Scientific Papers. Series B, Horticulture. Vol. LXVI, No. 1, 2022
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

ESTABLISHMENT OF NATIONAL INFORMATION SYSTEM OF PLANT GENETIC RESOURCES IN BULGARIA

Nikolaya VELCHEVA[1], Katya UZUNDZHALIEVA[1], Asya STOYANOVA-DOYCHEVA[2], Pencho MALINOV[2]

[1]Agricultural Academy, Institute of Plant Genetic Resources "K. Malkov",
2 Druzhba Str., 4122, Sadovo, Plovdiv district, Bulgaria
[2]Plovdiv University "Paisii Hilendarski", Faculty of Mathematics and Informatics,
Department of Computer Systems, 236 Bulgaria Str., Plovdiv, Bulgaria

Corresponding author email: nikolaya_velcheva@abv.bg

Abstract

Preservation and use of plant diversity is one of the global priorities for the development of sustainable agriculture in climate change conditions. During the period 1982-2021 in the National Genebank in Sadovo 53,545 accessions of cultural and wild plant species were stored. The enrichment of plant genetic resources collections in recent years has been focused on local traditional varieties, mainly by vegetable crops. The paper presents the status of conserved plant gene pool in Bulgaria in connection with optimization of the managing process of germplasm storage, study, reproduction, free exchange and use via establishment of an information system with specialized software. The created architecture follows the international standard of FAO/Bioversity. Passport data includes taxonomic description, biological status and origin of the accessions. The information system uses ontologies for facilitated free access and security of records through innovative blockchain technologies. As a result, the functionality of the documentation process as well as access to the plant gene pool to all stakeholders, in accordance with International Treaty on Plant Genetic Resources for Food and Agriculture and the Nagoya Protocol, is guaranteed.

Key words: *descriptor, documentation, EURISCO catalogue, ex situ collections, local plant genetic resources.*

INTRODUCTION

Plant genetic resources are the basis of the genetic improvement of cultivated plants, essential for food security and development of innovative bio economy (ECPGR, 2021). Agro biodiversity supports sustainable productivity of farmers under the current climate changes (Priyanka et al., 2021; Ron & Rodino, 2022). Seedbanks are collections of genetic resources which can be seen as selection of old plant materials at risk of being lost that are maintained for future use as inputs into the research processes for development of new varieties. In addition, these old crop varieties may have value in and of themselves apart from their use in the breeding process. Genebanks thus serve as both providers of valuable traits to breeding programs as well as repositories of diverse crop genetic material representing society's agricultural heritage (Rocchi et al., 2016; Weise, 2021).

The main goal of all EU programs regarding plant diversity is to improve the coordination of conservation activities in Europe and to facilitate the access to plant genetic resources and the information about them. Enrichment of genetic resources means collected, systematized and documented components of biodiversity of actual or potential value, stored in controlled conditions outside their natural habitats (*ex situ*) in order to maintain them alive, further study and rational use. The database of collections includes descriptive information about each accession. As the societies and economies become more and more driven by data exchange, the governance of information is increasingly important. In parallel, as biodiversity continues to decline the status quo is not acceptable and new solutions need to be found. Possible changes for proper genebanks quality management, guaranteeing the long-term conservation of, and immediate access to the plant genetic resources conserved in it, are recommended by Hintum et al. (2021). Bulgaria is an area particularly suitable for the cultivation of different crops. It is one of the richest in plant diversity countries in Europe.

Despite being small in size (110,910 km^2), the territory of the country includes various relief and geology, the specific microclimatic conditions and the millennium human activity determine the rich plant diversity (CBD, 2014). Over the last decades the area of Balkan Peninsula experienced genetic erosion, resulting in the loss of many traditional plant genetic resources (Knüpffer, 2016). Local varieties (landraces, old cultivars and neglected crops) have unique climatic and ecological tolerances. Therefore, the main priority for conservation at the national level is focused on the species and variety diversity in home gardens (Knüpffer, 2002; Kehlenbeck et al., 2007). The largest part of the home garden area in Bulgaria is occupied by vegetable crops of *Solanaceae* and *Cucurbitaceae* (Ivanova et al., 2021). The breeders and farmers need access to a wide diversity of genetic resources, predominantly farmers' varieties, landraces, and crop wild relatives (Ebert, 2020). Documentation units have been established in almost all genebanks worldwide. Without well-structured documentation it is not possible to make the information a useful resource. Information about the composition of collections allows statements about which species and/or regions of origin are under-represented and have to be explored. Comprehensive information management is a prerequisite for the further development of genebank collections (Weise et al., 2020).

The access to the information about the Bulgarian accessions is possible only through the international databases and that is a limiting factor for many Bulgarian stakeholders. Thus, it does not meet the requirements the collections to be visible and accessible to scientific, public, ecological and other organizations (Doychev et al., 2020).

The study aims to present the status of conserved *ex situ* plant gene pool in Bulgaria in connection with optimization of the managing process of germplasm storage and use via establishment of an information system with specialized software.

MATERIALS AND METHODS

The Institute of Plant Genetic Resources, Bulgaria is the National Coordinator in the European Program for Plant Genetic Resources (ECPGR). The National Genebank was established in 1984 and the research activities for conservation of plant germplasm are carried out according to the standards of FAO (2014).

The Information Centre for documentation of seed accessions has been established in 1982. It works according to the international standards for documentation in line to the activities for free access and guarantees the international cooperation (FAO/Bioversity, 2017).

The electronic register contains catalogue and European number of accessions, passport characteristics as country of origin, donor, ecology-geographical characterization of the collection site, 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 the 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) for Bulgaria (Weise et al., 2017).

From 2019 an integral national network for plant genetic resources with specialized software it starts to be established. 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 (Doukovska, 2021).

RESULTS AND DISCUSSIONS

Status of ex situ germplasm collections

During the period 1954-2021 the fund of National Genebank is enriched with 53,541 accessions (Table 1).

Table 1. Status of *ex situ* collection of plant genetic resources, conserved in Bulgarian genebank

Collecting period	Acquisition method	Origin	Number of accessions
1954-2021	Introduction	Foreign	36,716
1957-2021	Expedition	Local	10,777
1978-2021	Crop breeding	Bulgarian	6,048
Total number of accessions			53,541

Currently, accessions with local and Bulgarian origin are 31% of the collection and their

sustainable preservation is a main priority in connection with the climate changes.

The accessions from collecting missions are 10,777 - local varieties and populations from home gardens and crop wild relatives from their natural habitats. With higher percentage from the local accessions are vegetable crops and grain legumes, followed by cereals. Emerging from unconscious selection within a population and well adapted to environmental factors, the local plant genetic resources are of great importance for transfer of valuable economic traits as tolerance to abiotic and biotic stress in creation of new varieties.

The described geographical characteristics of the collected accessions make it possible for the traditional varieties to restore in the regions of origin through the seed resources, stored in the ex situ collections in the genebank.

Traditional vegetables have considerable commercial value and high market potential to contribute the household income. In home gardens were found local varieties of tomato, pepper, cucumber, pumpkin, melon, watermelon, onion, leafy vegetables and potatoes, perfectly adapted to specific environmental conditions, with valuable qualities as early maturity and high biological content (Krasteva et al., 2013).

In the database 6,048 breeding materials are registered – lines and improved new varieties with Bulgarian origin. They are conserved in long-term conditions and the access is regulated in accordance with the principles for the protection of breeders' intellectual property rights.

There are 36,716 genotypes, introduced from abroad by international free germplasm exchange. The National Genebank conducts professional contacts with about 197 genebanks worldwide. The main partners in the exchange are established research centers such as GRIN (USDA), ICARDA (Syria), VIR (Russia), NordGen (Sweden), IPK (Germany), INRA (France), John Innes Center (UK), Suceava Genebank (Romania), etc.

The requested foreign germplasm is investigated in the country environmental conditions and used as a donor of valuable traits in breeding programs. *Ex situ* collections from cereals, grain legumes, technical, fodder, vegetable, medical and aromatic crops are maintained (Figure 1).

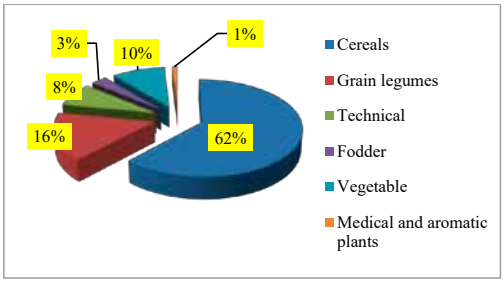

Figure 1. Distribution of plant gene pool in genebank by crop groups

Preservation of plant genetic resources in Botanical garden

A total of 450 plant species from 60 families are maintained in the Botanical Garden of the Institute of Plant Genetic Resources. Of these, eight species are Balkan endemics: *Achillea clypeolata*, *Allisoides bulgarica*, *Knautia macedonica*, *Chamaecitisus janke*, *Iris reichenbachii*, *Iris suaveolens*, *Aegilops cylindrica*, *Haberlea rhodopensis,* which also has the status of a rare species; five species of Bulgarian endemics: *Allium rhodopaeum*, *Sedum album*, *Vicia incisa, Aegilops neglecta*, *Soldanella rhodopaea;* four species of endangered plants: *Leucoyum aestivum*, *Artemisia pedemontana*, *Anemone sylvestris*, *Pyracantha coccinea*; and 11 rare species: *Meum athamanticum*, *Artemisia lerchiana*, *Artemisia pontica*, *Leontopodium alpinum*, *Leucanthemum vilgare*, *Andrachne telephioides*, *Aegilops triuncialis*, *Koeleria brevis*, *Secale cereale var. perene*, *Clematis alpina*, *Paeonia tenuifolia*. Thematic distribution of species is: essential oily, cereal grasses, fodder, decorative, protected and rare species, wild crop relatives.

International networks and databases for plant genetic resources

Bulgaria maintains the richest plant genetic resources collection in Southeast European region. According to EURISCO (data check February, 2022) the Bulgarian National Inventory comprises 69,767 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*. The crops with the highest number of accessions are presented in the Table 2.

Table 2. Crops with the highest number of accessions in EURISCO database (February, 2022)

Taxonomy	Number of accessions	With BGR origin
Triticum aestivum	13,175	2,909
Hordeum vulgare	6,365	303
Zea mays	4,827	1,939
Phaseolus vulgaris	3,488	1,698
Avena sativa	2,476	149
Triticum durum	2,370	1,193
Capsicum annuum	1,885	1,408
Pisum sativum	1,744	241
Triticosecale	1,461	532
Linum usitatissimum	1,461	77
Arachis hypogaea	1,373	444
Lycopersicon esculentum	1,371	534
Secale cereale	1,300	827
Cucumis sativus	1,031	95

Bulgarian National Inventory is a part from a "virtual" European Genebank Integrated System - AEGIS (Hintum, 2021). The status of the Bulgarian collection in the AEGIS database amounts to 391 accessions and it is presented by crops in the Table 3.

Table 3. Bulgarian accessions in AEGIS database (February, 2022)

Crop	Origin	Status of accession	Number of accessions
Triticum aestivum	BGR	Local	135
Triticum dicoccon	BGR	Local	26
Triticum durum	BGR	Local	126
Triticum monococcum	BGR	Local	32
Triticum spelta	BGR	Local	7
Secale cereale	BGR	Local	15
Lathyrus sativus	BGR	Local	9
Medicinal and aromatic plants	BGR	Local	41
Total number of accessions			391

Bulgarian Genebank Information System

The new intelligent system ensures the full public access to the information about the fund of Bulgarian genebank for all stakeholders and it is expected to increase the sustainable use of germplasm in breeding programs and agricultural production. Based on the analysis of the existing National register and EURISCO standard for documentation, a concept and analytical model of ontology for plant genetic resources has been developed (Stoyanova-Doycheva et al., 2020). The first version of the ontology, called GenBankOntology, of the plant genetic resources in the National genebank was developed. The ontology has been tested for consistency and integrity and the results show that it can be implemented in storage of plant genetic resources and management information system (GenBankSystem). The information system includes a database model, a system interface model and an implementation model. The database of the application has been implemented and the large part of the data of the genebank has been migrated. For this purpose, scripts were created for data migration.

The first version of GenBankSystem has been developed and it includes the implementation of the Central Register module, which is the core of the system. The system provides the access of the various users to the system and realization of the main functionalities for storage and management of plant genetic resources. The model has been created for the implementation of blockchain technology, which will be used in the functionality for security of records and germplasm exchange between different national and international organizations (Krasteva et al., 2020).

A server infrastructure on which the ontology and the relational database of the information system of the national genebank are deployed has been implemented.

The implementation of the system for storage and management of plant germplasm in the genebank and the integration of the ontology for plant genetic resources are applicable both in the institute for servicing the work in the genebank of different users and for external stakeholders from the gene pool in the ex situ collection, which is required of International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA, 2009) and the Nagoya Protocol (CBD, 2011).

By reviewing and highlighting the National state of conserved plant germplasm, we attempt to unlock food resources from some neglected and underutilized species, which along with the wealth of traditional knowledge about their uses and practices, could help support sustainable agriculture while ensuring better protection of the environment and the continued delivery of its ecosystem services.

The research is implemented on three priorities. In the first stage, attention is focused on the conservation of forgotten regional and ancient cultivars of plant species, which form in the country - part of natural resources and cultural heritage (vegetables, legumes, cereals and other species). This valuable collection of genotypes presents irreplaceable genetic resources for plant breeding for their high tolerance to biotic and abiotic environmental factors.

In the second priority, attention is paid to underutilized plant species, which are widespread throughout the country and regions, but the population used them only by harvesting a part of the plants for practical use in nutrition, health and quality of life (spices, medicinal plants). The people harvest significant parts of wild populations for sale in local markets. These plant species are vital to sustainable agriculture.

The third group is focused on less-known species. It is a group that has not been cultivated in the country so far, but current climate change allows their cultivation and spread. These lesser-known species can be practically used mainly by family and young farmers for their socio-economic development. Therefore, there is a special interest in their expansion and using.

CONCLUSIONS

Genebanks are the most important sources of potentially useful genetic diversity for improving quantity and quality of agricultural yields and for adapting crops to climate changes, meeting the environmental stresses.

Genebanks are centres of information on genetic resources and have to be able to provide relevant information to every potential user and the general public.

The Bulgarian National Genebank maintains one of the largest *ex situ* collections in Europe and the richest conserved plant diversity in Southeast European region.

Documentation system, according to the international standards of FAO/Bioversity, optimizes the management of plant genetic resources in relation to their sustainable conservation and target use.

The National Information System for plant genetic resources will gradually build a "knowledge bank" and also will be a great platform for scientists looking to enhance biodiversity as a source of agricultural development.

The results obtained within the framework of the project BGPlantNet “Establishment of National Information Network GenBank – Plant genetic resources” will be used in the National Research Program “Smart Crop Production”.

ACKNOWLEDGEMENTS

This research work was supported by Bulgarian National Science Fund of the Ministry of Education and Science under the project BGPlantNet “Establishment of National Information Network GenBank – Plant genetic resources”, Grant КП-06Н36/2/13.12.2019 and partly supported by National Research Program “Smart Crop Production”, Grant Д01-65/19.03.2021, approved by Decision of the Ministry Council No 866/26.11.2020.

REFERENCES

CBD (2011). Nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilisation to the Convention on Biological Diversity. United Nations Environmental Programme.

CBD (2014). Fifth National Report to the Convention of Biological Diversity (2009-2013), Ministry of Environment and Water of Republic of Bulgaria. https://www.cbd.int/doc/world/nu/nu-nr-05-en.pdf

Doychev, E., Malinov, P., Velcheva, N., Duchev, Z. (2020). A Genebank Architecture: A Distributed System for Management of Plant Genetic Resources, *2020 IEEE 10th International Conference on Intelligent Systems*, 580-583, doi: 10.1109/IS48319.2020.9199972.

Doukovska, L. (2021). Artificial Intelligence to Support Bulgarian Crop Production. *Engineering Sciences*. LVIII. DOI:10.7546/EngSci.LVIII.21.04.03.

Ebert, A.W. (2020). The Role of Vegetable Genetic Resources in Nutrition Security and Vegetable Breeding. *Plants*. 2020; 9(6):736. https://doi.org/10.3390/plants9060736

ECPGR. (2021). Plant Genetic Resources Strategy for Europe. *Rome, Italy*. https://www.ecpgr.cgiar.org/fileadmin/bioversity/publications/pdfs/PGR_STRATEGY_LP_22_Nov_revised.pdf

FAO. (2014) Genebank standards for plant genetic resources for food and agriculture. Rome. Italy.

FAO/Bioversity. (2017) Multi-Crop Passport Descriptors, Rome, Italy.

GRIN. (2015) Genetic Resources Information Network, Taxonomy for Plants. USDA.

Hintum, T.V, Engels J.M.M., Maggioni L. (2021). AEGIS, the Virtual European Genebank: Why It Is Such a Good Idea, Why It Is Not Working and How It Could Be Improved. *Plants*. 10 (10): 2165. https://doi.org/10.3390/plants10102165

ITPGRFA. (2009). International Treaty on Plant Genetic Resources for Food and Agriculture, Rome, Italy.

Ivanova, T., Bosseva, Y., Chervenkov, M., Dimitrova, D. (2021). Enough to Feed Ourselves! - Food Plants in Bulgarian Rural Home Gardens. *Plants*, 10, 2520. https://doi.org/10.3390/plants10112520

Kehlenbeck, K., Arifin H. S., Maass B. L. (2007). Plant diversity in home gardens in a socio-economic and agro-ecological context. In: Tscharntke, T., Leuschner, C., Zeller, M., Guhardja, E., Bidin, A. (eds), *Stability of Tropical Rainforest Margins, Environmental Science and Engineering (Environmental Science)*, Springer, Berlin, Heidelberg, Stability of Tropical Rainforest Margins, 295-317.

Knüpffer, H. (2002). Documentation of plant genetic resources in home gardens. *In: Watson, J. W.; Eyzaguirre, P. B. Home gardens and in situ conservation of plant genetic resources in farming systems.* IPGRI, Rome, Italy, 19-26.

Knüpffer, H. (2016). Plant genetic resources from the Balkan Peninsula in the world`s genebanks. *Journal of Agriculture, Food and Environmental Science*, 69, 53-68.

Krasteva, I., Glushkova, T., Moraliyska, N., Velcheva, N. (2020). A Blockchain-Based Model of GenBank Store System, *IEEE 10th International Conference on Intelligent Systems*, pp. 606-611, DOI: 10.1109/IS48319.2020.9200133.

Krasteva, L., Neykov, St., Velcheva, N., Chavdarov, P., Zhan Yun, Guo Mu, Tsvetkov, Y. (2013) Inventory and collection of local genetic resources from vegetable crops for their conservation and targeted use. *Agro-knowledge Journal*, Republic of Srpska, 14 (1), 97-104, DOI: 10.7251/AGREN1301097K.

Priyanka, V., Kumar R., Dhaliwal I., Kaushik P. (2021). Germplasm Conservation: Instrumental in Agricultural Biodiversity, Review, *Preprints.org*, DOI: 10.20944/preprints202104.0461.v1.

Rocchi, L., Paolotti, L., Cortina, C., Boggia, A. (2016). Conservation of landrace: the key role of the value for agrobiodiversity conservation. An application on ancient tomatoes varieties. *Agriculture and Agricultural Science Procedia*, 8, 307-316, https://doi.org/10.1016/j.aaspro.2016.02.025

Ron, A.M.D., Rodino, A.P. (2022). Analysis of Crop Genetic and Germplasm Diversity. *Agronomy*, 12(1): 91. https://doi.org/10.3390/agronomy12010091.

Stoyanova-Doycheva, A., Ivanova, V., Doychev, E., Spassova, K. (2020). Development of an Ontology in Plant Genetic Resources, *IEEE 10th International Conference on Intelligent Systems*, pp. 246-251, DOI: 10.1109/IS48319.2020.9199935.

Weise, S., Oppermann, M., Maggioni, L., Hintum, T.V., Knüpffer, H. (2017). EURISCO: The European search catalogue for plant genetic resources. *Nucleic Acids Research, 45, (D1):D1003-D1008*. doi:10.1093/nar/gkw755.

Weise, S., Lohwasser, U., Oppermann, M. (2020). Document or Lose It - On the Importance of Information Management for Genetic Resources Conservation in Genebanks. *Plants*. *9(8):1050*. https://doi.org/10.3390/plants9081050

Weise, S. (2021). Data management for preserving genetic diversity: Experiences and challenges. Proceedings of the 34th Meeting of the EUCARPIA Fodder Crops, 12-16. http://doi.org/10.5507/vup.21.24459677