Iraqi Journal of Desert Studies 2025, 15 (2): 59-65 **Review Article**

Genetic banks and Their Role in Developing the Agricultural Sector

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Abstract

Because of extreme climatic and environmental conditions in Iraq that vary from cold winters to extreme hot and dry summers, genetic deterioration could still be a major threat for locally grown cultivars especially those economically important. Then on top of it all, the requirement for Precautionary measures against any environmental hazard will be of concern, since its aftermath directly relates to our agricultural output as seen observed throughout the country. Therefore, this study aims to emphasize the necessity of establishing a genetic bank dedicated to preserving both local and acclimatized imported genetic structures. Such a bank should be capable of further development and of sharing expertise with international genetic banks. This would help secure a sustainable agricultural future capable of meeting food requirements in the event of any environmental, geographical, or other natural disasters.

Keyword: Gene banks; plant genetic resources; germplasm conservation; food security; biodiversity preservation.

البنوك الوراثية ودورها في تطوير القطاع الزراعي

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المستخلص

نظراً لما يمر به البلد من تغاير عالي في الظروف الجوية والبيئية ما بين موسمي الشتاء البارد نسبياً والصيف الجاف وشديد الحرارة فأن إمكانية انحدار الصفات الوراثية للأصناف المزروعة وخاصة الاقتصادية واردة جداً فضلاً على ضرورة أخذ الحيطة والحذر من أي تهديد أو خطر بيئي ممكن أن يؤدي إلى نتائج كارثية ممكن أن تؤثر بصورة مباشرة على الواقع الزراعي خاصة بعد موجة السيول التي ضربت العراق مؤخراً وقبلها الاضطرابات الزلزالية التي سادت في مدن عديدة من البلد. لذا هدفت الدراسة (موضوع البحث) إلى ضرورة إنشاء بنك وراثي خاص بكل التراكيب الوراثية المحلية والمستوردة المؤقلمة مع إمكانية تطويره وتبادل خبراته مع البنوك الوراثية العالمية لضمان مستقبل زراعي من شأنه أن يؤمن الاحتياجات الغذائية حال حدوث أي طارئ بيئي أو جغرافي أو غير ذلك من الكوارث الطبيعية.

الكلمات المفتاحية: **بنوك الجينات؛ الموارد الوراثية النباتية؛ حفظ الأصول الوراثية؛ الأمن الغذائي؛ الحفاظ على التنوع البيولوجي**

Introduction

There is no doubt that genetic banks have played—and continue to play—a vital role in securing the long-term livelihood of nations. They safeguard humanity's most important biological assets by preserving global and local germplasm of economically important crops, legumes, and valuable native lines threatened with extinction during natural disasters, regional conflicts, or internal disturbances. For example, the ICARDA genetic resources bank maintains the world's largest collection of key crops, including wild and cultivated forms of durum and bread wheat, as well as barley, lentil, and broad bean. It contains many accessions, most of which represent unique lines of cereals, legumes, and forage crops collected from regions known to be among the earliest centers of domestication in human history, such as the Ethiopian Highlands, the Nile Valley, and other centers of diversity in North Africa, Central Asia, and the Caucasus. Over thousands of years, these crops have naturally acquired genes that enable them to withstand diverse environmental stresses (Sustainable Agricultural Development Strategy, 2009; Zaraq et al., 2016).

Genetic banks are regarded as indispensable resources for the formation of genetic structures in different plant species, since they are considered to be a reliable and secure place for preserving seed germplasm. They function as a living insurance policy for nations against any kind of natural disaster that might destroy crops, in the process helping to maintain crop diversity and secure future food crops. Climate change presents a significant risk to numerous crops and food security, especially in the developing world, particularly in arid regions. This is compounded by the steady increase in population density, crop degradation due to environmental conditions and various human activities, and the introduction of agricultural varieties that are often unsuitable for local climates.

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Therefore, those concerned with agriculture worldwide are making every effort to preserve wild varieties that are unaffected by climate change and contribute to securing food supplies (Badr & Qasim, 1993; Afana, 2010).

Preserving the genetic diversity of agricultural crops in private and accredited banks under direct government supervision, especially for the four crops (wheat, rice, corn and potatoes) that constitute about 60% of an individual's food energy needs, is a high-value safeguard against any potential crisis that could threaten this diversity. Through this, we can face future challenges, especially for crops that are resistant to diseases and adapted to the country's climatic conditions or threatened by genetic depletion, because they contain genes that resist these risks and make them able to survive in the face of these environmental and disease challenges (Qasim, 2007; Food and Agriculture Organization of the United Nations, 2014).

The first institute dedicated to a seed bank was established by the Russian scientist Nikolai Vavilov in 1924. With this foundation, he conserved various plant crops in Saint Petersburg and initiated the study of conservation biology in botany. His extensive travels –he made 64 visits around the world- had given an immense contribution to enrich international knowledge with the most remarkable plant diversity. In these travels he collected near 60,000 plant specimens especially of wheat and rye sources with the ability to withstand extreme climatic conditions. His team of researchers accumulated another 250,000 plant samples and he became the first person to practice plant selection science, which later formed the fundamental basis for crop breeding and improvement programs (Al-Zu'bi, 1997).

A genetic resources bank is now a national priority because it brings great advantages. It is treated as a sovereignty right to defending biodiversity, and the availability of it when necessary. Today there are some 1,750 genetic banks around the world and they contain agricultural crop varieties that have been driven to the edge of extinction through a process of genetic erosion. Large-scale projects in this direction are currently underway in Brazil, China, Turkey, and Malaysia to preserve national agricultural genetic resources. Prior to this, the Svalbard Genetic Bank was established in Norway on the island of Svalbard in 2008, where agricultural seeds were preserved for Syria during the political crisis in the country. The National Genetic Bank in Britain was established to store approximately one million varieties of agricultural seeds and achieved its first goal in 2009, collecting about 10% of the plant varieties distributed worldwide (approximately 30,000 varieties). It is currently working towards collecting 25%. All these efforts have been made to protect plant genetic diversity, which represents a treasure trove and through which any future threats can be confronted. Therefore, every effort must be made to establish such a bank. After ensuring its sustainability and continuity for the benefit of the general public (Obaid, 2004; Rasen, 2011), preserving genetic resources through gene banks is crucial for the following reasons (Saifan et al., 2016):

1. Addressing potential global food production shortages at any moment.
2. Utilizing plant genetic resources to achieve national food security.
3. Providing researchers and research centers with seeds and genetic sources possessing desirable traits for transfer to other important crops through hybridization and other breeding and improvement methods, reducing reliance on imports.
4. Acquiring new genetic sources.
5. Developing breeding and crop improvement programs to achieve an agricultural renaissance.

A study by Beshay (2003) indicated that gene banks preserve plant collections with the aim of keeping them viable for as long as possible and maintaining their characteristics for their future benefit to humanity and the environment. The preserved plants include economically important crops such as modern and ancient varieties and their wild relatives, horticultural plants, forages, medicinal plants, and trees. All preserved genetic material, whether seeds, tissues, or live growing plants, is called germplasm. For clarification, a genetic bank is not merely a cold room filled with seeds; it encompasses a range of activities that make the germplasm more useful for scientists and researchers. These activities include (Arab Organization for Agricultural Development, 2016):

1. Acquiring new samples of plant resources.
2. Multiplying and regenerating diverse genetic resources.
3. The characterization and preliminary evaluation of all deposited plant resources.
4. Conserving plant resources of all types.
5. Increasing the numbers of plant resources and working to collect them, especially wild sources.
6. Documenting and exchanging information on all preserved plant resources.
7. Cooperating with other genetic centers and banks in collecting and exchanging plant genetic resources.

8. Organizing technical meetings and holding training workshops to raise awareness about the importance and role of genetic banks.
9. Conducting research related to the viability of plant resources and seed physiology.

Objectives of Establishing Genetic Banks

1. Preserving plant biodiversity within its natural habitats or outside them by multiplying seeds in experimental stations affiliated with the genetic bank.
2. Developing specialized research plans to conserve genetic resources using scientifically validated methods.
3. Improving cultivars by providing genetic materials that carry traits enabling tolerance to various stresses or suitability for saline soils.
4. Supplying the genetic material and essential information required for different breeding programs.
5. Strengthening cooperation among genetic banks, institutes, universities, research centers, and the private sector to ensure mutual benefit.
6. Collaborating with international genetic resource banks and related organizations that operate under global standards set by the Commission on Genetic Resources for Food and Agriculture of the Food and Agriculture Organization (FAO).
7. Enhancing international cooperation through implementing regional and global agreements that regulate the conservation and use of plant genetic resources and biodiversity via the exchange of genetic materials.

8- Training, education, and workshops to prepare specialists to work in gene banks (FAO, 2014).

Types of Gene Banks

1- Institutional Gene Banks
2- National Gene Banks
3- Regional Gene Banks
4- International Gene Banks

Preserving genetic resources in their natural environment (In Situ)

This method aims to preserve plant species in their natural environment and in the reserves where they originated for the following reasons:
1- Continued variations and interactions between genetic material and environmental inputs allow species to evolve.
2- Most of the genetic diversity, including wild species and their relatives, is found in the wild environment.
3- It allows for the interaction of pathogens and the species, leading to the development of resistance.
4- It facilitates the development of resistance to various biotic and abiotic stresses.
5- It is used for species with high seed moisture content (recalcitrant). (Sawahil, 1999).

Conservation of genetic resources outside their natural environment (Ex Situ): advantages and disadvantages

No.	Advantages	Disadvantages
1	Genetic material can be preserved in the form of seeds.	It limits the emergence and development of genetic material due to reduced environmental variation.
2	Easy and rapid access for evaluating and improving resistance to pests and diseases.	Significant loss of genetic variability.
3	Low maintenance requirements for genetic material in the long term.	
4	Suitable for species facing extinction or decline.	
5	Low cost.	
6	Applicable to all products of biotechnology and genetic engineering.	

Source (Badir, 2007)

Benefits of Genetic Banks

(Food and Agriculture Organization of the United Nations, 2019)

1. Protecting national heritage—represented by local genetic resources and indigenous cultivars—from long-term degradation and extinction.
2. Characterizing, evaluating, and regenerating different plant genetic resources, and organizing their exploration, collection, and importation at the national level.
3. Enhancing the productivity of cultivated cultivars to achieve food security by conserving biodiversity and providing agricultural systems with high-quality genetic resources capable of tolerating prevailing biotic and abiotic stresses.
4. Ensuring rapid access to any required information about genetic materials through an advanced and well-organized database.
5. Strengthening international cooperation and adhering to agreements that promote fair use of genetic resource exchange, training, and technical meetings.

International facilitation for accessing genetic resources

Sa'ifan et al. (2016) reported that the improvement of many economically important cultivars in the United States was accomplished through importing genetic materials from other regions. For instance, the enhancement of resistance to barley yellow dwarf virus in American barley cultivars originated from Turkish varieties, and the resistance genes to stem rust in American wheat were sourced from Caucasian countries.

Genetic resources have long been viewed as a shared heritage of humankind. However, the situation that emerged was that developing countries provided genetic materials to industrialized nations free of charge, only to later reimport them as high-yielding improved cultivars. This practice generated significant criticism from developing countries (Al-Muhib, 2011).

Departments and Laboratories Affiliated with the Genetic Bank

- Seed Maintenance Department
- Seed Viability Testing and Regeneration Department
- Genetic Resource Evaluation Department
- Documentation and Information Department
- Taxonomy Department
- Chemical Analysis Laboratory
- Molecular Genetics Laboratory
- Plant Tissue Culture Laboratory
- Cytogenetics Laboratory
- Plastic and Glass Greenhouses
- Genetic Bank Field Stations
- Genetic Herbarium

(Food and Agriculture Organization of the United Nations, 2014)

Seed conservation and storage procedures

Seed cleaning: Removing broken seeds, damaged or infected seeds, foreign materials, and seeds of other species.
Seed drying: Reducing seed moisture content to the recommended level.
Seed packaging: Placing weighed quantities or a fixed number of seeds in airtight containers for subsequent storage.

Seed storage includes the following:

1. Drying seeds to approximately 5% moisture content for traditional orthodox seeds, which are stored at low temperatures.
2. Storing seeds that retain high moisture levels (more than 15%), known as recalcitrant seeds (Al-Zu'bi, 1997).

Types of Sample Storage

Two main storage types are used (Al-Dabbagh et al., 2012):

1- Base Collections: These are used for long-term seed preservation. Samples of genetic inputs are separated and sorted according to their genetic similarity. They are stored for future use and are not distributed directly to users but are used for repropagation. The storage temperature for this method is below 0°C and can reach -20°C.

2- Active Collections: These store genetic inputs ready for amplification and distribution to users. They are stored under medium-term storage conditions that ensure viability of more than 65% for 10-20 years at temperatures of 0-5°C.

Safety Duplication of Storage Samples

Safety duplication refers to storing genetic material samples in an additional location—preferably outside the country—particularly for Base Collections, to ensure their long-term preservation under secure conditions. There are several forms of genetic material duplication:

1. Black Boxes: In this system, the receiving institution is responsible for maintaining seed viability and performing regeneration when necessary.
2. Active Duplication: Includes regeneration, multiplication, and distribution of genetic materials.
3. Base Duplication: Ensures long-term preservation of samples under optimal storage conditions.

General Procedures for Preserving Diverse Plant Genetic Resources

(**A journey of a genetic accession in the CIMMYT gene bank**)

(Arab Organization for Agricultural Development, 2016)

1. Inspect seeds to ensure they are free from infestation or damage.
2. Incubate seeds under controlled growth conditions to detect fungal contamination; afterward, wash the seed samples with disinfecting agents and filter the rinse water using filter paper to examine fungal spores.
3. Germinate seeds to assess their viability and overall health.
4. Use healthy seed samples for breeding programs or store them in the gene bank after proper cleaning and drying.
5. Package wheat seeds, for instance, in tightly sealed aluminum envelopes—some designated for researchers and others for long-term storage in international seed vaults such as the Svalbard Global Seed Vault.
6. Specialists in these gene banks regenerate wheat seeds in soils free of pathogens—for example, desert soils that lack disease-causing organisms.
7. Before seeds are shipped abroad, they are washed with a chlorine solution and treated with fungicides. For instance, the CIMMYT bank annually sends around 1,500 wheat seed sets to various countries around the world.

Conclusions

The first priority of creating gene banks for a number of agricultural crops, is to be ready in such eventuality. At the same time, it conserves genetic diversity and accessibility for breeders, stakeholders, researchers. Plant genetic resources are a strategic resource for sustainable crop production, and their effective maintenance is essential to ensuring food security now and in the future. The loss of genetic diversity reduces the options for sustainable management of local agriculture under unfavorable and rapidly changing environmental conditions. Preserving and recording the genetic resources of economically important crops adapted to the country's conditions allows for their development, expansion, and improvement. Building a strategic reserve of key agricultural crops to secure food supplies and maintain food security whenever needed. Confronting environmental risks and natural disasters is inevitable, and ensuring food availability for humans and livestock is a national necessity. Exploring, collecting, evaluating, and characterizing all wild, local, and introduced plant genetic resources and including them in research programs. Encouraging the scientific objectives pursued by researchers, within the limits of available resources and working conditions, to improve the agricultural sector at all levels. Meeting the massive challenges of local agriculture, subject to severe limitations in capacity and lacking the necessary infrastructure to support experts advancing and promoting agricultural development.

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Authors' Contribution

Rasha Adil Al-Bakri designed the study, supervised the research activities, and contributed to data interpretation. Heba A. Hussein conducted data collection, carried out the laboratory and field procedures, and assisted in drafting the manuscript. Ahmed A. Kadhim performed the literature review, completed the data analysis, and finalized the manuscript for submission.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this research.

Novelty Statement

This study highlights the strategic necessity of establishing national genetic banks as a proactive safeguard against environmental hazards and genetic erosion. It provides an updated, consolidated scientific framework on germplasm conservation practices and their role in strengthening food security under current and future agricultural challenges.

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