Methods of Conserving Plant Genetic Ressources

Terminologies and Arguments

I. Introduction

In the international treaties such as the Conventions on Biological Diversity (CBD), Agenda 21 and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA, Art. 6.2f) the live conservation (on – farm) is declared as an essential component for sustainable agriculture.

Since the beginning of agriculture about 10,000 years ago, the diversity of plants was the raw material from which agricultural systems could develop. The selection process which was based from the past thousands of years forms the basis for modern high-performance breeds.

Edible plants were collected, domesticated, selected and bred over generations. Today only 12 species of plants and 5 species of animals generate 75 % of the world's food. In total about 150-200 species of plants are used for food. Out of this three species (rice, maize and wheat) contribute 60% of the global calorie and protein intake from plants.

Breeding and agronomic improvements lead to a linear increase of food production worldwide. From 1961 to 2007 the increase was in average 32 million tons per year. About half of this belongs to plant breeding.

Homogeneity of plant varieties - in the spirit of modern farming practices; has a big disadvantage. It leads to the so-called genetic vulnerability, that means susceptibility to diseases, climate and soil transformations; and it can ruin an entire agricultural sector (e.g. potato blights in Ireland during mid-19th century, taros in Samoa 1993).

II. Definitions

The basic conservation methods "in – situ" and "ex – situ" are defined in the International Treaty on Plant Genetic Resources for Food and Agriculture, Article 2 (www.planttreaty.org).

> **Ex – situ** conservation is defined as "the conservation of plant genetic resources for food and agriculture outside their natural habitats"
>
> **In – situ** conservation is "the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and in the case of domesticated or cultivated plant species, in the environment where they have developed their distinctive characteristics."

On – farm conservation is the continuous cultivation, propagation, care and management in the field (or in the garden) of a diverse number of populations by farmers, gardeners, and private locals.

Genebanks: ex – situ conservation
Method for conservation of genetic diversity, usually in the form of seeds (moisture 3-7 %, short- term storage at 5°C , long-term storage at -18 to -20°C). Many seeds of tropical origin cannot be stored at these low temperatures. They lose their fertility.

Cryoconservation (sperm and in vitro): storage under extremely low temperatures (-196°C) in liquid nitrogen. In vitro refers to the conservation „in glass“, that is in cultures. This for example, applies for potatoes and grapes.

DNA conservation
Conservation of DNA sequences (germplasm, tissue) usually for research purposes or restoration of conventional methods.

III. In – situ and ex – situ-convention are complementary

The application of only one conservation strategy always includes a risk. The conservation of plant genetic resources through technical methods has real advantages compared to in – situ / on – farm conservation at their place of breeding. But also the living conservation has several advantages. Therefore, live conservation and gene bank conservation are complementary methods.

The reason for the complementarities of ex – situ and in – situ conservation lies in their main difference: ex – situ means the conservation of genetic material outside its native habitat in which the variety was developed, and it aims to conserve the genetic material, just as it was at the time of its collection. In – situ conservation is a dynamic system in which the plant material changes over time either naturally or developed and modified by human selection processes and will automatically change. Articles 5 and 6 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) include both forms of conservation. A comprehensive protection strategy involves a combination of different conservation measures that aim together to an optimum of sustainable conservation of plant genetic resources

Live conservation in – situ and / or on – farm

Up to now, only about 10 % of the plants were examined for their nutritional or medical potential. Through the live conservation of as many plants as possible we thus obtain **future opportunities** also for medical uses.

A wide diversity is necessary in order to manage the various (agro-) ecosystems adequately and to keep the relevant knowledge, what, where and when can be applied. This knowledge is based on traditional experience as well as on how the plants continuously adapt to their environment. A written documentation can therefore only provide a partial picture of the whole experience-based knowledge. But without documentation, this part of knowledge is faster lost than the seed or breed itself.

Planting and growing, propagation and cultivation were carried out since the beginning of agriculture by the farmers. Thus, the live conservation of plant genetic resources can be seen as the "prototype" of conservation and the development of varieties. The conservation of diversity through **agricultural practices** includes seed production and distribution systems, as well as the management itself and its relation with the natural environment.

No organism exists independent in the environment. **Interactions** with the living environment are essential for survival. These interactions can be difficult to track in the gene bank (for example, seed formation and dissemination mechanisms, depending on nitrogen- soil bacteria, fungal symbioses, compatibility with other types).

The **evolutionary adaptation** of varieties cannot be done in gene banks and laboratories. This adaptation to changing environmental conditions is very complex and until today, not conclusively studied.

IV. Advantages and Disadvantages of the Methods

Advantages Ex – situ

Cryoconservation (sperm, in vitro)

- Needs little space
- Conservation of an endangered gene pool independent of the environment
- Representative samples can cover a wide range of the gene pool
- Scientific exchange and comparison are simple
- Evaluation and documentation of the material is possible
- No exposure to pests, disease and other danger
- Almost stable (with appropriate maintenance)
- Expenses are calculable and transparent

DNA-Conservation

- needs the least amount of space
- Sequential conservation is possible
- Suitable back-up security for conventional methods, for reproduction material which cannot be stored easily (for example, cold sensitivity)

Advantages In – situ

- No storage problems with sensitive seeds
- Allows continuous development and improvement through exposure to pests, diseases, and other environmental factors
- Provides indirect advantages such as ecosystem support
- Sustainable conservation and breeding through local people
- Universal applicable: requires no high-tech facilities and laboratories

Disadvantages Ex – situ

Cryopreservation (seeds, in Vitro)

- Needs appropriate technical and spatial conditions (sterile, germ-free environment)
- Needs trained staff
- Energy consuming
- Not suitable for all kinds of seeds / propagating material
- Needs appropriate protocols (unified guidelines how storage should be done)
- **Most significant disadvantage of in vitro conservation: Possible genetic instability through the cultivation process**

DNA-Conservation

- Needs advanced technology
- Needs specially trained staff
- Energy consuming
- Needs unified guidelines (protocols)
- **The current technology doesn't allow the restoration of the original plant.**

Disadvantage In – situ

- Needs space
- Limited coverage of the genetic diversity in one place
- Susceptible to diseases
- Susceptible to bad environment conditions (climate)
- Access can be difficult when no acquisition and registration follows
- Conflicts with landowners, property owners are possible
- Conservation can be very expensive if it is not supported by the informal sector

Literatur

Bellon, M. R., Pham, J. L. and Jackson, M. T. 1997. "Genetic Conservation: a Role for Rice Farmers", in Maxted, N., Ford-Lloyd, B.V. and Hawkes, J.G., Plant Conservation: the In – situ Approach

FAO. 2010. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture. Available at: http://www.fao.org/docrep/013/i1500e/i1500e.pdf (accessed 25 July 2016).

FAO/IPGRI. 1994. Genebank Standards. Available at: ftp://ftp.fao.org/docrep/fao/meeting/015/aj680e.pdf (accessed 25 July 2016).

FAO, 2012. What is Conservation and Sustainable Use? The Provisions of Articles 5 and 6 of the International Treaty, Available at: http://www.fao.org/3/a-i2579e/i2579e01.pdf (accessed 26 July 2016).

FAO, 2012. Conservation and Sustainable Use under the International Treaty. ISBN 978-92-5-107134-2 Available at: http://www.fao.org/3/a-i2579e (accessed 26 July 2016)

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