them are at risk of extinction or erosion and many have been overlooked in terms of use and development. To know what is stored in a seed genebank is the greatest challenge. Collections must be relevant and that means they must provide useful genetic diversity that is accessible to the public. They must also be efficient and mustn't duplicate materials that are already conserved. There is an urgent need to address these deficiencies, and sustainable management strategies

to be implemented effectively (Pilling et al., 2020; Weise, et al., 2020; Weise, 2021).

The aim of our study is to present the status of plant genetic resources in Bulgarian seed genebank, existing European collaboration and optimization of the managing process via developing an intelligent documentation system.

MATERIAL AND METHODS

The Center for information and documentation of plant genetic resources at IPGR-Sadovo has been established in 1982 and completely renovated in 2021 under a project BGPlantNet, financed by Bulgarian National Science Fund of the Ministry of Education and Science (Grant KP-06H36/2/13.12.2019). It works according to the international standard of FAO/Bioversity (2017) following the priorities for free access to the conserved genebank collections in Europe and maintaining global system for free germplasm exchange (ECPGR, 2021).

The enrichment of the genebank collections is a result from long-term dedicated work of the crop curators in Department of Plant Genetic Resources. Annually, accessions from foreign genebanks are introduced, registered in IPGR database, studied and maintained. Expeditions in different geographical regions of the country are conducted and valuable local varieties and crop wild relatives are collected. In the fund of genebank are stored new improved varieties with Bulgarian origin from the specialized breeding institutes.

The electronic database contains the following passport information: taxonomy, catalogue number of accessions, acquisition date, country of origin, donor of the sample, collection site, ecology-geographical characterization, biological status, type of storage: base collection (long-term), exchange collection (medium-term), work collection (short-term), *in vitro* and/or field collection, botanical garden, etc. The taxonomic description of the crops is under the nomenclature of USDA (GRIN, 2015).

The National Genebank is nominated as a focal point in the European Search Catalogue for Plant Genetic Resources – EURISCO (<http://eurisco.ecpgr.org>). EURISCO is an open access network, providing information about *ex situ* plant collections in Europe (Hintum & Knüpfper, 2010; Dias et al., 2012; Weise et al., 2017; Kreide et al., 2019). It

provides information at accession level about more than 2 million samples from 6,736 genera and 45,171 species, conserved in European genebanks. Numerous of ECPGR Central Crop Databases are *on line* available, as well as knowledge on their potential for use (Gass et al., 1997). Through EURISCO the information about the Bulgarian National Inventory is accessible in other international databases, such as A European Genebank Integrated System – AEGIS (Engels & Maggioni, 2012; Velcheva et al., 2017; Hintum et al., 2021), World Information and Early Warning System – WIEWS (FAO, 2020) and electronic platform for Plant Genetic Resources for Food and Agriculture, conserved in genebanks worldwide - GENESYS (2015).

From 2020 a national network for plant genetic resources with software is developed in IPGR-Sadovo. Starting with the use of field books, a gradual development of electronic data base as national register, nowadays the intelligent data management system aims to improve the availability of conserved seed accessions in genebank to users (Doychev et al., 2020; Popchev & Orozova, 2020; Stoyanova-Doycheva et al., 2020a; Doukovska, 2021). To implement the application, the Java program language is used in the Vaadin platform, and the database is MySQL. Based on the analysis of the existing national register and EURISCO standard for documentation, a concept and analytical model of an ontology called GenBankOntology was developed (Stoyanova-Doycheva et al., 2020b). A server infrastructure to locate relational database and the ontology of the genebank information system has been created. In the intelligent model block chain technology, which is used to ensure the security

of records, is implemented (Krasteva et al., 2020; 2021; Radeva, 2022; Radeva & Popchev, 2022).

RESULTS AND DISCUSSION

During the period 2007-2021, the fund of the national genebank in IPGR - Sadovo was enriched with 12,454 accessions, distributed according to their status and acquisition source (**Figure 1, Table 1**).

Through conducted expeditions, 6,571 accessions - great diversity of cereals, grain legumes and vegetable local varieties (called also farmers' varieties or landraces) from home gardens and crop wild relatives from natural habitats, were collected.

Expeditions are organized under five target projects: „Conservation and management of plant genetic resources in Bulgaria” (2007-2010; 2011-2013; 2014-2016; 2017-2020; 2021-2024) and funded by international projects under EU and FAO programs, through partner bilateral projects with Slovakia, Slovenia, North Macedonia, China and Korea, as well as under a National Scientific Program “Healthy Foods for a Strong Bioeconomy and Quality of Life” (2019-2022). Standardized template according to FAO/Bioversity (2017) to be used by all curators for direct collecting the data by expeditions had been developed.

The first direction of expeditions is collection of cultural forms from field and vegetable crops. Traditional accessions from tomato (373 acc.), pepper (1549), cucumber (65), pumpkin (260), melon (190), watermelon (63), onion (412), lettuce (58), adapted to the specific agro-ecological conditions, characterized with valuable traits such as early maturity,

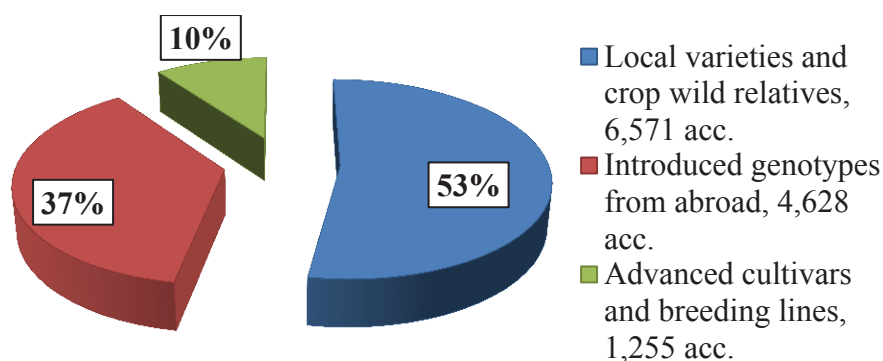


Figure 1. Enrichment of conserved plant diversity in Bulgarian seed genebank (2007-2021)

Table 1. Status of the accessions by acquisition source

Year	Collecting missions	Introduction	Breeding	Total number of accessions
2007	970	424	83	1,477
2008	751	718	112	1,581
2009	1,438	489	198	2,125
2010	347	178	80	605
2011	541	895	180	1,616
2012	417	528	148	1,093
2013	60	248	108	416
2014	147	247	10	404
2015	69	110	50	229
2016	431	38	19	488
2017	294	156	48	498
2018	166	139	29	334
2019	523	205	72	800
2020	331	223	54	608
2021	86	30	64	180
Total number	6,571	4,628	1,255	12,454

* Source of data is National Register of plant genetic resources (IPGR-Sadovo)

resistance to biotic and abiotic stress, high biological content, were found in home gardens. For cereals and grain legumes the attention is directed to collecting of primitive wheat accessions (*Tr. boeoticum* – 81 acc.; *Tr. dicoccon* – 4; *Tr. monococcum* – 63; *Tr. spelta* – 5), old and local populations of corn (23 acc.), 1097 bean acc. (*Ph. vulgaris* – 984; *Ph. coccineus* – 113), cowpea (75), lentil (8), chickpea (27), fava bean (93), etc. Of particular interest is the species diversity of forgotten spices and medicinal plants, which are being rediscovered for the purposes of dietary, healthy nutrition and applied in therapies for the alternative treatment of a number of diseases.

Another direction of expeditions is the preservation of wild, semi-natural diversity and crop wild relatives. The high urbanization, developed transport infrastructure and ecological threats put a large number of wild species of different botanical families at great risk.

The described ecologi-geographical characteristic of the collected accessions makes it possible to return the local varieties to the regions of origin through the seed samples, stored in the *ex situ* collections, which has also been reported by other au-

thors, such as Knüpffer (2002; 2016), Kehlenbeck et al. (2007) and Ivanova et al. (2021).

4,628 accessions of advanced varieties and breeding lines of diverse geographical origin were introduced for evaluation in our conditions and for use as donors of valuable economic traits in crop breeding. The germplasm free exchange significantly contributes to the enrichment of the plant diversity and expands the possibilities for accelerating the breeding process of peanut and sesame. 499 peanut accessions, characterized by disease resistance (489 acc. from USA016 – USDA-ARS, Griffin, Georgia; 9 from ESP003 – Spanish genebank in Madrid, 1 wild accessions from ITA011 – Botanical garden in Genova) and 189 sesame genotypes, suitable for mechanized harvesting and with short growing period (169 from USA016 – USDA-ARS, Griffin, Georgia; 10 from MKD001 – Faculty of Agriculture in Skopje, 7 from ISR003 – Institute for Cereal Crops Improvement, Tel-Aviv, 3 from Portuguese genebank in Oeiras). Active international contacts with centers of plant genetic resources from all over the world are maintained. The main partners of the National Genebank are: USDA (USA), ICARDA (Syria), VIR (Russia), NordGen (Sweden), IPK

(Germany), INRA (France), John Innes Center (Great Britain).

Analyzing the status of newly registered accessions during the period, a relatively low percentage (10%) of the enrichment with new Bulgarian varieties and breeding lines was found. 1,255 advanced cultivars and breeding lines from breeding institutes in Bulgaria are conserved in IPGR - Sadovo.

The documentation system optimizes the data management of collection activities in the process of registration, storage, study, reproduction and distribution. The National Register is characterized by 3,701 taxonomic descriptions, distributed in 122 botanical families. The number of addresses of foreign partners in germplasm exchange is 203. Increasing the quality of passport data is noticed due to using a GPS system during the expeditions and *online* catalogues for germplasm exchange, compared to previous analyzes of the documentation system (Velcheva, 2017).

Bulgaria maintains the richest plant genetic resources collection in Southeast European region. According to EURISCO (data check – July, 2022) the Bulgarian National Inventory comprises 69,768 accessions. The collection consists of genotypes from crop research institutes in the country and it is characterised with diverse geographical origin. The Bulgarian collection is the 7th biggest in Europe and has a share of 3,4%, after Great Britain, Russia, Germany, Ukraine, Poland and Spain. In connection to its taxonomic composition, the preserved accessions belong to 532 genera and 1,927 plant species. The highest number of accessions is from the genera *Triticum*, *Hordeum*, *Zea*, *Phaseolus*, *Avena*,

Capsicum, *Pisum*, *Arachis*. Distribution of accessions by crop groups is presented on **Figure 2**.

Bulgarian National Inventory is a part from a “virtual” European Genebank Integrated System – AEGIS. The status of the Bulgarian collection amounts to 391 local accessions and it is presented by *Tr. aestivum* (135 acc.), *Tr. dicoccon* (26), *Tr. urum* (126), *Tr. monococcum* (32), *Tr. spelta* (7), *Secale cereale* (15), *Lathyrus sativus* (9) and 41 accessions of medicinal and aromatic plants.

The intelligent system will improve the management of all processes related to conservation, study and access to the stored plant gene pool. Basic elements of the ontology are the taxonomic description and EURISCO descriptors. It is possible to supplement the passport information with characterization and evaluation data and photos. The information system includes a database model, an interface, and an implementation model. The database has been included in the application and the data from the National Register has been transferred. Data migration scripts were used for this purpose. A first version of the GenBankSystem was developed and it included the Central Register module, which is the core of the system, and the GenBank System database, which consists of 30 tables, according to EURISCO. Different levels of access are allowed (registration-curators-storage), which makes system management efficient and flexible.

Blockchain has the potential to become the basis for a next generation approach for developing equal economic and regulatory relationships in the cyber-physical environment in agriculture and smart crop production framework. The built server infrastruc-

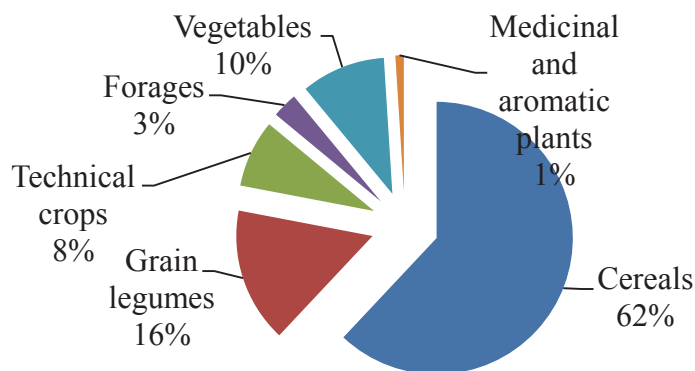


Figure 2. Distribution of accessions by crop groups

ture “GenBank - plant genetic resources” will be used for the purposes of the National Research Program “Smart Crop Production”. The overall goal of the program is to conduct fundamental and applied scientific research to create models for diagnosis and forecasting through digital methods for managing agricultural holdings in crop production and ensuring a sustainable and efficient food system (Doukowska, 2021).

CONCLUSIONS

During the period 2007-2021, the largest part of enrichment of the gene pool are local accessions (53%), but further work on evaluation and characterization of these valuable farmers’ varieties and landraces and adding the passport documentation continues.

Bulgaria has an important number of conserved plant genetic resources with high degree of diversity and wide represented in European networks. According to international standards and to increase the effective use of this national capital it is necessary to build capacity for better managing *ex situ* collections.

A priority in data management of plant genetic resources is implementation and development of documentation system to serve the genebank conservation, the information center and curators. The National plant genetic resources information network is a ‘knowledge bank’ and a platform for collaboration between researchers, plant breeders and all users.

Intelligent technologies are entering powerfully in agriculture and in this direction broad challenges and new horizons are revealed to the scientific teams.

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