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Integrating *Ex situ* and On-farm Conservation Approaches in the Management of Local Vegetable Diversity in Austria

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Abstract

Traditional on-farm management of plant genetic resources (PGR) has almost disappeared in developed countries. PGR of local origin is limited to gene banks. In rare cases relicts of landraces have persisted on-farm. In contrast interest in “old varieties” has grown over the past 15 years. Increased demand for vegetables in various market niches has paved the way for a revival of landraces and “heirloom varieties”. However, many local PGR were developed for subsistence farming and will perform best in small-scale settings (i.e. in gardens). Therefore, exclusively targeting the commercial sector as a carrier for on-farm management will not suffice. The Austrian NGO “Arche Noah” pursues both *ex situ* and on-farm conservation strategies. 360 accessions from the Arche Noah Gene Bank have been identified as PGR of particular relevance for Austria. *Ex situ* conservation strives to maintain a maximum of original genotypic diversity in these accessions. Long-term storage and technical minimum standards form a well established framework for regeneration in gene banks. A current project aims to establish gene bank accessions in gardens and on farms to allow for further adaptation and diversification. The project is based on a Seed Network of approximately 400 people, comprising both farmers and amateur gardeners. 151 gene bank accessions were selected for potential on-farm management based on a set of criteria (regionality, usability, status of conservation). The selection can be expanded by network participants on the basis of the selection criteria. By the end of 2007, 52 people were cooperating on the project, which currently encompasses 89 different vegetable varieties. Additional measures include training, counseling and regular meetings to exchange experiences. Various aspects of the project, such as varietal identity, seed quality and regularity of regeneration, continue to be monitored. A good working atmosphere is created by personal contact and incentives.

INTRODUCTION

In the debate on the management of plant genetic resources (PGR) it is often emphasized that *ex situ* and *on-farm* conservation strategies must be considered as complementary rather than competitive in safeguarding crop genetic diversity (Piergiovanni, 1999). Each method has its strengths and weaknesses. *Ex situ* collections (gene banks, botanical gardens, breeding collections) can preserve germplasm of a wide range of crop species for decades independent of their respective status of cultivation and utilisation in the field. A gene bank provides a centralised collection for research and breeding. In the long run, it faces the problem that diversity tends to decline and the collection turns antiquated because the material is excluded from the process of co-evolution (Hawkws et al., 2000). On-farm conservation requires a certain demand or incentive on behalf of the farmer or gardener to cultivate and utilise rare or endangered crops. Socio-economic factors determine whether or not and on what scale a variety is cultivated (Jarvis et al., 2000). This method is decentralised and potentially includes a wide range of people making a monitoring difficult and adding imponderables as to the long-term effects of the activities.

Concepts for effective on-farm conservation strategies are often oriented towards traditional agricultural systems in developing countries where agro-biodiversity is still important in subsistence agriculture (Maxted et al., 2002. Jarvis et al., 2004.). The situation in industrialized countries is different. On-farm cultivation of traditional crop varieties has almost entirely disappeared. Market-oriented agriculture prevails and uses modern, high-yielding varieties. Traditional varieties are sporadically found in home gardens, grown for private consumption, or on farms that sell produce directly to consumers, retailers or restaurants. Structural change in agriculture has been so profound that efforts of maintaining crops on-farm were considered impractical (Zeven 1996).

However, in recent years, traditional varieties and biodiversity products have received increased attention, both from consumers and farmers. In some cases, crops have become scarce that make up traditional meals. The revival trend is also due to a wide-spread perception that the market is increasingly limited to highly standardised, uniform products that do not always fulfil consumers' expectations (taste, processing quality). The diversification trend has opened new possibilities for the cultivation of PGR in industrialised countries.

The current article describes an approach in which *ex situ* and on-farm strategies are combined. The aim is to establish PGR of vegetables in gardens and on farms. Activities are organised in the framework of the NGO "Arche Noah" that performs as a platform for farmers and amateur gardeners interested in the utilisation of traditional and rare crops.

RESULTS

Since 1990, the Austrian NGO “Arche Noah” is active in the conservation, dissemination and development of PGR. It was founded by farmers and gardeners who were concerned by the unabated loss of traditional varieties and the increasing preponderance of F1-hybrids in many agricultural and horticultural crops. Promoting the collection and active utilisation of PGR is the heart of the organisation’s activities.

1. Ex situ Management: the Gene Bank.

The concept of the the Arche Noah Gene Bank (“seed archive”) is that of a non-profit institution that maintains genetic resources and makes its holdings accessible to as many potential users as possible. The primary motivation was to collect varieties on the verge of extinction (landraces, obsolete cultivars), but also to explore, demonstrate and give access to a wider range of varieties and crop species than were so far available in Austria.

The collection currently comprises approx. 5.700 accessions of horticultural and agricultural species that have been characterised and regenerated over a period of 15 years. The management is based on technical standards of gene bank management (storage in deep freezers, minimum regeneration intervals, germination tests). Gene bank staff also periodically monitors availability of non-hybrid cultivars in the EU catalogue of varieties to see whether cultivars relevant to Austria will be withdrawn and thus disappear from the public domain.

Recently the collection underwent an examination based on a set of conservation priorities. The aim is to differentiate between PGR that is of particular importance for the region and PGR that is maintained for other purposes (research, reference material, education). Approximately 360 vegetable varieties from Austria and Central Europe have been identified as pivotal for Arche Noah’s conservation efforts. Another 500 accessions were estimated potentially valuable, but needing further evaluation and characterisation. 151 accessions have been selected and considered promising for on-farm conservation. Accessions for on-farm conservation meet several (but not all!) criteria summarised in Table 1. The criteria take into account objectives of PGR conservation, potential benefits for users and practical considerations of project monitoring.

2. On-farm Management: The Seed Network.

Arche Noah focuses its activities on Austria, though a part of the Network extends to Germany and other countries. The Seed Network comprises growers of PGR, in total approximately 400 people. They are either farmers or amateur gardeners. All participants are members of the organisation. The common aim is to grow, utilise and exchange crops – in particular rare crops and crop varieties. Some growers actively collected material *in situ*, some obtained material for evaluation from public gene banks (e.g. IPK Gatersleben). Of course, most seed growers have also adopted material from the Arche Noah Gene Bank and grow it in their gardens or on their farms.

The Network includes formal and informal interaction. Informal interaction occurs through personal contact between Network participants based on common interests that often exceed the narrow field of PGR utilisation. In some cases regional initiatives have emerged. People organise events (plant fairs) or garden groups on a regular basis. The Arche Noah main office does not play a steering role in these activities. It contributes when input is requested, but the initiatives act independently as to where, how, and what should be treated. Apart from this there are more formal elements for cooperation in which seed growers may participate. These activities are designed according to certain principles to ensure that the work is implemented in an orderly manner and include cooperation with the Arche Noah Gene Bank.

Seed Savers and The Seed Handbook. The Arche Noah Seed Handbook is a central instrument of information on crop varieties within the Network. It is edited and published on an annual basis. It indicates which varieties are available and who offers them, including variety descriptions and personal observations.

To ensure minimum quality standards, a set of criteria define which varieties qualify for inclusion in the register. No varieties are accepted as long as they are still listed in the EU Common Catalogue of Varieties. The variety description must be sufficiently detailed, including basic plant characteristics and information on the origin of the material. Seed savers may not sell seeds or planting material commercially and they must have credibility in propagating the varieties themselves.

Temporary Regeneration Assignments. They include the reproduction of gene bank material for conservation purposes. Seed growers are, thus, functioning as a “branch” of the Gene Bank, supporting *ex situ* conservation activities where help is urgently needed. This can be the case for crop species that make up a proportionally large amount of the collection (e.g. *Phaseolus sp.*, *Lycopersicon esculentum*, *Capsicum sp.*). Sometimes assistance is needed with open-pollinated crops (e.g. *Cucurbita sp.*, *Papaver somniferum*) or crops that are climatically poorly adapted to the location where the Gene Bank usually regenerates its material (e.g. *Pisum sativum*, *Vicia faba*). Seed savers grow the crop for one generation only and subsequently return a certain amount of seeds to the Gene Bank for storage. The person is required to conform to certain gene bank standards such as planting at least a minimum population and keeping minimum distance to other varieties of the same species. Seed growers are given a form to keep track of basic variety traits. If specific and valuable observations on evaluation properties are made (e.g. yield, plant health, utilisation purposes), they are included in the documentation of the Gene Bank.

Seed Guardians. Seed Guardians take care of the regeneration of accessions that are included in the list of target varieties for on-farm conservation. Seed guardianship is designed as a continuous assignment. People grow one or more varieties on a regular basis. These varieties are part of the farming

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system or the garden. Seed Guardians are growing the crops for their own use. They produce seed at regular intervals (e.g. every 3 years). Seed Guardians are encouraged to share their seeds with other people - also outside the Arche Noah Network. As many people as possible should benefit from the seed or from plants derived from this work. Seeds are generally not returned to the Gene Bank. The Seed Guardian project aims to acquire 6 Seed Guardians for each of 100 target varieties over a 3-year period. The option of 6 growers per variety was chosen to allow for exchange of material among the growers in order to maintain the genetic basis. Predefining a list of target varieties for on-farm conservation is intended to draw attention to genetic resources of local importance that carry potentially useful or attractive characteristics. Furthermore it is important to set certain limits to the system to be monitored. Subsequently, it is up to the Seed Guardian to find out, if he or she can make use of it. Usually it takes 1 to 3 years for the growers to do the assessment. Sometimes growing techniques and selection methods must be developed or refined. When a variety proves not suitable for a specific Seed Guardian, it is possible to withdraw from the assignment. However, even in cases of failure, there may be new information available to the Gene Bank that will influence future handling of the variety in the on-farm process. Vice versa it is possible for a seed saver to assign new varieties to the list of target varieties, if they have proven useful, carry significant characteristics and fulfill the criterion of a traditional variety. By the end of 2007, 52 people were cooperating on a regular basis within the project, which currently encompasses 89 vegetable varieties from 27 different crop species. 81% of the participants are amateur gardeners, 19% farmers.

3. The role of the Arche Noah Gene Bank in the Seed Network.

The Gene Bank performs multiple tasks at the interface of *ex situ* and on-farm conservation. It regularly supplies PGR directly to seed savers – via the Seed Guardian project or via the Seed Handbook - providing new input to the Seed Network. Primary characterisation and documentation of origin (passport data) provide the basic datasets on the varieties in the Gene Bank. Historical research and comparison to commercial varieties generate new insights on the frequency of certain genetic material. Gene bank documentation, thus, is often used for reference when “new” material emerges. Furthermore, the Gene Bank edits the Seed Handbook and monitors the conservation status among Seed Guardians on an annual basis.

4. Motivation of Network Participants.

Seed Guardianship is a voluntary assignment. Getting actively involved as a Seed Guardian, thus, requires a high level of motivation. Moreover, the commitment should be permanent to sustain conservation efforts in the long term. Motives for joining the project are manifold (Tab. 2). Diverse motives and diverse interests are a vital basis for a wide range of vegetable varieties to be maintained.

5. Capacity Building.

Establishing sound knowledge of seed production is one of the objectives of Arche Noah's mission. It forms the basis for any on-farm activity, particularly in industrialized countries where traditional practices of seed saving have been lost. Arche Noah offers an 8-day course that provides participants with the basic knowledge of how to regenerate crops true-to-seed. The course is open to non-members and is, thus, an entrance point for new participants to join the Network. Approximately 180 people have so far completed the course indicating the demand for capacity building in this field on this subject.

Regular meetings and field days are another important way to spread information and stimulate communication. Each year 4 to 5 meetings are held in varying parts of Austria. They include garden visits, discussions and demonstrations of varieties and seed saving techniques, food processing and utilisation issues. At the meetings personal contact to seed growers is established.

6. Sustainability and Monitoring.

Concern is sometimes raised about the sustainability of on-farm management schemes. There are doubts that the integrity of varietal identity can be assured. Varieties could get mixed up or cross with other varieties during cultivation. Also, there is concern that cultivation would not be permanent.

The "social factor" is crucial in any human activity, and therefore also in the cultivation of crops. Fluctuations in the involvement of persons in regeneration activities can be expected. However, there are certain factors that contribute to quality control and enhance mutual reliability.

A Seed Guardian

- has a vital interest in utilising a variety and therefore cares for its maintenance.
- strongly identifies with the project aims (special interest group).
- is subject to a certain level of social control within the Network (personal contacts, seed exchange).
- will share a variety with other people (friends, neighbours, network participants) inducing a multiplier effect.
- can be succeeded by new Guardians, once a variety has been given up for a specific location.

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The Gene Bank

- keeps backup samples of a variety for ex situ conservation.
- monitors the conservation status with Seed Guardians.
- controls integrity of a certain variety based on documentation data provided.

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Monitoring tasks are performed by the Gene Bank and cover two aspects of conservation.

Status of on-farm conservation. Seed Guardians are contacted on an annual basis to check the conservation status of the varieties. Background information on each Seed Guardian is processed in a database. Further records include which varieties are grown, when a variety has last been regenerated, observations on the variety and selection procedures. Individual communication with the seed saver is also recorded.

Genetic identity of the variety. In periodic intervals Seed Guardians return variety descriptions, photos and seed samples to the Gene Bank for comparison. When new information on a variety has been collected, the existing documentation is amended. Some target varieties for on-farm conservation have been chosen on the basis of characteristic traits that facilitate identification and monitoring. Garden visits are also a means to form an impression of conservation practices and status. However, these can only be implemented on a case-by-case basis.

7. Selected Issues Regarding PGR Management in the Seed Guardian Project.

The transfer of seeds from the Gene Bank to Seed Guardians is essentially a process of re-introduction of PGR (Figure 1). Varieties are not necessarily grown in the locations where they originated. This has pragmatic reasons: the most important issue is that the variety is cultivated at all and that it meets the needs of a grower. However, cultivating a variety under different agro-environmental conditions also facilitates a further differentiation of the genetic material, particularly in outbreeding crops that contain a certain level of genetic heterogeneity.

The Seed Guardian project strives to provide a framework for cooperation with amateur gardeners in the maintenance of traditional varieties. Many accessions from gene banks will not perform well in current mainstream agriculture because they do not meet requirements as to yield, disease resistance and/ or marketing standards. Amateur gardens are suitable environments for cultivating such “obsolete” varieties as long as they are of value for the grower. Via the Seed Network some varieties have acquired popularity among amateur gardeners, such as the Moravian cucumber landrace “Znojmia” that was obtained via the gene bank in Gatersleben, Germany.

Objections to PGR management in gardens concern the limited space available for planting. Small plant populations increase the risk of genetic drift and inbreeding depression. Introgression may occur between different varieties of the same species. Tackling such questions and finding solutions in practice is a continuous effort in the Seed Guardian project. Generally, minimum population sizes and distances to other varieties are recommended for regeneration. Seed Guardians are encouraged to exchange seeds with each other to avoid inbreeding depression. Another recommended practice is to keep seed from previous generations and use them in later regeneration cycles. For a broad bean variety - *Vicia faba* “Pinzgauer Saubohne” - a

collective management strategy has been implemented in which a group of gardeners from a region are pooling their seeds.

As for potential introgression, the aim of the Seed Guardian Project is to keep the typical traits of a variety. Hence, Seed Guardians are encouraged to familiarize themselves with the most important variety traits and document them. Preventing introgression from other crops is particularly important in outbreeding crops (e.g. cucurbits, maize) when conservation of certain varieties is pursued. However, it is acknowledged that introgression in gardens can create new variability, and, therefore, constitutes an important benefit of on-farm management. This is demonstrated by an example from the Seed Guardian project that has yielded a vining form of bush-bean landrace “Rotholzer” that is now appreciated by gardeners because of better yields.

DISCUSSION

The present article describes a network oriented approach in managing PGR of vegetables on farms and in gardens. The Network consists of qualified seed growers (amateur gardeners or farmers) that cooperate on a voluntary basis. They generally grow and regenerate PGR for their own use and exchange material with other network participants. This approach is different from strategies that are based on instructing and paying maintainer farmers to regenerate crop varieties for *ex situ* conservation purposes (Zeven, 1996. Arsia, 2006.).

The network management applies three methods to facilitate on-farm management of rare varieties (Seed Handbook, Seed Guardian project, temporary regeneration assignments). These methods all imply - to varying degrees – monitoring, characterisation and evaluation of varieties and improve access to PGR. Capacity building in seed saving is considered crucial because this know-how has been lost in industrialised countries – along with traditional PGR. Apart from training in seed saving techniques, it is important to convey attitudes of observation and experimentation. A prerequisite for the re-establishment of varieties is the development of appropriate cultivation methods and food processing techniques to ensure that the potential of a variety is recognised and exploited.

Ex situ and on-farm management methods are considered complementary. The Gene Bank provides long-term backup of seed samples of PGR, documentation of varieties and background information on the conservation status. The Gene Bank also mediates between current (or previous) growers of varieties and potential new users, bridging the gap where the direct transfer on the regional level or between family generations is discontinued. By supporting on-farm conservation the vision of an integrated gene bank is followed (Hammer 2003).

In the specific case of the Seed Guardian Project, an attempt is being made to re-establish valuable PGR in gardens and on farms. Varieties are adopted with a long-term perspective. Many participants used to grow commercial varieties and did de-facto seed saving. These varieties have now been replaced by traditional landraces or obsolete cultivars. The project is driven by the pleasure that people find in growing unique and rare varieties and by their willingness to actively contribute to the loss of crop biodiversity. Establishing 100 varieties with 6 Seed Guardians each, is a clear goal with which participants can identify. This vision motivates new participants to join the project. It also focuses the conservation and evaluation efforts of the Gene Bank. Growers can contribute valuable information regarding utilisation, ecological adaptation of certain varieties and appropriate cultivation methods to be applied. This adds information to the documentation of the varieties that could not be generated during *ex situ* regeneration. All this serves to promote practical use of PGR.

Currently, the Seed Guardian project favours “conservative” maintenance breeding of varieties. Selection for desired traits is allowed within the given variability of the variety. Care should be taken that the varietal identity is preserved. This is particularly important for outbreeding varieties. However, it is acknowledged that hybridisation is an important source for new

variation. Traditional varieties are often heterogeneous, consisting of multiple lines. Hybridisation can even counteract the narrowing of the genetic basis in small populations (Zeven, 2002). It will be a subject for future work within the Seed Network to balance maintenance breeding and dynamic management of PGR and develop examples of good practice.

The large proportion of amateur gardeners within the Seed Guardian project is not a coincidence. In fact, the project was designed to enhance involvement of hobbyists in on-farm conservation. Several measures within the Seed Network (online forum, seed handbook, articles in magazines) are designed to make private activities visible to the broad public. Engaging amateur gardeners in PGR conservation corresponds to the importance that traditional varieties have for private consumption and subsistence agriculture (Brush and Meng, 1998. Negri, 2003). Home gardens are considered particularly important for the conservation of vegetables and herbs (Esquivel, 1992. Becker, 2000).

Arche Noah is also engaged in other activities such as promoting the marketing of rare varieties (e.g. in cooperation with the organisation „Slow Food”), cooperation with breeders in the marketing of seeds of “Conservation Varieties”, complementing the spectrum of on-farm conservation efforts. It is assumed that the diverse range of measures and participants engaged in these activities is essential to promote conservation and development of crop genetic diversity (Hammer et al., 2003).

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Tables

Table 1. Selection criteria for varieties in the on-farm management project.

PGR conservation	User benefits	Project monitoring	
▪ Landraces and obsolete cultivars	▪ Species diversity	▪ Easy to identify (characteristic traits)	Formatiert: Nummerierung und Aufzählungszeichen
▪ Under-utilised crop species	▪ Utilisation in home gardens	▪ Distinct from mainstream varieties	Formatiert: Nummerierung und Aufzählungszeichen
▪ Varieties from Austria or adjacent regions	▪ Regional identity		Formatiert: Nummerierung und Aufzählungszeichen
▪ Varieties not included in other gene banks	▪ Outstanding traits		Formatiert: Nummerierung und Aufzählungszeichen

Table 2. Motives for participation in the Seed Network.

▪ Continue traditions of seed growing or food processing
▪ Self-sufficiency from healthy, tasty food
▪ Enthusiasm for crop diversity (“collecting”)
▪ Pleasure in crop experimentation
▪ Improved chances for marketing
▪ Independence from expensive seed (F1-hybrids)
▪ Independence from a fluctuating seed market
▪ Ensure availability of a variety
▪ Guarantee GMO-free seed
▪ Service to society and the public good

Figures

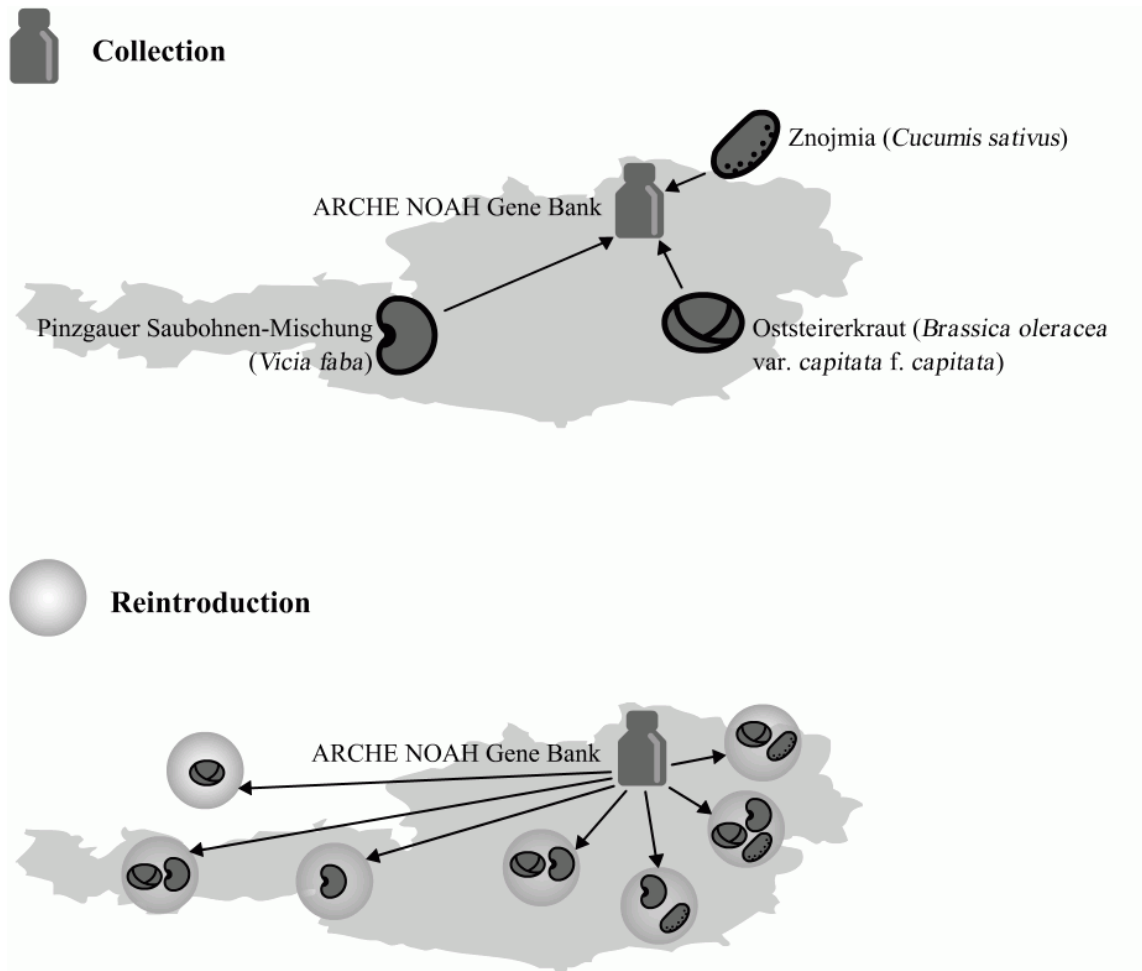


Figure 1: Examples for collection and reintroduction of varieties.