Biological Times Volume No. 5 | Issue No. 8 | Pages 15-16

PRESERVING SEEDS FOR THE FUTURE AND THE DOOMSDAY VAULT FOR SEEDS

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ABSTRACT

Seed conservation protects crops from climate change and habitat loss. When weather gets extreme, plants can't adapt, and farms lose yield. Seed banks store plant genes for future farming and restoration work. There are more than 1750 individual gene banks and approximately 2500 botanical gardens worldwide, collectively storing over 7.4 million accessions with intentional redundancy built into storage. Local community seed banks help farmers protect plant variety and share seeds. Wild sourcing of seed can result in further loss of biodiversity and habitat, especially if unmanaged, thereby making seed supply unpredictable from year to year. The Svalbard Global Seed Vault provides a form of insurance by preserving genetic material for future use. Future tools like AI and biotech will make seed work faster and fit new climates.

Keywords: seed conservation, seed banks, Svalbard Seed Vault, climate change, biodiversity, community seed banks, future of seeds

To cite this article: Hannia, A Razaq, AJ Khan, GA Jamali & MY Ishaq. PRESERVING SEEDS FOR THE FUTURE AND THE DOOMSDAY VAULT FOR SEEDS. Biological Times. 2026. August 5(8): 15-16.

Introduction

Seeds are the units for the sustainability of agriculture and for the next generation. To preserve seeds, seed banks play a major role in maintenance and regeneration. Large-scale land degradation is being observed globally, which is caused by both climate change and human-made activities. There is an increased awareness of the need to stop this trend, which is increasingly threatening the survival of the human race. Ecological restoration is now receiving considerable attention and is a global priority. The UN has named 2021-2030 as the Decade of Ecosystem Restoration. The importance of restoring degraded natural habitats is recognized by the Convention on Biological Diversity (CBD), which set a target of restoring 15% of degraded ecosystems by 2020 [1]. However, these targets were not achieved, and the post-2020 Global Biodiversity Framework has been developed, aiming to restore 30% of degraded habitats by 2030 [2].

The future climate crisis threatens our very existence, evidenced by recent catastrophic events such as wildfires (rare occurrences) and the global destruction of natural resources [3]. Seeds, which transmit genetic material to the next generation, are also vulnerable to risks while in storage [4]. Some seeds exhibit incredibly long natural survival [5]. Seed conservation for food security and biodiversity is a critical component of any preparedness plan, helping to mitigate the potentially devastating effects of natural disasters and preserve the genetic diversity of crops [6]. This durable early growth can contribute to better resistance against biotic and abiotic stress factors such as pests, diseases, drought, and inadequate soil conditions, ultimately leading to improved crop yields [7].

Several major seed conservation centers, such as the Svalbard Global Seed Vault (SGSV) and the Kew Millennium Seedbank, play a crucial role in conserving genetic resources for the future [8]. Despite long-term preservation, it is crucial to emphasize the need for mandatory and regular monitoring of seed health within these facilities to ensure sustainability [9]. The maintenance of ex situ (outside the field) seed banks is recognized as a resource-intensive undertaking, requiring adherence to strict quality control measures established by international forums to optimize the conservation of genetic resources [10]. The SGSV, a central storage facility built into the mountain permafrost on a Norwegian island in the high Arctic. Thousands of years ago, major changes in culture and society arose when humans began to harness the diversity of plant seeds and their capacity over the long term [11].

Need for Seed Conservation

Seeds are a priority to conserve biodiversity as each seed has diverse genetic material to protect the gene pool in its specimen[26]. Furthermore, seeds develop into seedlings without any requirements for costs and other procedures. Thus, the samples of higher plant species are mostly stored in seed banks as seeds[27]. So, Global climate change, with extreme weather events, impairs the reproductive development of crops and reduces their overall yield. On the other hand, increased species diversity has been recorded, indicating the emergence of more favorable climates [12]. Changes have been observed in the distribution ranges of many species [13].

Seeds Preservation Methods

Conventional storage means that seeds are treated in climate control environment. Drying seeds at 5-20 °C and 10-25% relative humidity; at this stage, it holds 5% moisture [15]. According to the standard method, for a short time period, > 18 months, the temperature was kept between 0-5 °C [16]. In Mediterranean gene banks, seeds of native plants are stored at -25 °C [17]. Cryopreservation is the most advanced technique to store seeds at extremely low temperatures by using liquid nitrogen (-196 °C); it effectively ceased the cell aging in seeds [18]. In cryogenic storage, it solidified the solution without the formation of ice crystals, resulting in a glassy structure [19].

Role of Community Seed Banks

Community seed banks serve as a vital platform for the community-based management of biodiversity and informal seed systems. These community seed banks can be organized into networks linked to national seed banks, thereby enabling the exchange of germplasm among them. Local sourcing is a key strategy for resource acquisition for recovery projects [22, 28]. During this process, local communities have also demonstrated their capacity to provide ample tree-planting materials for restoration and to assist poor households with alternative livelihoods Harrington's rule [23]. The establishment of community seed banks can strengthen the capacity of communities to provide high-quality and genetically diverse planting material.

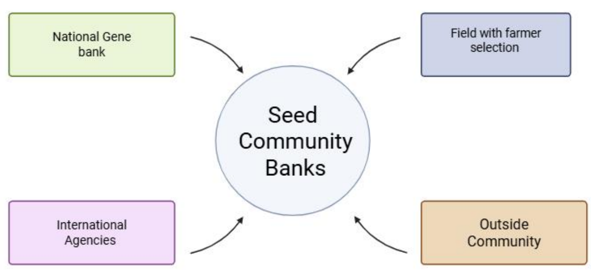

Fig.1: Community seed bank as an institution for access

The Doomsday Vault

GenBank gives seeds to scientists and plant breeders; it's allowed to keep extra safety copies at the SGSV[24]. The facility opened in 2008 and underwent major upgrades between 2021 and 2023, including new seed deposits. According to a 2023 report by the 'Crop Trust,' the vault houses more than 1.2 million seed samples from over 70 countries [25]. The internal temperature stayed at -18°C due to rock insulation in Svalbard, thus seeds are stored for the long term. During the war, researchers withdrew seeds from Svalbard to replenish their stocks. This was the first "withdrawal" of seeds and serves as proof that the vault functions effectively.

Limitation and Future Prospects

Preserving seeds in seed banks with different techniques have safest way, but it meets some challenges and limitations. A large number of seed banks are poorly resourced and have difficulties in seed testing and their regeneration [20]. Seed banks have made significant progress in conserving plant diversity, but many plant species and other wild plants still have not stored their seed [21]. Predicting future climate conditions for a region through climate models is becoming increasingly feasible, and "seed banks" can prove genetic material compatible with these "future climates" [14]. So, biotechnology is improving seed quality. Rapid tech growth is changing seed science quickly. This means that in the future, every farmer can get good quality seeds easily. Artificial intelligence (AI), machine learning (ML), and Nanotechnology will hold the potential for breeding of seed quality and traits. They will transform the science of seed conservation

Conclusion

In conclusion, preserving seeds now will protect our future food and plant diversity. Climate change and extreme weather are threatening crops and wild plants faster than before. Seed banks, restoration seed banks, and Svalbard Global Seed Vault act like insurance by storing seeds for later. Furthermore, seed handling in storage conditions plays a vital role in observing seed quality and durability. Restoration seeds may not need to be stored in long-lasting storage conditions; it is essential to ensure that they are stored in conditions that maintain viability. Community seed banks help local farmers keep many types of climate-strong seeds. New tools like biotechnology, AI, and climate models will improve seeds and help breeders pick the right ones for future weather.

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