Indian J. Plant Genet. Resour. 32(3): 303-306 (2019)
DOI 10.5958/0976-1926.2019.00031.7

SPECIAL ARTICLE

Global Seed Vault: A Pledge to Mankind

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The Svalbard Global Seed Vault was opened in 2008, as a storage facility for duplicates of seed samples that are conserved in gene bank collections. Many gene banks have faced threats that often caused loss of plant genetic resources due to war and conflicts, natural disasters or lack of human or economic resources.

By mid-2019 the Svalbard Global Seed Vault holds today close to one million seed samples that are back-up copies of seeds that are conserved in regular gene banks. The seeds are the property of the depositor gene banks, and the owner gene bank can have the seeds back whenever they might need them.

Key Words: Gene bank, Plant genetic resources, Seed, Svalbard Global Seed Vault

Introduction

Seed gene banks conserve plant genetic resources with the purpose of securing genetic diversity for research, plant breeding and development of agriculture and food production. Genetic diversity in crops is considered to be crucial for future food security, and maximum security for the resources is required. Gene banks face threats and witness incidents that cause loss of plant genetic resources such as war and conflicts, natural disasters or lack of human or economic resources.

To meet the need for securing the resources Norway has built the Svalbard Global Seed Vault as a facility for free of charge conservation of duplicates of seed samples that are stored in gene banks. The Seed Vault was established after significant international support and seed deposits are made in accordance with international agreements and with a depositor agreement between the depositing gene bank and the Norwegian Ministry for Agriculture and Food.

Storing Seeds in the Arctic

The story about the Svalbard Global Seed Vault started already in 1984 when the Nordic Gene Bank put backup samples of the Nordic seed collection in a coal mine in Svalbard. Svalbard is a Norwegian archipelago of islands in the Arctic, not far away from the North Pole. The grounds in Svalbard provide constant permafrost conditions, securing that seeds remain frozen even without artificial cooling.

The Nordic solution gained significant international interest, and the idea of establishing a facility for back up samples of other national and international gene banks in permafrost was launched. After comprehensive

The NBPGR seed box in the Seed Vault shelves between boxes from other countries

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international support Norway presented the offer to build and manage a global seed vault in Svalbard at the FAO Commission on Genetic Resources for Food and Agriculture meeting in Rome, Italy in 2004. The Seed Vault was built and funded by the Norwegian government during 2007 and opened on the 26th of February 2008.

The Nordic Genetic Resource Centre (NordGen) was involved in the planning process and has been responsible for management and operation since the start. Thanks to significant joint efforts and financial support from the Global Crop Diversity Trust, many gene banks prepared and shipped seed samples for depositing at the Seed Vault already for the opening in 2008. Thanks to these efforts, 320,549 seed accessions from 22 gene banks were deposited in the Seed Vault already during the first year of operation.

Today, more than 11 years after its opening, the establishment of the Seed Vault has proven to be an unconditional success. Now, in 2019, 76 gene banks located in 58 different countries have deposited security seed samples in the Seed Vault. The depositor gene banks are international agricultural research centres, national and regional gene banks and gene bank collections held by universities, breeding and research institutes and NGO's. More than one million seeds samples have been deposited in the Seed Vault.

The Facility

The Seed Vault facility is unlike the Nordic security storage in the coal mine, constructed in virgin solid rock without any coal layers. The facility consists of a tunnel of about 100 m, a fore hall and three seed storage chambers, each with the capacity to store around 1.5 million seed samples. The Seed Vault is located 130 m above sea level, which is above worst case climate change scenario for sea level rise.

Artificial cooling secures that the temperature in the seed storage is maintained at -18^{o}C, which is in accordance with the FAO Gene Bank Standards. Permafrost in the soils secure that seeds stay frozen even if the cooling system should fail.

Conserving seeds in the Seed Vault is a free of charge service. All gene banks making their genetic resources available for research, breeding and education are invited to conserve backup copies of their seed collections in the Seed Vault. Seeds are stored in sealed seed boxes and only the owner gene banks can get access to the seeds.

The Seed Vault is owned by the Norwegian government and the management is the responsibility of NordGen. Funding is secured through a three party agreement between the Ministry, Crop Trust and NordGen.

The operation of the Seed Vault is overseen by an International Advisory Panel reporting to the Ministry. The Svalbard Global Seed Vault is considered to be a vital part of the global system for conservation and use of plant genetic resources, as stated by the International Treaty for Plant Genetic Resources for Food and Agriculture. (ITPGRFA 2017).

Cooperation NBPGR and NordGen

As having one of the world's largest national gene banks, NBPGR is in particular invited to deposit security copies of seed samples in the Seed Vault. By the end of 2018, NordGen Director and Seed Vault Coordinator visited the NBPGR headquarter and Gene Bank in Delhi. The Nordic visitors were informed about the comprehensive National Gene Bank in India holding about 438,000 seed accessions, in addition to germplasm cryopreserved and conserved *in vitro*.

NBPGR Director Kuldeep Singh and NordGen Director Lise Lykke Steffensen met at Dehli in November 2019

Cooperation between the NBPGR in Delhi and the Svalbard Global Seed Vault was established already in 2008, when NBPGR signed the Seed Vault depositor agreement with the Norwegian Ministry of Agriculture and Food. The first seed deposit was made in 2014 and so far, the gene bank has in total deposited 225

seed samples of pigeon pea (*Cajanus cajan*), rice (*Oryza sativa*) and sorghum (*Sorghum bicolor*). Plans for conserving security samples of the 26,000 NBPGR accessions that are registered in the Multilateral System (MLS) of the Plant Treaty in the Seed Vault have been included in NBPGR and NordGen discussions.

Seed Vault coordinator Åsmund Asdal putting the seed packages from NBPGR into a standard box before inserting in the seed storage

About NordGen

The Nordic Genetic Resource Center is a Nordic organization dedicated to the safeguarding and sustainable use of genetic diversity within crop plants, farm animals and forest trees. The Nordic countries have been co-operating for more than 30 years on conservation of genetic resources, and NordGen was established in January 2008 as a result of a merger between Nordic Gene Bank, the Nordic Gene Bank Farm Animals and the Nordic Council for Forest Reproductive Material. NordGen is mainly financed by the Nordic Council of Ministers. The Nordic Gene bank for plants was established back in 1979.

NordGen is a Nordic knowledge centre and its primary task is to contribute to securing the broad diversity of genetic resources linked to food and agriculture. This is done through conservation and sustainable use, solid documentation and information work and through international cooperation and agreements.

NordGen is today one of few regional gene banks in the world, covering gene bank activities for neighbouring countries in a geographical region. The SADC Plant Genetic Resources Centre (SPGRC) gene bank in Lusaka, Zambia, is the other major regional gene bank. SPGRC is facilitating conservation of seeds and other regional cooperation carried out at national centres for plant genetic resources in 16 countries in southern Africa. NordGen and SPGRC have through decades cooperated on regional gene bank developments and projects.

The Nordic seed collection conserved at NordGen consists of 35,000 unique accessions representing 530 different crop species and wild plant species related to crops.

NordGen is managing the so called *Public Private Partnership for Pre-Breeding* (PPP) project which is funded by the Nordic countries and gathers research and plant breeding companies in the countries in joint efforts for improving plant genetic material for agriculture in the region. The PPP project has sub-projects for apples, barley and rye-grass which are important crops for the Nordic agriculture and horticulture. The project is an important link connecting gene bank material to practical plant breeding and agriculture.

NordGen distributes every year between 8,000 and 12,000 seed samples to users in the region and abroad, within research, breeding and training, but also to farmers and hobby growers that want to cultivate this unique material.

Seed Vault Deposits

NordGen is aiming at securing its entire seed collection in Svalbard Global Seed Vault. At the moment more than 70% of the seed collection has been duplicated in the Seed Vault.

After nearly twelve years of operation, the total number of deposited seed samples in the Seed Vault has reached 1,078,673. The major part, about two thirds, has been deposited by international agricultural research centres (CGIAR institutions). Four of these have deposited more than 100,000 samples each: CIMMYT (International Maize and Wheat Improvement Center) in Mexico, IRRI (International Rice Research Institute) in The Philippines, ICRISAT (International Crop Research Institute for the Semi-Arid Tropics) in India and ICARDA (International Institute for Agricultural Research in Dry Areas), which until recently had its genebank in Syria.

The largest depositors among national genebanks are the USA, Germany, Canada, Australia, the Netherlands, South Korea and Switzerland. Genebanks in several developing countries have deposited seeds as well; Mali,

Nigeria, Sudan, Uganda, Zambia, Burundi, North-Korea, Myanmar and Pakistan, among others.

The Seed Vault now holds samples of about 5,000 different species. Rice and wheat are represented by more than 150,000 seed samples each. Further, 15 major cereal, vegetable and forage crops are represented by more than ten thousand seed samples.

So far, only one institute has requested seeds to be returned. This took place in the autumn 2015, when ICARDA, which until then had its headquarter in Aleppo, Syria, lost access to its gene bank due to the ongoing conflict in Syria, and needed seeds from Svalbard to establish new functional genebanks at ICARDA units in Lebanon and Morocco. Seeds from the Seed Vault were shipped back on three occasions, and have been sown and multiplied at these sites. Since the spring of 2017, ICARDA has already re-deposited new seeds in the Vault on four occasions. Withdrawals and redeposits of seeds by ICARDA imply that the current number of seed samples secured in the Vault by September 2019 is 962,186.

Open Invitation

Gene banks are invited to ship seeds to Svalbard on three or four regular Seed Vault opening occasions every year. Every year since 2008 between 12 and 29 institutes have deposited seeds. Many of these have deposited seed several times, as part of a comprehensive program for securing their seed collections. NordGen maintains a web portal database where transparent data about all deposited seed samples, depositor institutes, countries of origin etc. is displayed, i.e. the Seed Portal at https://www.nordgen.org/sgsv/.

The main conditions for depositing seeds in the Seed Vault imply that the depositing gene bank shall conserve the original and primary seed sample in its own long-term gene bank. Only orthodox seeds of crops and their wild relatives can be accepted for storage in the Seed Vault. The genetic material should be available for breeding and research in accordance with applicable international law. Storing seed samples in the Seed Vault is free of charge, and the seeds remain the property of the depositor. The seeds are returned to the depositor on request if the accessions are lost or inaccessible from their own or from cooperating gene banks' repositories. Only the depositing institution can obtain access to the seeds it has deposited in the Vault.

Ever since the Seed Vault opened it has been a great attraction. It has drawn attention to the issues on conservation and sustainable utilization of plant genetic resources. Influential politicians and policy makers have regularly paid visits to Svalbard and the Seed Vault and there has been a continuous great interest from many of the world's leading media to tell the story about the global undertaking of conservation and utilization of crops and their wild relatives.

The Seed Vault is now probably Norway's internationally most well-known building and it has been an iconic symbol of the importance of taking care of plant genetic resources. The ultimate goal is that all unique plant genetic material conserved in gene banks is secured and copied in the Svalbard Global Seed Vault. The long term security of deposited seeds is guaranteed for by the Government of Norway.

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