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# DON'T LET IT GO! Saving endangered plants through seed storage

Many species and varieties of plants are at risk of extinction. Seed banks offer a way to conserve their seeds as frozen assets for the future.

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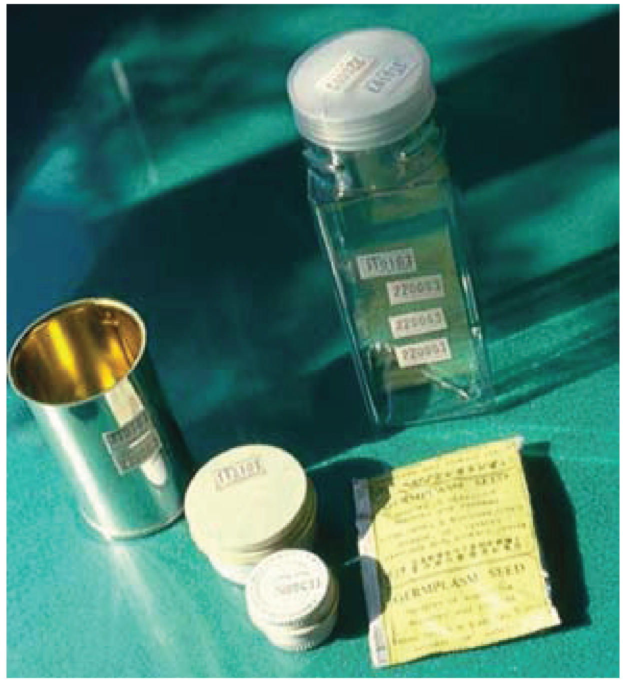
The diversity of life on earth is being threatened by extinction due to human activities, climate change and natural disasters. Once a species or variety is gone, it is gone for good. One of the ways to avoid catastrophic losses is to store seeds in a seed bank.

The practice of storing seeds for future use began with farmers keeping and storing a portion of their harvested seeds to use as planting material for the next season. The most simple arrangement was to hang up the seed-bearing stems in the kitchen to dry, under shelter from sun and rain.

With crop seeds like cereals, legumes and most vegetables, storage of seeds for periods of one year or more is possible under dry cool conditions. Seeds that can be stored in this way are said to be *orthodox*. For storage in seed banks, orthodox seeds are dried to low moisture levels of around 6% moisture content and stored under air conditioning at 20°C for medium-term storage or at -20°C for long-term storage.

Most seeds in the humid tropics are *recalcitrant*. Recalcitrant seeds are seeds that cannot survive being dried, and also cannot survive at low temperatures. Examples of species with recalcitrant seeds are rubber (*Hevea brasiliensis*), nangka (*Artocarpus heterophyllus*) and most Malaysian forest tree seeds. Such species have to be treated differently.



Types of seed containers used in seed banks.

**Importance of biodiversity and conservation**

Malaysia is a small country but is the 12$^{th}$ richest mega centre for biodiversity in the world, with more than 185,000 species of animals and 15,000 species of flowering plants. Unfortunately, the numbers are decreasing and many species are under threat, according to the Red Data List of the International Union for Conservation of Nature (IUCN). Hence, Malaysia needs to do more to conserve its flora and fauna.

Natural disasters, diseases, pests and even the green revolution are putting the world's

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agricultural future in grave jeopardy. In the tropics, human population growth is already obliterating some of the world's richest plant breeding grounds. Some scientists estimate that by the turn of the century, the great forests of Africa and the Amazon basin will have been ravaged in the search for minerals and by the development of huge industrial plantations. Even the miracle plants of the green revolution are not free from blame. The introduction of miracle wheat in Afghanistan averted famine in the 1970s, but at the same time it also virtually wiped out all the old, indigenous strains of native wheat that had fed the people of Afghanistan for hundreds of years. As a result, the priceless store of genetic variation was irretrievably lost.

The production of a new 'miracle' plant or seed is the result of the crossing of genetic materials present in the gene pool followed by selection of desirable types. The continuing disappearance of plant varieties reduces the number of different genes available for breeding. Today, we depend only on four cereals — wheat, rice, maize and sorghum to supply the staples for the world's population. This dependence on a narrow selection is dangerous, with serious repercussions should any one of these fail for any reason. Our ability to cope with a disaster depends on the genetic resources of plants that are available to plant breeders for breeding. In 1970, Brazil's high-yield coffee crop, the country's biggest export item, was suddenly struck by an epidemic of leaf rust that devastated the crop plants. Many other examples can be quoted. The narrowing of the genetic base has the result of limiting the options available to breeders for improving today's plants or creating those of tomorrow. We have no way to predict what our genetic needs in the future will be. It would be best to save all of the world's plant species, just in case.

Diversity of tomato varieties

Conservation can take various forms. One form is to prevent further destruction of forests so that their species can propagate themselves naturally. Another way, requiring greater effort and expense, is to grow and care for plants in botanic gardens and arboreta. The third way to to conserve plants is by storing their seeds in seed banks. Seed storage in sealed containers in seed banks has the advantage that it does not occupy much space

The world's two largest seed banks are the national seed storage laboratory at Fort Collins USA and the Vavilov Institute in Russia. In addition, there are regional banks such as the one at Izmir, Turkey, for the conservation of seed of plants native to Turkey and adjacent lands. For rice alone at the International Rice Research Institute (IRRI), Philippines, there are 80,000 accessions (collections) of rice (*Oryza sativa*) and its relatives. The importance of such banks is best expressed by a remark made by a visitor to the International Rice Research Institute about its seed bank. "These seeds are a treasure far more valuable to mankind than all the hoards of gold, precious stones, and other material wealth in the world".

Around the world, teams of scientists are racing against time to rescue the genetic heritage on which our future depends. For example, early in 1981, the Rubber Research Institute of Malaysia sent a team to Brazil to collect wild rubber species to preserve and to widen the genetic base for the cultivation of *Hevea brasiliensis*. This and other examples illustrate the importance of international cooperation in research and conservation of the world's gene pool.

**Seed banks for orthodox seeds**

In a typical seed bank, the initial task is to conduct field collection of seeds. For example IRRI in the Philippines had innumerable contacts with rice-affiliated persons all over the world to help in building up its seed bank. All seed samples collected or received are checked against records to avoid duplicates. They are then planted and fresh seeds are collected and fumigated for short or long term storage. A duplicate is sometimes sent to other laboratories for additional safety. For rice, seeds are reduced to 6% moisture content, sealed in air-tight and moisture-proof containers and stored in cold rooms at -20°C and relative humidity of 15%. The length of time of seed viability is expected to be 25 to 50 years. The IRRI stores over a thousand lines or varieties of rice and is a resource from which the world's rice scientists can draw upon to develop new rice in keeping with demands for better rice strains.

In up-to-date seed-storage laboratories all over the world, computerised systems have been developed for keeping track of the vast number of seed collections in storage, distribution and rejuvenation.

Bean seeds stored in sealed cans in a seed bank.

Unfortunately, not many countries are keen or able to maintain seed banks. A regional bank run by an international body is the next best alternative. For research institutes or universities where plant breeding is conducted, small cold seed stores are good enough for storing breeder's seeds.

**Conservation of recalcitrant species**

For recalcitrant seeds, no method is yet available to store seeds for more than a year. Many can only remain viable for a month under the best conditions. For such seeds, which include rubber, cocoa and Dipterocarps the only storage method possible is to maintain living plants in an arboretum or botanical garden. This method requires a large area of land.

Recently Normah *et al.* (1986) has shown the possibility of cryopreservation of *Hevea* embryos in liquid nitrogen at -196°C. Embryos stored in this way in cryo-tanks are said to be cryopreserved, and they may, in this state, remain viable indefinitely. This method does not require electricity and does not involve heavy capital investment and maintenance. Cryogenic storage can be applied to orthodox as well as recalcitrant species.

**Trends in seed banking**

Seed banks differ a lot in size and complexity. The simplest ones store seeds for short term, under room temperature or under normal air conditioning temperature of 20°C. At a higher level of complexity are the cold rooms for long term storage at -20°C. There is a unique one in the Science City of Japan in Tsukuba that is equipped with robots, storing not only seeds but also microorganisms and sperms in cold rooms at -20°C. The National Seed Storage Laboratory (NSSL) at Fort Collins, Colorado USA has a capacity of 400,000 samples. A new Millennium Seed Bank has been established in Kew Gardens, UK.

The Svalbard Global Seed Vault, established in 2008 in Norway's remote Svalbard archipelago, within the Arctic Circle, has the capacity to store 4 to 5 million seed samples. It has been built to survive rising sea levels, power outages, and other calamities. Seeds are stored well below freezing. Storing seeds from all over the world Svalbard has been called the Global Doomsday seed vault.

**Seeds for the future**

Miracle plants and seeds have been produced in the last two decades in wheat and rice. These plants are not only high yielding but also high in seed quality and nutrition. We look forward to miracle species in other food crops. For example, many in the third world suffer from chronic protein malnutrition which could be overcome by producing plants with very high protein content. Similarly, plants can and have been bred for tolerance to drought, high salt, low soil nitrogen and extreme temperature. Investigations on the content of amino acids, proteins, alkaloids, salts, starches and enzymes are being conducted. From the biochemical profile of a plant, together with its performance record, the plant breeder is able to judge whether its germplasm is what he needs to develop a new plant with genetic capability that thus far exists only in his mind. Nowadays in germplasm collection, all such details are computerized and one can at short notice pick up a desirable line for crossing. With advances in technology, gene manipulation has become possible and we may look forward to perfect seeds in which are incorporated all the desirable characteristics required for a super- productive plant.

**Challenges ahead**

In the past 30 years many seed banks have been established all over the world. However some of them have become white elephants as they are not utilized or are left empty due to high cost of maintenance. It is a challenge to establish seed banks and to ensure that they are maintained and utilized properly.

Scientists also face the challenge of having to convince consumers that genetically modified seeds have no harmful effects and are safe to consume.

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