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Status of Conserved Local Plant Biodiversity in Bulgaria – New Challenges and Research Priorities

Nikolaya V. Velcheva[*]*, Tsvetelina D. Stoilova*

Agricultural Academy, Institute of Plant Genetic Resources "K. Malkov", Department of Plant Genetic Resources, 2 Druzhba Str., 4122 Sadovo, Plvovdiv district, BULGARIA
*Corresponding author: nikolaya_velcheva@abv.bg

Abstract. Bulgaria is one of the countries with the greatest plant biodiversity in Europe, as well as with a significant number of unique ecosystems. The study aims to present the documented local plant genetic resources, conserved in the Bulgarian seed genebank, and to address the new challenges, created by climate change. The research priorities of the national program on plant genetic resources in Bulgaria are focused on expanding the role of biodiversity in agricultural food systems to increase the sustainability of agriculture and livelihood of farmers and to offer consumers the traditional taste of agricultural produce. The survey is based on the national register of plant genetic resources and the international databases such as FAO WIEWS, GENESYS, EURISCO and AEGIS. The results show that the national collection compares 65,015 accessions with passport descriptors. Among those, 16,010 accessions are characterized with Bulgarian origin. Through expeditions 10,687 seed samples of local varieties have been collected within the country. The overview of plant genetic resources originating from Bulgaria is an indication of the wealth of crop plant species and their wild relatives, and the national register may assist in identifying gaps and needs for further collecting. It may also be a good starting point for compiling checklists of cultivated plant species and help define future research activities. The results of this study will integrate description of local origin of landraces, taking into account consumers' perceptions and farmer's needs for creation of rural thematic networks aimed to promote the durable use of local plant genetic resources. The research was supported by the Bulgarian Ministry of Education and Science under the National Research Programme "Healthy Foods for a Strong Bio-Economy and Quality of Life", approved by DCM № 577/17.08.2018.

Key words: landraces, *ex situ* collections, databases, climate change, sustainability.

Introduction

Plant genetic resources for food and agriculture are vital to food security, nutrition and crop productivity, resilience and adaptability of production systems in the crop sectors (Pilling et al., 2020).

Plant genetic diversity disappears in parallel with the entry of intensive agriculture and the introduction of high-yielding cultivars into the farm. As a result of the modern plant breeding, the genetic base of new crop varieties and hybrids is significantly narrowed. This fact turns genebanks preserving *ex situ* plant genetic diversity into a major factor limiting the genetic erosion of agrobiodiversity. Therefore, it is extremely important to fill gaps and continuously enrich the genetic diversity of the preserved collections by collecting additional local plant genetic

resources from the wild and cultivated land, eventually leading to their sustainable use. The foci of the collecting missions should be on local traditional varieties and crop wild relatives, having valuable genes for the breeding process, organic production and sustainable agriculture (Ulian et al., 2020).

Climate change, as well as the restructuring of the breeding criteria towards high biological quality of crop production, directs the researchers to the inexhaustible source of useful genes – the local gene pool (Borrell et al., 2020; Maggiore et al., 2020). Originating from a long-term selection process by farmers based on valuable traits and qualities in wild and domesticated crop populations, and adapted to the specific conditions of the area in which they are grown, the landraces are a unique source material for breeding to restore the traditional taste of crop varieties (Knüpffer, 2002; Kehlenbeck et al., 2007).

The availability of comprehensive information on the composition of conserved germplasm is an important prerequisite to further develop genebank collections. Easy access to plant genetic resources and to traditional knowledge about their cultivation and application contributes to enhancing their sustainable use and increases the capacity of breeders to respond to climate change. Conservation of genetic resources of crop genepools, including landraces, crop wild relatives, breeding and research materials are the pillars of modern plant breeding, as well as of localized breeding efforts by farmers and farming communities (Ebert & Engels, 2020).

Bulgaria is one of the countries with the greatest plant biodiversity in Europe, as well as with a significant number of unique ecosystems (Knüpffer, 2016). The preservation of the plant biodiversity from the wild and cultivated flora is the main priority in the research work of the Institute of Plant Genetic Resources in Sadovo serving as a national coordinator of plant genetic resources and as a member of the European Programme for Plant Genetic Resources (ECPGR). The main mission of the national seed genebank is the conservation of plant genetic resources, and ensuring their availability and distribution to local and foreign users in relation with the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA, 2009) and Nagoya Protocol (CBD, 2011).

This study aims to present the documented local plant genetic resources, conserved in the Bulgarian seed genebank, and to address the new challenges, created by climate change.

Material and Methods

The Computer center, established in 1982 at the Institute of Plant Genetic Resources "K. Malkov " – Sadovo, maintains a specialized database Phyto'2000 in Microsoft Access format. It contains information about all seed accessions, preserved in the national genebank.

The documentation system optimizes the management of plant genetic resources in relation to their targeted storage, study, reproduction, free exchange and use. All accessions are described by 33 descriptors: catalogue number, taxonomic description, biological status of the genotype, donor and geographical origin, type of conservation – long term, medium term or working collection, availability for exchange, safety duplication in another genebank, etc. according to the Muli-crop passport descriptors of FAO/Bioversity (2017) and the international genebank standards (FAO, 2014).

The taxonomic description of the crops is under the nomenclature of the USDA Genetic Resources Information Network (GRIN, 2015).

The national genebank in Sadovo has been nominated by ECPGR as a focal point for Bulgaria in the European Searching Catalogue on Plant Genetic Resources – EURISCO (http://eurisco.ecpgr.org), providing information about *ex situ* collections, maintained in Europe (Weise et al., 2017).

Through EURISCO the information about the Bulgarian National Inventory is accessible in other international databases, such as A European Genebank Integrated System - AEGIS of ECPGR (Engels & Maggioni, 2013), World Information and Early Warning System – WIEWS (FAO, 2020) and online platform about Plant Genetic Resources for Food and Agriculture, conserved in genebanks worldwide - GENESYS (2015).

Results and Discussion

During the period 1982-2020 the germplasm stock of the national seed genebank in Sadovo was enriched with 53,338 additional accessions, comprising 122 botanical families, 3,583 taxonomical descriptions, including 36,675 accessions, received through international free exchange, 10,687 accessions - collected during expedition missions and 5,976 entries of – breeding materials with Bulgarian origin.

The *ex situ* collections of the national genebank comprise cereals (62 %), grain legumes (16 %), oil and industrial crops (8 %) forages (3 %), vegetables (10 %), medical and aromatic plants (1 %).

The foreign genotypes in the collection are being introduced via professional contacts with about 195 genebanks, plant genetic resources centers and botanical gardens worldwide. The main partners of the institute in the free germplasm exchange are research centers such as USDA (USA), ICARDA (Syria), VIR (Russia), NordGen (Sweden), IPK (Germany), INRA (France), John Innes Centre (UK). The requested foreign germplasm is investigated under the country's environmental conditions and used as a donor of valuable traits in breeding programs.

In the database, 5,976 breeding materials are registered, composed of – lines and improved new varieties from the institutes of the Agricultural Academy, Bulgarian Academy of Science, Agricultural University, and others. The access to the accessions of those institutes is regulated in accordance with the principles for the protection of breeders' intellectual property rights.

Currently, accessions with local Bulgarian origin comprise 30% of the genebank holdings, their conservation and sustainable preservation is a top priority in the activities of enrichment of the collections, in accordance with the new national-level aims. The accessions from collecting missions are amounting to 10,687, composed of – local varieties and populations from home gardens and crop wild relatives obtained in their natural habitats. The organized data sets show significant enrichment of the *ex situ* collections with local plant genetic resources in recent years (Fig. 1).

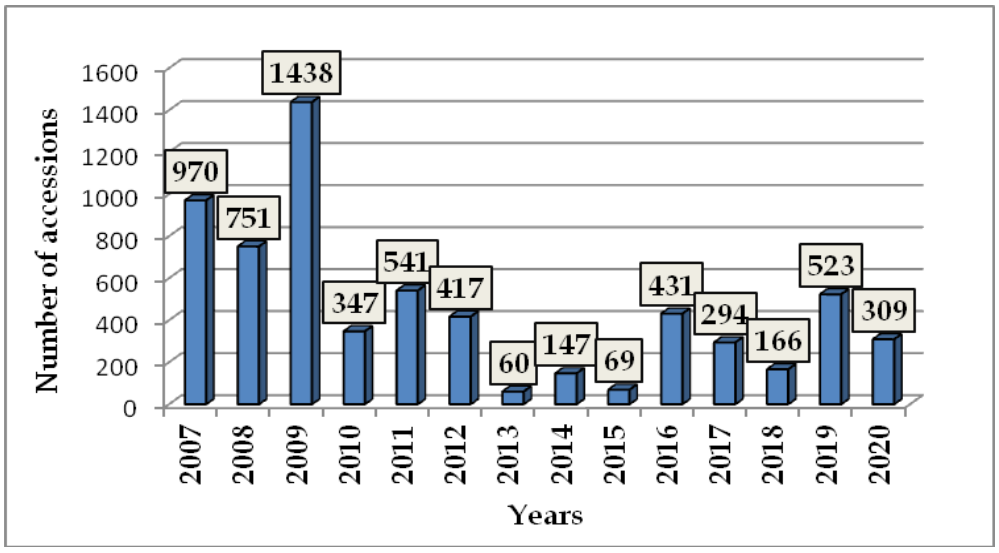

Fig. 1. Enrichment of the Bulgarian *ex situ* collection with local plant genetic resources.

The germplasm samples - species and varietal diversity of landraces from small farms and crop wild relatives obtained in their natural habitats, have been collected through expeditions, funded by projects. The routes of the collecting missions are determined on the basis of prior awareness of the specifics of the respective production areas or local habitats.

The first direction of any local expedition activity is the collection of cultural forms from field and vegetable crops. In small farms and home gardens traditional samples of tomatoes, peppers, cucumbers, pumpkins, melons, watermelons, onions, salads, potatoes were found, perfectly adapted to specific agro-environmental conditions, with valuable qualities and properties such as early maturity, resistance to biotic and abiotic stress, high content of biologically active substances, etc. (Krasteva et al., 2013). Regarding the cereals and legumes, the attention is focused on collecting samples of ancient and primitive forms of wheat, of old and local populations of corn, beans, cowbeans, lentils, and others. Of particular interest is the species diversity of some forgotten spices and medicinal plants, presently rediscovered for the purposes of dietary and healthy nutrition, used in therapies for alternative treatment of several diseases.

Another approach of collection missions is the protection of wild, semi-domesticated diversity and crop wild relatives of cultivated plants. The high urbanization, developed transport infrastructure and environmental threats put a large number of wild species from different botanical families at great risk. On the one hand, their conservation is important for biodiversity, and on the other - they have valuable qualities for breeding, such as being sources of high protein, starch, resistance to fungal, bacterial and viral diseases, high adaptability in connection with global warming and climate changes (Dempewolfetal., 2014).

As a result of the enrichment of germplasm collections and the passport description of the accessions made accessible in a well-organized database, suitable conditions have been created for mapping and zoning of the local gene pool. These are necessary prerequisites for expanding the expeditionary activity in specific regions of the country, which contain valuable plant resources as a result of primitive breeding, aimed mainly in selection by taste, fruit size, and disease resistance.

Another direction of the expedition activity is searching for varieties and species that are suitable for cultivation in semi-mountainous and mountainous areas, on poor productive lands, for areas with regular droughts, as well as for organic farming.

In recent years, the local accessions became associated with more complete passport information, because of the use of a GPS system during expeditions. For older germplasm samples the lack of eco-geographical characteristics could be partially restored through the modern satellite systems.

As a result of enrichment of *ex situ* collections, a rich plant diversity of field, vegetable, medicinal and aromatic species has been collected in the genebank. Core collections within evaluation and characterization data in accordance with the perspective of the source material for its inclusion in breeding programs, as well as a selection of samples for improving the species and varietal structure in Bulgarian agriculture have been created.

The wheat breeding started in 1902 as a part of the first programme of the Agricultural experimental station in Sadovo. During its long history 46 new common wheat varieties have been created and successfully introduced in agriculture. The main priority of the breeding is creation of high-yielding and characterized with good quality varieties of common wheat and triticale with wide ecological plasticity and resistance to biotic and abiotic factor. The focus of the resent years is the new varieties to be acceptable for low inputs cultivation in relation to sustainable and conservation agriculture. The new wheat varieties are suitable for South and North Bulgaria climate conditions, as well as for Turkey and North Greece.

During the period 1982-2020 in the Institute of Plant Genetic Resources through the multi-year study and selection in populations of local plant genetic resources as an initial material in plant breeding 27 new varieties

from durum wheat, barley, rye, oat, pea, chickpea, cowpea, bitter vetch, garden bean, tomato, pepper, eggplant, kohlrabi, and lettuce were created. All these varieties possess the traditional taste of landraces and they are very well adapted to the specific conditions in the country. Seeds from these new varieties are distributed annually to farmers, farmer communities, NGOs, etc.

The peanut and sesame breeding is aimed at creating lines and varieties with a complex of valuable economic qualities such as high productivity, early maturity, complex resistance to fungal diseases, balanced chemical composition, good taste, opportunities for mechanized harvesting, etc. Both crops are thermophilic, and the sesame falls into the category of plant species that are successfully grown in hot and dry climate.

Organic farming is a system of farming that promotes environmental, social and economical sustainability of food production. As the awareness about the harmful effects of chemicals on health, soil, environment etc., is increasing inorganic farming is slowly shifting towards organic farming. Bulgaria with diverse agro climatic conditions and plenty of diverse local varieties has great potential for organic farming. Organic agriculture contributes to the social well-being by reducing the losses of soil, water contamination, biodiversity erosion, food loss, and pesticide poisoning. By using local plant genetic resources and associated, local knowledge, and by connecting farmers, consumers and their markets, the economic conditions and the well-being of rural people can be improved. Organic agriculture stresses diversification and adaptive management to increase farm productivity, decrease vulnerability to weather vagaries, and consequently improves food security, either with the food the farmers produce or the income from the products they sell. The increasing demand for organic products creates new research and economic opportunities.

The national genebank of Bulgaria implemented free germplasm exchange by providing samples to national and foreign users. The exchange collection contents 2,989 accessions of 42 genera and 89 plant species. According to the annual reports in the period 2017-2020, 258 seed samples from cereals, oil crops, legumes and vegetables were provided to researchers in Bulgaria for research and breeding activities. By seed requests totally 709 seed samples from 27 plant species were sent to scientific organizations as genebanks, research institutes, etc. within EU countries (549 samples), Japan (61 samples), China (50 samples), India (20 samples), Israel (11 samples), Mexico (11 samples), and New Zealand (7 samples). The scientific interest of the partners abroad is focused mainly on the local germplasm from genus *Triticum*, *Hordeum*, *Avena*, *Zea*, *Pisum*, diverse forage grasses, vegetables, as well as the new varieties of *Arachis hypogaea* and *Sesamum indicum*, related to the climate change. The germplasm is distributed internationally complying with the quarantine requirements of the recipient country.

The free access to the conserved germplasm accessions by international networks has direct impact on sustainable and efficient utilization of plant biodiversity and genetic resources related to the new challenges, created by the climate change.

The Bulgarian National Inventory comprises the richest *ex situ* collection in Southeast Europe. According to the EURISCO (data check February 2021) it comprises 69,435 accessions from three Bulgarian institutes with diverse geographical origin (Table 1).

The Bulgarian National Inventory is the 7th biggest in Europe and has a share of 3,4 %, after the National Inventories of the Great Britain, Russia, Germany, Ukraine, Poland and Spain. It consists of genotypes of various geographical origins, with 26% of the samples (17,843 accessions) being of Bulgarian origin. The highest group of accessions is from the genera *Triticum*, *Hordeum*, *Zea*, *Phaseolus*, *Avena*, *Vicia*, *Capsicum, Pisum*, *Linum, Arachis* (Fig. 2). The species with more than 1,000 accessions are shown in table 2.

The status of the Bulgarian National Inventory in the AEGIS database (data check February 2021) includes information about 341 local accessions with Bulgarian origin of six plant species (Table 3).

Table 1. Status of the Bulgarian National Inventory in EURISCO (February 2021).

FAO INSTCODE	Institutes	Number of accessions	With BGR origin
BGR001	IPGR Sadovo	65 015	16 010
BGR005	IREMC Kazanlak	563	4
BGR029	DAI General Toshevo	3 857	1 829
	Number of accessions	69 435	17 843

Table 2. Species with the highest number of accessions in the Bulgarian National Inventory.

Taxonomy	Number of accessions	With BGR origin
Triticum aestivum	12,959	2,821
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

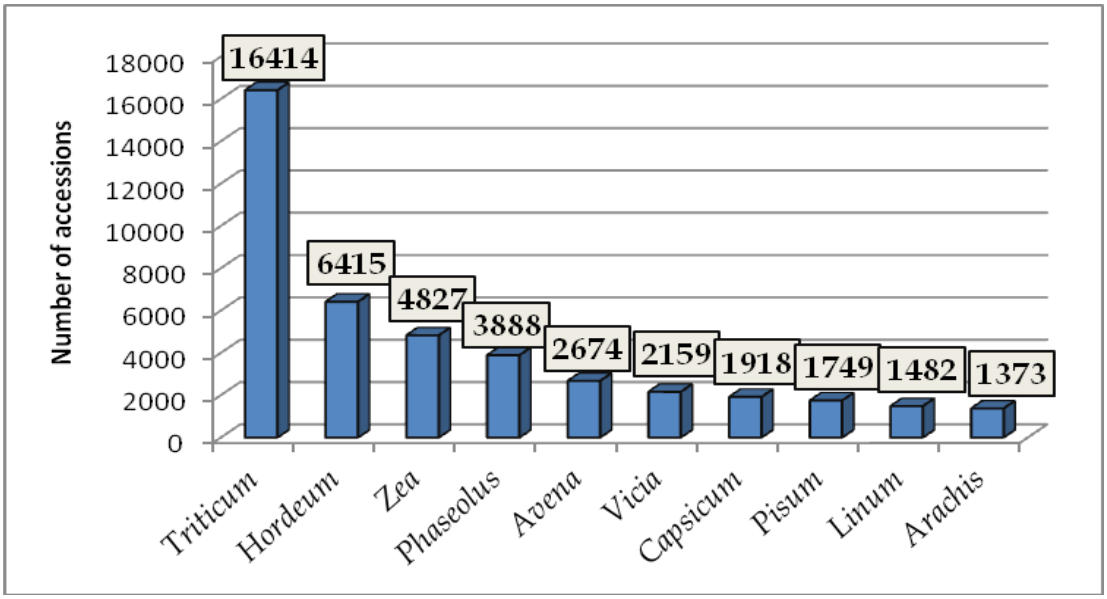

Fig. 2. Genera with the highest number of accessions in the Bulgarian National Inventory.

Table 3. Bulgarian accessions in AEGIS database (data check February 2021).

Taxonomy	Country of origin	Sample status	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
		Number of accessions	**341**

The beneficiaries of the international networks of plant genetic resources are all stakeholders at regional, national and international level – scientists, breeders, farmers (including bio-producers), NGOs, environmental organizations, students in the field of agricultural sciences, etc.

Ex situ collections can be considered as a backup copy of the plant diversity in nature and thus their preservation is guaranteed. According to FAO WIEWS (http://www.fao.org/wiews/data/) and GENESYS (https://www.genesys-pgr.org/) 1,750 genebanks and more than 2,500 botanical gardens are currently actively working in the world, and they are responsible for conservation of more than 7,4 million plant germplasm accessions. Through EURISCO, the information about the Bulgarian National Inventory is presented in the world databases FAO WIEWS and GENESYS. It comprises one of the richest *ex situ* collections in Europe and the richest conserved plant diversity in Southeast Europe. Conservation and targeted use of plant genetic resources is a national responsibility and priority, the successful implementation of which is directly dependent on the good coordination among all partners and stakeholders: storage and documentation specialists, curators of collections, breeders, scientists, farmers, NGOs, politicians etc.

By signing of the International Treaty for Plant Genetic Resources (ITPGRFA, 2009) and the Nagoya Protocol (CBD, 2011) free access to the conserved germplasm for scientific, public, ecological and other organizations has been regulated for fair and equitable distribution of the benefits arising from their use.

At international level, the EU plays an active role, contributing to ensure the achievement of the global appointments for biodiversity and conservation. In relation to access to the plant diversity, transferring data about Bulgarian *ex situ* collections to international networks requires highly specialized information that is made available to all users of plant diversity to ensure guaranteed and equitable access. One of the priorities of ECPGR is creation of equal mechanisms in databases construction in connection with the inclusion of the national collections.

Conclusions

The Bulgarian national genebank maintains one of the largest *ex situ* collections in Europe and the richest conserved plant diversity in Southeast Europe.

Its documentation system, according to the international standards, optimizes the management of plant genetic resources in relation to their sustainable conservation and target use.

The free electronic access to the information about the Bulgarian *ex situ* collection is achieved through participation in the international databases, such as GENESYS, EURISCO, AEGIS, and FAO WIEWS.

International networks provide free access to potential users regarding to

conserved genotypes according to the principles of the International Treaty on Plant Genetic Resources for Food and Agriculture and the implementation of the Nagoya Protocol on equitable distribution of their benefits.

The overview of plant genetic resources originating from Bulgaria is an indication of the wealth of local crop plant species and their wild relatives, and this may assist in identifying gaps and needs for further collecting. It may also be a good starting point for compiling checklists of cultivated plant species and to define future research activities.

The research priorities of the national program on plant genetic resources in Bulgaria are focused on expanding the role of biodiversity in agricultural food systems to increase the sustainability of agriculture and the livelihood of farmers and to offer consumers the traditional taste of agricultural products.

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