Chickpea and Lentil Germplasm

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Chickpea and lentil have great importance due to their role as a staple food for millions of people. Nowadays, the largest chickpea collection, 41.2% of the total stored accessions, is held by ICRISAT, while the main lentil collection is held in the ICARDA facilities. The main fraction of both collections is constituted by landraces collected in India. Several efforts have been made to integrate the thousand of genebanks present in the World into a global conservation system of plant genetic resources. The release of new informatic platforms allowed the creation of virtual genebanks, which are powerful tools routinely consulted by germplasm users.

Keywords: ex situ conservation ; genebank ; genetic resource management ; online database

1. Introduction

Chickpea and lentil are, together with cereals, among the founder crops of agriculture [1][2]. Domesticated in the Near East about ten millennia ago, these species spread towards the west side of the Mediterranean basin and central Asia in a relatively short time. Successively, their cultivation started in Ethiopia and neighbouring regions, and only some centuries ago were introduced in America and Australia. From the beginning of their cultivation to the present, chickpea and lentil have significantly contributed to human nutrition, being valuable sources of proteins, minerals and vitamins. Over time, small-scale farmers selected a myriad of landraces, choosing from the annual harvest the best seeds for the subsequent sowing and through seed exchange based on local social networks or family relationships. These empiric processes progressively enhanced the adaptation of the chickpea and lentil to different environments, increasing yield, stress resistance and seed nutritional quality [3]. Nowadays, chickpea and lentil are among the most cultivated legumes, with a worldwide production of 15,083,871 and 6,537,581 tons in 2020, respectively (FAOSTAT http://faostat.fao.org/default.aspx, accessed on 1 August 2022). Starting from the 1950s, the cultivation has progressively declined in European Mediterranean countries, increasing elsewhere such as in Canada [4]. The relocation of cultivation regions prompted the new producers towards the extensive cultivation of improved cultivars, which were better adapted to the new pedo-climatic conditions. This has caused the abandonment and consequent disappearance of an unknown number of landraces. As for other species [5], the assessment of genetic erosion experienced by chickpea and lentil cannot be quantified exactly due to the lack of inventories of materials grown more than a century ago. The systematic collection of crop germplasm started in the first decades of the 20th century, and after the beginning of this activity were the first genebanks created. Nowadays, a very low number of chickpea and lentil landraces are still cultivated by some local communities, mainly in the marginal areas (*on farm* conservation) of some countries, such as Algeria, Italy, Spain and Greece [6][7][8]. Based on these considerations, it can be inferred that germplasm collections retain the main fraction of the early genetic variation of chickpea and lentil.

2. Assembly and Management of Chickpea and Lentil Collections

In the second half of the 20th century, the genebanks, progressively founded around the world, started to create their own collections through collection missions or seed sample exchange with other institutions [9]. In 2008, the chickpea and lentil collections held by the genebanks jointed to the CGIAR (Consultative Group for International Agricultural Research) network were constituted by 41.096 and 18.114 accessions for chickpea and lentil, respectively. At that time, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) held 41.2% of chickpea accessions (**Table 1**). The assemblage of this collection started in 1972 with the institute foundation, and chickpea was one of the five assigned mandate crops to ICRISAT [10]. As concerns lentil, in 2008, the International Centre for Agricultural Research in the Dry Areas (ICARDA) maintained 55.8% of the accessions in their own facilities (**Table 1**).

Table 1. The most important chickpea and lentil collections conserved by the worldwide genebank network (source CGIAR 2008).

Genebank Name	No. of Accessions	
	Chickpea	Lentil
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, India)	16,928	-----
International Center for Agricultural Research in the Dry Areas, (ICARDA, Lebanon)	12,331	10,113
United States Department of Agriculture (USDA, USA)	4652	2672
N.I. Vavilov Institute of Plant Industry (VIR, Russia)	2113	2376
Aegean Agricultural Research Institute (AARI, Turkey)	1790	615
Institute for AgroBotany (ABI, Hungary)	815	857
Others	2467	1481
TOTAL	41,096	18,114

Over time, the size of both collections has increased, and presently, the two institutes conserve in their facilities 33.9% of chickpea and 43.5% of lentil accessions (**Figure 1**). The relevance of ICRISAT and ICARDA, with respect to the other genebanks, is related to the extensive cultivation of both these legumes in the semi-arid climatic conditions that are typical of several Asian and sub-Saharan regions.

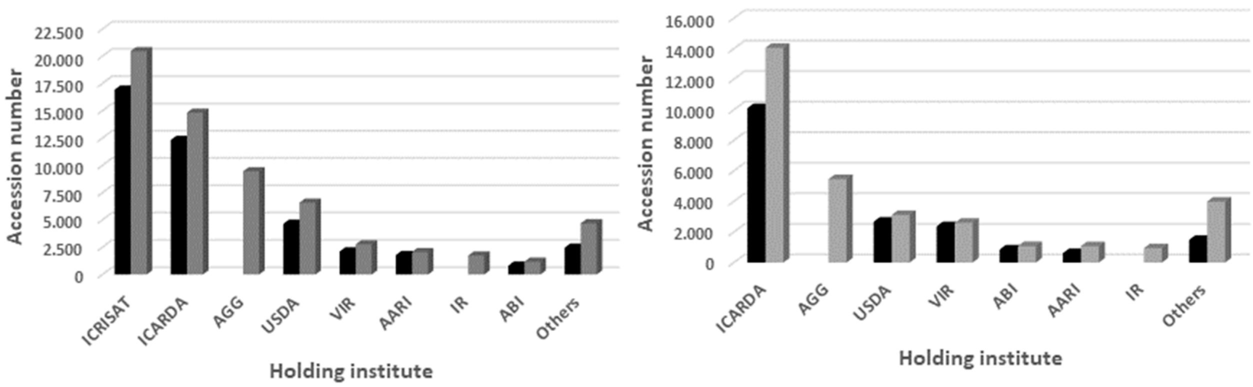

Figure 1. Size increase in the most important collections occurred from 2008 to 2022 (black and grey bars, respectively). **Left**: chickpea; **right**: lentil (source Genesys).

The collections held by European genebanks, as returned by the European Search Catalogue for Plant Genetic Resources (EURISCO), shows that this network keeps an accession number (**Figure 2**) that is significantly lower with respect to ICRISAT and ICARDA.

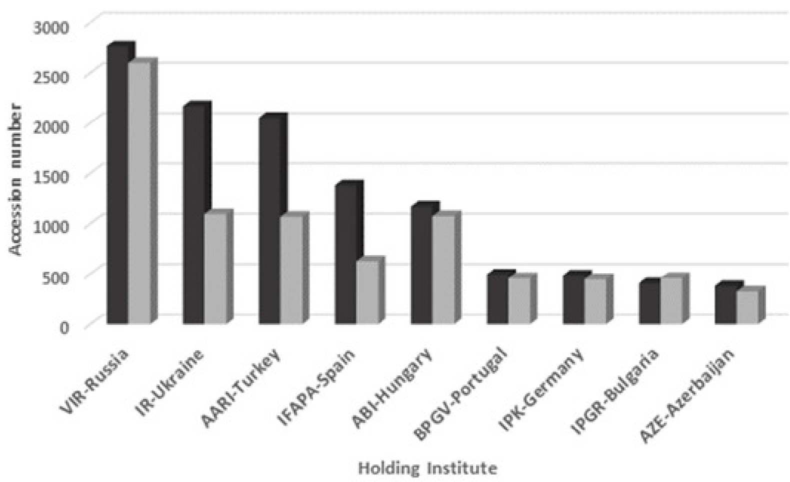

Figure 2. Size of the collections held by the most important European genebanks. Bar colour: black—chickpea; grey—lentil (source EURISCO).

However, it should be underlined that European collections are not merely duplicates of subsets of the collections held by ICRISAT and/or ICARDA.

The Russian genebank, Vavilov Institute of Plant Industry (VIR), keeps the largest European collections of both species (**Figure 2**). The importance of VIR among the European genebanks is due to its very long activity in the field of plant genetic resources safeguarding. It should be underlined that the first lentil collection was created and characterized by Russian scientists at beginning of the 20th century [11]. This collection still maintains high scientific relevance because it includes samples collected in the 1920–1930s [12]. The query of the EURISCO database shows that in addition to large collections, small or very small chickpea and lentil collections are stored in European genebanks (**Table 2)**.

Table 2. Size of chickpea and lentil collections conserved by some minor genebanks (source EURISCO).

Institute Code	GRC005	CYP004	ROM007	ARM059	ALB026
Lentil accessions					
Total	**97**	**19**	**38**	**34**	**2**
Domestic	**97**	**19**	**24**	**22**	**2**
Chickpea accessions					
Total	**177**	**28**	**127**	**42**	**9**
Domestic	**177**	**28**	**22**	**36**	**9**

GRC005: Greek Genebank, Agricultural Research Center of Macedonia and Thrace, National Agricultural Research Foundation, Greece; CYP004: National Genebank, Agricultural Research Institute, Ministry of Agriculture, Rural Development and Environment, Cyprus; ROM007: Suceava Genebank, Romania; ARM059: Scientific Center of Agrobiotechnology, Armenia; ALB026: Plant Genetic Resources Center, Albania.

Despite their small collections, these genebanks have a complementary role respect to the most important ones. Generally, the scientists of small genebanks devote particular attention toward the collection, characterization and conservation of landraces and populations of their own country. This allows the *ex situ* conservation of autochthonous genetic resources that are under the threat of disappearance within a very short time [13][14].

The *ex situ* conservation of chickpea and lentil germplasm offers to breeders the opportunity to broaden the genetic bases of commercial varieties belonging to both species. Scientists working at ICRISAT and ICARDA released several improved varieties in recent decades [15][16][17][18][19]. The diffusion of these new varieties has had positive effects on the production in several underdeveloped countries, contributing to alleviating the chronic scarcity of food.

The main drawback of the management of very large collections is the costs of keeping, distributing and multiplying the accessions, in addition to the obligation of cyclical acquisitions of new samples [20]. In consequence of this great efforts were devoted to setting up chickpea and lentil core collections or mini core collections [21]. These collections encompass a reduced number of accessions that are as representative as possible of the genetic diversity present in the whole collection. In this way, the amount of material that needs to be distributed and multiplied can be reduced. Several chickpea and lentil core collections—including the diversity of important traits such as pest resistance [22], morphological characters [23][24][25] and so on—have been created by ICRISAT and ICARDA. This process is far from completion as a consequence of the cyclic acquisition of new materials, and the new data derived from omic techniques [26][27].

It is well known that the narrow genetic variation of modern varieties of chickpea and lentil is the major issue in the further improvement of these species, as required by present and future challenges. For example, the most popular chickpea varieties are particularly vulnerable to water stress and climate changes [28]. A more efficient use of available germplasm requests broadening the genetic diversity of commercial varieties and the enhancement of genetic gain during the breeding steps [29]. The core collections could be a very useful starting point for germplasm users. They can remove time- and resource-consuming steps, such as the screening of large germplasm segments to identify the parents carrying the desirable traits.

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