Seed systems and crop genetic diversity on-farm

Proceedings of a Workshop, 16–20 September 2003, Pucallpa, Peru

Devra I. Jarvis, Ricardo Sevilla-Panizo, José Luis Chávez-Servia, and Toby Hodgkin, editors
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IPGRI
Via dei Tre Denari, 472/a
00057 Maccarese (Fiumicino)
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Dedication

These proceedings are dedicated to Dr. Alfredo Riesco de la Vega, National Project Coordinator of the Peru Country Component, and national focal point for economic aspects of the global project, “Strengthening the Scientific Basis of In Situ Conservation of Agricultural Biodiversity” and whose enthusiastic support helped to achieve the results presented here.

Estos resúmenes están dedicados al Dr. Alfredo Riesco de la Vega, Coordinador Nacional del Proyecto en Perú, y punto focal nacional para los aspectos económicos del proyecto global “Fortalecimiento de las Bases Científicas para la Conservación In Situ de la Biodiversidad Agrícola”, y cuyo apoyo entusiasta ha permitido obtener los resultados aquí presentados.
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Foreword

Alfredo Riesco
Consortium for Sustainable Development of Ucayali (CODESU), Lima, Peru

IPGRI organized the workshop “Seed Systems and Crop Genetic Diversity On-farm”, under the framework of the Global Project Strengthening the scientific basis of in situ conservation of agrobiodiversity on-farm. The meeting was held in Pucallpa, Peru, a city of 300,000 inhabitants located in the lowlands of the Amazon Basin east of the Andes. Pucallpa is a fast-growing city and is the endpoint of the road that runs from Lima, located at the Pacific Ocean, through the Andes to the Amazon rain forest. Within the region, most of the transportation, communications and trade are made by navigable rivers. The selection of Pucallpa for hosting the meeting has a special social, economic and cultural significance for seed systems and in situ conservation of agricultural biodiversity, because of the following:

- The Peruvian Central Amazon is one of the regions where biodiversity is most threatened by fast population and market growth;
- There are 240 indigenous communities in this region, which belong to 12 Amazonian ethnic groups, with different patterns of consumption and different systems of production;
- Pucallpa has been declared a “focal point” in the Peruvian strategy for conservation and sustainable use of biodiversity by the National Council on Environment (CONAM);
- A very active inter-institutional working relationship is concerned with management and conservation of natural resources, with participation of members of the CGIAR.

IPGRI has been working in Pucallpa since 1999, with CODESU, an organization comprised of 17 institutions in the region, and the National Agricultural Research Institute (INIA). IPGRI’s activities in the region have been devoted mainly to the In situ Conservation Project, with strong efforts devoted to understanding farming decision-making processes that influence in situ conservation; strengthening national and local institutions for planning and implementation of conservation programmes for agricultural biodiversity, and broadening the use of biodiversity by farming communities.

The workshop was attended by participants from 19 countries and 5 continents. Following presentations and discussion sessions, one day was devoted to a field visit to Nuevo Paraiso, a representative Shipibo¹ community 3 hours upstream from Pucallpa on the Ucayali River. Nuevo Paraiso is one of the 60 communities participating in the In situ Conservation Project – Peru Component.

The workshop papers presented in this volume are focused on four areas: Diagnostics and descriptions of seed systems (Session I); Factors affecting seed systems (Session II); Genetic diversity consequences of seed systems (Session III), and Interventions and scaling up (Session IV). This volume also reports a summary of the discussion sessions and concludes with proposed future directions for seed systems in relation to on-farm conservation of genetic diversity.

This international workshop was brought about by the creativity and efforts of IPGRI staff, coordinated by Devra Jarvis, with the collaboration of local institutions like CODESU and INIA. The many users of this volume will also, I am sure, appreciate very much the work done by the authors of the papers and by the editors.

¹ The Shipibo along with the Ashaninka are the most important indigenous ethnic groups in the Peruvian Central Amazon, in terms of population size.
Introduction

Seed systems and the maintenance of diversity on-farm: Introductory remarks

*Toby Hodgkin and Devra Jarvis*
*International Plant Genetic Resources Institute, Rome, Italy*

**Introduction**

The various processes involved in seed provision, selection and storage can be considered as constituting a system (McGuire 2001). In fact, the concept of a seed system is usually taken to include not only the processes but also the components themselves and descriptions, analyses and interventions often focus as much on the actors (farmers and institutions) and the components (different types of planting material) as on the processes. In this introductory paper we discuss some of the different descriptions or definitions of seed systems, the ways in which seed systems can be investigated and analyzed, their operation, and their importance in the maintenance of traditional crop varieties in production.

Discussions of seed systems commonly treat “seed” as shorthand for any form of planting material including vegetative materials such as tubers, offsets or bulbs as well as seeds. In fact, most of the published information on seed systems deals with major cereal or legume crops, although Second and Iglesias (2001) provide interesting information on supply of cassava planting materials in Brazil, and Valdivia and colleagues report on Andean roots and tubers in Session I of this book. In developing countries provision of seed is nearly always through informal supply systems. Local farmers maintain and exchange seed or obtain them from neighbouring communities or markets. The system is largely independent of government institutions and the materials seldom come from formal sector institutions and private breeding companies or seed houses.

Much of the work on seed systems has come from those interested in provision of seed aid following drought, war, floods or other disasters. In these situations it is generally supposed that traditional seed systems are likely to break down and farmers will be unable to obtain the seeds they need. Seed aid, often in large amounts, using varieties developed for different environments, is frequently supplied to deal with the presumed seed deficit. This has caused concern in that it is felt that the wrong varieties are supplied, which may require high inputs, and do not meet the needs of resource-poor farmers seeking to deal with post-disaster production problems (e.g. Richards and Ruivenkamp 1997; Sperling 1997).

**Definitions and descriptions**

Descriptions or definitions of seed systems are usually concerned with their dynamic properties rather than with the elements themselves. Thus, as noted above, McGuire (2001) talks in terms of the processes involved in seed provision and ICRISAT (2002) describes seed systems as “the ways in which farmers produce, select, save and acquire seeds.” Similarly, Almekinders and colleagues (1994) discuss seed systems in terms of the flows of seed and other planting materials through the production system and the roles of both formal and informal sector institutions and farmers in these flows.

These descriptions probably reflect, to a large extent, the concerns of those working on the question of whether the local or national seed systems are functioning sufficiently well to allow farmers to obtain the seeds they want. Those concerned with on-farm maintenance of diversity will have a much stronger concern with what materials (especially what local traditional varieties) are present in the seed system and in what amounts. We would also want to include in any description of a seed system some discussion of who maintains the different materials and the processes of
exchange, and would seek to relate this, in some way, to the different varieties present in the system, their characteristics and roles in production.

**Investigating and analyzing seed systems**

Given that we are likely to be as interested in the components of a seed system as in the processes, a preliminary checklist of major concerns might include:

- What materials are present in the seed system and in what amounts?
- Where do they come from?
- How are they maintained and by whom?
- How are they made available to farmers in the community?

Weltzien and vom Brocke (2001) provided a useful framework for investigating seed systems by focusing on the function of a seed system. They suggested that seed systems have to fulfil a series of functions so that healthy, viable seed of the preferred variety is available to farmers, at the right time, under reasonable conditions and in ways that ensure that land and labour resources can be used optimally. This leads them to provide an analysis framework that is concerned with:

- The germplasm base - the varieties in the system, their characteristics, the selection processes involved in their maintenance, the extent of their cultivation, and the processes involved in introducing new materials;
- Seed production and quality - the production and maintenance of good-quality seed, seed production practices, storage procedures, and preparation for sowing;
- Seed availability and distribution - ways of accessing seed, the extent to which farmers save, exchange or purchase seed, market systems and government involvement;
- The knowledge and information available - the ways in which knowledge of materials and practices is maintained and made available, obtaining and disseminating new knowledge of new materials.

It is important to spend some time thinking about what analysis frameworks or approaches are going to be most relevant from the diversity maintenance perspective. Seed systems are extremely diverse in respect of almost all the elements noted above. Some depend almost entirely on continual flows of known varieties from a single external source of supply (e.g. cassava in Brazil). Others are largely self-sustaining with most seed maintained by farmers themselves and rather little exchange (e.g. *Phaseolus lunatus* in Cuban home gardens, Session III) Still others are open dynamic systems with constant exchange and opportunities for introduction of new materials and traits as in the case of maize in México (Louette et al. 1997; Session III, this volume).

In many cases, the processes of maintenance and distribution and the people involved will not only be crop specific, they may well be variety specific, depending on the importance of the variety, and its characteristics and function within production systems. There may even be differences in the ways that different communities maintain and distribute the same variety.

As in all work on maintenance of diversity in farming systems it is important that, whatever framework of analysis is used, there is a strongly multidisciplinary approach and a commitment to participatory practices. Information is needed not only on the social and cultural practices and procedures and the mechanical aspects of identities and amounts, it is also needed on agronomic practices and agroecological aspects. The genetic data need to be able to confirm variety identity and differences between varieties, to provide estimates of numbers of types, evenness and difference (see Brown, Session III), and to allow some exploration of within-variety and between-variety geneflow. The papers in the rest of this volume provide some preliminary descriptions in many of these areas and show how information from different disciplines and areas of study can be combined.

**Stress in seed systems**

Farmers in many developing countries are often unable to obtain healthy viable seed of preferred varieties at the time and under the conditions that are best for them. In this sense, many seed systems are often functioning imperfectly and McGuire (2001) described this in terms of the health of the seed
system and whether particular systems are under stress. McGuire was using a ecological approach and drawing parallels with healthy ecosystems and those that are under stress. He identified two kinds of stress: acute, following major disasters such as floods or war, and chronic, where farmers (particularly the poorest) can access the varieties or amounts of seed that they want. This latter, it has been suggested, is common in many parts of the developing world.

Continuing the parallel with ecosystem health, it is possible to identify properties that would be characteristic of a healthy seed system. These might include:

- Stability - acceptable production and yields over a range of different circumstances and situations;
- Resilience - the ability to return to a pre-existing level of function after acute disruption;
- Diversity - the presence of a wide enough range of different varieties;
- Efficiency - an acceptable level of production in relation to inputs by producers;
- Equity - access to the necessary inputs by farmers in the system.

The analogy is attractive but further investigations are needed of seed system function to identify the most important factors that contribute to effective function, and to determine how they relate to the ecosystem characteristics noted above.

During an international meeting in Uganda in 2000 (Sperling 2001) the ideas of health and stress in seed systems were used to develop a series of indicators of stress which are likely to be generally useful in the context of on-farm maintenance of diversity. These included:

- Changes in patterns of access to seed materials by farmers;
- Changes in variety and quality of seed in the area;
- Increased use of sub-optimal varieties;
- Lack of stored seed where it is normally maintained;
- Increases in seed prices in local markets;
- Lack of labour leading to unplanted and untilled fields.

Any of these are likely to indicate changes in the identity and amounts of the varieties being grown in an area and therefore are important indicators of changes in patterns of on-farm conservation. We may want to explore both the general idea of developing indicators of this type for on-farm conservation and the specifics of what such indicators might be.

**Seed systems and conservation**

Clearly, understanding the nature and operation of seed systems is central to effective support for maintenance of diversity on-farm. Analysis of the seed system can provide essential information on population sizes of varieties, on local management and exchange practices, on the relative importance of individual farmer maintenance as against seed flow and market factors, as well as many other aspects. The following issues have been the focus of the papers presented and resulting discussions of this meeting:

- How can we relate knowledge of processes and flows to information on extent and distribution of genetic diversity, amount of geneflow, population size and the other genetic characteristics that we need to understand to support conservation decisions?
- Seed systems are essentially dynamic processes while much of the work to date has necessarily been concerned with descriptions of situations at a single point in time. How can we relate best studies of process to descriptions of state?
- Is the seed system health approach useful in the context of on-farm diversity management and how can we best adopt and develop it?
- What characteristics of seed systems work to support maintenance of diversity and what features tend to limit diversity maintenance?
- How can seed system function be supported in ways that optimize the maintenance of diversity within the seed systems? What might be beneficial interventions and what might limit diversity maintenance and use?
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Almekinders CJM, Louwaars NP and de Bruijn GH. 1994. Local seed systems and their importance for an improved seed supply in developing countries. Euphytica 78:207–216.


Mayan home gardens: sites for *in situ* conservation of agricultural diversity

Juan J. Jiménez-Osornio¹, Ma. del Rocío Ruenes Morales¹ and Adrián Aké Gómez²

¹Departamento de Manejo y Conservación de Recursos Naturales Tropicales, Facultad de Medicina Veterinaria y Zootecnia, Universidad Autónoma de Yucatán, Mérida, Yucatán, México
²Facultad de Economía, Universidad Autónoma de Yucatán, Mérida, Yucatán, México

Introduction

The rural production unit in México is the *campesino* family; the most common production systems are the home gardens, the *milpa* and usually there are other production systems which can be agricultural but recently they have become more influenced by and dependent upon urban centres (Figure 1). Of the three subsystems that form the management strategy of rural communities, the home garden is the most intensively utilized one, yet it is the least understood.

The home garden is an area of the natural environment transformed by the inhabitants to establish their living quarters. It can be large or small, depending on the socioeconomic level of the family in the community. The home garden is rich in wild and domesticated plant species, and its structure, defined mainly by perennial species, can be varied and appear to be “disorganized”. It also keeps domestic animals (poultry, pigs, goats, sheep) and wild animals (deer, wild boar and several fowls) in interrelation with the plant species. Home gardens have been a part of the integrated management of natural resources of Mayan communities in the Yucatan Peninsula for millennia.

The home garden is the space where other activities are integrated (use of firewood from the vegetation, preparation of dyes and handicrafts, storage and utilization of crops from the *milpa*, investment or utilization of the wages from outside...
jobs, etc.). There is direct influence of the home garden on the species diversity, management practices, and other factors on the milpa and vegetation, and there may be indirect influence on the processes of the other systems as well, such as nutrient cycling, dynamics of succession, etc. Therefore, the home garden is considered as a biological and socioeconomic buffer for the campesino production system. The integration of the home garden with the other systems can be seen in many examples, and therefore it cannot be studied in isolation. Since it is also the one that has the most human control and input, it may be the most productive (few studies have been done on the productivity and efficiency of home gardens).

Research being conducted by PROTROPICO-FMVZ-UADY has an objective to generate management options to improve the quality of life of rural communities in the Peninsula, based on the woody species characteristic of the Peninsula home gardens, which could provide resilience to the system and be important elements in the design of sustainable agroecosystems.

**Methods**

All publications available on Mayan home gardens were analyzed, with special emphasis on floristic richness. A comparison of tree species reported was made, and according to their frequency (number of home gardens in which a species occurred/total number of home gardens), core species were proposed.

In order to obtain information about production relationships that connect land-use activities to biodiversity, the management relative prices (MRP) proposed by Montgomery et al. (1999) were estimated for twelve of the structural species in the community of Sahcabá, Yucatan. Determination of MRP helps us to know what species obtain high marginal returns for conservation efforts, which is necessary to prioritize these species.

The types of information and assumptions required to construct management prices viability functions for each species, diversity indices that measure the contribution of each species to the benefits associated with biodiversity, and the relative value of biodiversity for society were adapted to this case study. The species replacement index was utilized; additionally, the importance value of species was considered, as well as the index of direct use for the model proposed by Montgomery et al. (1999). Biodiversity value for society was based on product prices of each species and the price given to the ecosystem functions such as biological control and pollination of the species.

**Results**

Many descriptive studies of the Mayan home gardens show the enormous diversity of their flora (Table 1). There is sufficient archaeological and botanic evidence to suggest that floral diversity in home gardens dates back to pre-Hispanic times. There is no common pattern of increase or decrease of diversity in space and time of the home gardens. They contain a large diversity of animal and plant species that can satisfy the needs of the family. The difference in floristic richness of the home gardens also demonstrates the variances of the studies conducted in the region, e.g. one study depicted only 15 species while another study identified 387 plants, which happens to represent one-sixth of the total flora reported for the entire Peninsula. The differences among the studies vary not only in the number of plant species but also in the type of plants identified within the same community; that is, although the studies were conducted within the same community the numbers for the identified plants differed greatly. Such contrasts reflect the duration and season of the study. While some studies only recorded what was present in the home garden at that specific time (Barrera et al. 1977; Stuart 1993), others were conducted throughout the year (Herrera 1992; Ortega 1993).

In the study conducted by Ruenes et al. (1999) it was found that 55% of the plants identified in their survey were tree species. Analysis of all available data revealed that 22 plant species are usually found in the home gardens, with water availability being the limiting factor. These plants are proposed as the founding species that give a characteristic structure to the home gardens (Table 2). Most of these species have multiple uses, yet they appear to be most important for human
Table 1. Floristic richness of Maya home gardens in the Yucatan Peninsula according to studies conducted between 1959 and 2001

<table>
<thead>
<tr>
<th>Locality</th>
<th>State</th>
<th>Author</th>
<th>Floristic richness†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticul, Muna, Oxfutzcab, Valladolid, Tekax</td>
<td>Yucatan</td>
<td>Hernández-X (1959)</td>
<td>50</td>
</tr>
<tr>
<td>Campeche, Bolonchen, Holpchen, Dzibalchen</td>
<td>Campeche</td>
<td>Hernández-X (1959)</td>
<td>50</td>
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<td>Ruins of Cobá</td>
<td>Quintana Roo</td>
<td>Barrera et al. (1977)</td>
<td>15</td>
</tr>
<tr>
<td>Ticul, Oxfutzcab</td>
<td>Yucatan</td>
<td>Smith &amp; Cameron (1977)</td>
<td>19</td>
</tr>
<tr>
<td>Ruins of Cobá</td>
<td>Quintana Roo</td>
<td>Barrera (1980)</td>
<td>91</td>
</tr>
<tr>
<td>Yaxcabá</td>
<td>Yucatan</td>
<td>Vara-Morán (1993)</td>
<td>85</td>
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<td>Southern and Northeastern Yucatan Peninsula</td>
<td>Yucatan</td>
<td>Barrera (1980)</td>
<td>91</td>
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<td>Ruins of Cobá, Macario Gómez</td>
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<td>Villers et al. (1981)</td>
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<td>Yohaltún</td>
<td>Campeche</td>
<td>Rico Gray et al. (1985)</td>
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<td>Yucatan</td>
<td>Sanabria (1985)</td>
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<td>Gómez-Pompa (1986)</td>
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<td>Chonchintoc, Hampolol, Ejido Haro, La Moza</td>
<td>Campeche</td>
<td>Ruénes et al. (1999)</td>
<td>44</td>
</tr>
<tr>
<td>Xcupi, Chuyanxic, Pich</td>
<td>Campeche</td>
<td>Ruénes et al. (1999)</td>
<td>56</td>
</tr>
<tr>
<td>Lechugal, 20 de Nov., Xcumchei</td>
<td>Campeche</td>
<td>Ruénes et al. (1999)</td>
<td>64</td>
</tr>
<tr>
<td>Dzacauchen, Kastamay</td>
<td>Campeche</td>
<td>Ruénes et al. (1999)</td>
<td>76</td>
</tr>
<tr>
<td>Katab</td>
<td>Campeche</td>
<td>Ruénes et al. (1999)</td>
<td>82</td>
</tr>
<tr>
<td>Chac-choben, Los Divorciados, Honzonot</td>
<td>Quintana Roo</td>
<td>Ruénes et al. (1999)</td>
<td>55</td>
</tr>
<tr>
<td>M. Ocampo, Ucum, Fco. Hu May</td>
<td>Quintana Roo</td>
<td>Ruénes et al. (1999)</td>
<td>65</td>
</tr>
<tr>
<td>3 Reyes, Chan-Chen</td>
<td>Quintana Roo</td>
<td>Ruénes et al. (1999)</td>
<td>75</td>
</tr>
<tr>
<td>Kantemoc</td>
<td>Quintana Roo</td>
<td>Ruénes et al. (1999)</td>
<td>89</td>
</tr>
<tr>
<td>Abala</td>
<td>Yucatán</td>
<td>García De Miguel (2000)</td>
<td>96</td>
</tr>
<tr>
<td>Ucu, Tzucacab, Dziuché, Temax</td>
<td>Yucatán</td>
<td>García De Miguel (2000)</td>
<td>75</td>
</tr>
<tr>
<td>Tenabo</td>
<td>Campeche</td>
<td>García De Miguel (2000)</td>
<td>81</td>
</tr>
<tr>
<td>Hampolol</td>
<td>Campeche</td>
<td>García De Miguel (2000)</td>
<td>70</td>
</tr>
</tbody>
</table>

† Number of species.
consumption and on occasion fruits are sold or more often distributed among other members of the community. It is important to mention that recently the composition of home gardens has been affected by government programmes such as the promotion of citrus species that resulted in their abundance throughout the Peninsula.

Table 2. Proposed core plant species of the Mayan home gardens of the Yucatan Peninsula

<table>
<thead>
<tr>
<th>Species</th>
<th>Maya name</th>
<th>Usage</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annona squamosa L.</td>
<td>Ts’almuy</td>
<td>Human consumption</td>
<td>Antillano</td>
</tr>
<tr>
<td>Bixa orellana L.</td>
<td>Ki’wi</td>
<td>Human consumption</td>
<td>Tropical America</td>
</tr>
<tr>
<td>Brosimum alicastrum Sw.</td>
<td>Ox</td>
<td>Fodder</td>
<td>México</td>
</tr>
<tr>
<td>Bursera simaruba Sw.</td>
<td>Chaca</td>
<td>Wood, Fodder</td>
<td>México</td>
</tr>
<tr>
<td>Byrsonima crassifolia (L) H.B.K.</td>
<td>Chi</td>
<td>Human consumption</td>
<td>México</td>
</tr>
<tr>
<td>Carica papaya L.</td>
<td>Put</td>
<td>Human consumption</td>
<td>México &amp; Central America</td>
</tr>
<tr>
<td>Cedrela mexicana (L.) Roem.</td>
<td>Kulché</td>
<td>Wood</td>
<td>México</td>
</tr>
<tr>
<td>Chrysophyllum cainito L.</td>
<td>Chi keejil</td>
<td>Human consumption</td>
<td>Antillano</td>
</tr>
<tr>
<td>Citrus spp.</td>
<td>Kán-pakák</td>
<td>Human consumption</td>
<td>China</td>
</tr>
<tr>
<td>Cnidoscolus chayamansa McVaugh.</td>
<td>Chay</td>
<td>Human consumption</td>
<td>México</td>
</tr>
<tr>
<td>Cocos nucifera L.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cordia dodecandra A.DC.</td>
<td>Chak kóopte</td>
<td>Human consumption; Wood</td>
<td>México</td>
</tr>
<tr>
<td>Ehretia tinifolia L.</td>
<td>Beek</td>
<td>Wood, condiment</td>
<td>México</td>
</tr>
<tr>
<td>Manilkara sapota (L.) van Royen.</td>
<td>Sak-ya’</td>
<td>Human consumption; Wood</td>
<td>México</td>
</tr>
<tr>
<td>Melicoccus bijugatus Jacq.</td>
<td>Huayum</td>
<td>Human consumption</td>
<td>Antillas</td>
</tr>
<tr>
<td>Musa x paradisiaca L.</td>
<td>Ja‘as</td>
<td>Human consumption</td>
<td>Africa</td>
</tr>
<tr>
<td>Plumeria rubra L.</td>
<td>Nicté</td>
<td>Ornamental</td>
<td>Central America</td>
</tr>
<tr>
<td>Pouteria sapota H.E.Moore.</td>
<td>Chi‘iich’ya’</td>
<td>Human consumption</td>
<td>México</td>
</tr>
<tr>
<td>Psidium guajava L.</td>
<td>Chak-pichi</td>
<td>Human consumption</td>
<td>México &amp; Central America</td>
</tr>
<tr>
<td>Sabal yapa (Wright.) Stand.</td>
<td>Bayaxaan</td>
<td>Construction</td>
<td>México</td>
</tr>
<tr>
<td>Spondias purpurea L.</td>
<td>Abal</td>
<td>Human consumption; Fodder</td>
<td>México</td>
</tr>
<tr>
<td>Talisia olivaeformis (H.B.K.) Radlk.</td>
<td>Huayum</td>
<td>Human consumption</td>
<td>México</td>
</tr>
</tbody>
</table>

There are several introduced species—citrus (*Citrus* spp.), banana (*Musa x paradisiaca*) and coconut (*Cocos nucifera*)—but majority of species are native to México. Fifty percent of these species are deciduous, which is normal considering that the potential vegetation of the region consists mainly of deciduous tropical forest. Nevertheless, it is important to note that 50% of evergreen species commonly found in medium tropical forest, such as *B. alicastrum*, *S. yapa*, *C. dodecandra*, *T. olivaeformis* and *M. sapota*, are not found in the surrounding vegetation. It might be possible that some of these species are in a process of domestication and if this is the case, it will be very important to understand how these populations are maintained. Not all trees are planted by the *campesinos*; such is the case for *B. alicastrum*, *C. dodecandra* and *S. yapa*. They are considered to be tolerated species since their seeds are distributed by animals and the *campesinos* allow them to grow.

Despite the high diversity of Mayan home gardens in the Yucatan little is known regarding the development, multiplication, processing and storage of seeds from the plant species, even though their importance has been recognized in domestication and diversification of cultivated species. Garcia De Miguel (2000) found 22 citrus cultivars (11 species and 11 varieties) in the region of Yucatan State where citrus orchards have been promoted. Improved varieties are mostly found in the orchards outside the communities, while the other cultivars are found in the home gardens. The seed supply system for home gardens is mainly informal though there is also acquisition through formal seed supply systems (governmental, NGO and research institution programmes).
All cultivars of *S. purpurea* described in the 1920s are still present in the home gardens, though their relative importance has decreased and some of these can be considered rare. Hurricane Isidore impacted seriously the home gardens of several communities; we have estimated that 70–80% of home gardens were destroyed, and farmers now demand off-community seed. It will be important to study how campesinos start their home gardens again, where and how they obtain their seeds and plants and what main features they look for. This represents an opportunity to study the resilience capability of the system.

During the past five decades, agricultural development policies have been “market oriented,” dependent on external inputs to promote specialization of agricultural production and associated with the decline of mixed farming. Some challenges for sustainable agriculture will be: to incorporate natural processes into agricultural production; to reduce dependence on external and non-renewable resources; to increase self-reliance among farmers, and to protect and if possible to promote agricultural diversity.

The future of biodiversity conservation is strongly linked to the development of better, more efficient and sustainable agroecosystems. In the search for responsible ecosystem construction and management activities that permit a balance between use and conservation in the tropics, the Mayan home gardens should be considered.

Results indicated that selected indices for diversity measurements did not help the pricing of marginal returns of middle, low or null market values. However, the factors that affect the marginal product of population size are: the slope of the viability function and the diversity measure. The species *B. alicastrum, Musa × paradisiaca, C. mexicana* and *S. purpurea* show higher marginal returns to conservation effort and therefore these are the species that would be more sorely missed. This ranking is supported when population size of each species decreases over three productive cycles but the management relative price for 92% of the species decreases. Only one species (*A. squamosa*) increases MRP when its abundance decreases in each productive cycle, which suggests that a reduction in its population may generate spaces for substitute species to increase its probability of survival.

As can be seen in Figure 2 the conservation effort is lower for those species whose abundance is either low or high, while species that are in the middle such as *B. alicastrum, M. paradisiaca, C. mexicana* and *S. purpurea* represent the highest conservation efforts. Furthermore, as these species have the highest commercial value, according to the management relative prices they should be considered in development programmes.

Only *A. squamosa* increases its MRP when abundance decreases through time. This suggests that space could be available to plant other species. On the other hand, *E. tinifolia, C. dodecandra, A. paniculata* and *M. sapota* have a low commercial value. It is necessary to search for indicators that consider other characteristics of these species in addition to the direct use values, taking into account the ecosystem benefits they may provide.

**Conclusion**

The Yucatan Peninsula is undergoing a rapid process of transformation as a result of development and globalization. In spite of these processes the home gardens are sites where agricultural diversity has been and continues to be maintained. There are 22 core species, all of them having at least one use and according to the management relative prices only *A. squamosa* can be replaced.

Mayan home gardens are in a process of change. It has been suggested that there exists a trend toward a change in the structure and function of the home garden in response to development (Rico-Gray et al. 1990). This trend also refers to the loss of the genetic pool of native species (Caballero 1992).

Little is known about tree seed systems and a long-term study can be started in the communities impacted by the hurricane not only to understand how the home garden seed system functions but even more important, to develop a network for *in situ* conservation of germplasm and promote new policy initiatives that could help support seed systems that maintain or increase crop diversity.

The continuation of the present trend of development will not lead to a desirable future of land-use options. The importance of home gardens must be recognized because of their desirable characteristics such as diversity, self-sufficiency and local control. It is necessary to develop, promote and provide incentives to encourage long-term investments for *in situ* conservation of agricultural diversity.

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Xuluc TF. 1995. Caracterización del componente vegetal de los solares de la comunidad de Sahcabá, Yucatán, México. Tesis Licenciatura, FMVZ- UADY.
Maize seed supply systems in a Mayan community of México

Luis Latournerie M.¹, Luis M. Arias R.², John Tuxill³, Elaine de la Cruz Yupit Moo¹, Martín Gómez L.¹ and José G. Ix Nahaut¹

¹Instituto Tecnológico Agropecuario de Conkal (SIGA-ITA2), Mérida-Motul, Conkal, Yucatán, México
²CINVESTAV-IPN; Unidad Merida, CORDEMEX, Merida, Yucatan, México
³Joint Program in Economic Botany, Yale School of Forestry and Environmental Studies, New Haven, CT, USA

Introduction

In México the composition of crop diversity conserved in communities that practise traditional agriculture is strongly influenced by farmers’ management, conservation and provisioning of seed stocks, both where farmers maintain their own networks of seed exchange at the family level and among agricultural producers, and where formal seed supply systems play a substantial role. In the Yucatan region of México, Mayan farmers conserve and utilize an impressive diversity of maize, bean and squash varieties within traditional slash-and-burn agricultural plots known as *milpa* (or *kool* in Yucatec Maya). In order to understand how Mayan communities maintain the diversity of their traditional crops, it is necessary to study how seeds are exchanged, selected and stored, as well as the attributes of new varieties introduced from outside. The present work was begun with the objective of understanding seed flows and the seed supply system for maize in the community of Yaxcaba, with a specific focus on documenting traditional seed management by local farmers and its implications for *in situ* conservation.

Methods

The community of Yaxcaba is located in central Yucatan state, 108 km to the east of the capital city of Merida at approximately 20°32'N latitude and 88°56'W longitude at an average altitude of 30 m above sea level. The region has a seasonally dry warm subtropical climate, with a mean annual temperature of 25.9°C and mean annual precipitation of 1118.3 mm. Regional soils are young, permeable and extremely stony, with the majority comparable in composition to cambiosols (Duch 1988).

From early 1999 to mid-2001, we conducted a socio-economic survey of local farmers designed to provide baseline information on seed flows across two annual agricultural cycles. The survey documented crop genetic diversity managed by farmers, predominant channels for acquiring seeds, and the origin and movement of crop germplasm present in Yaxcaba. From mid-2001 to mid-2002, we concentrated our efforts on documenting the formal seed supply system and quantifying local storage technologies.

In the survey and subsequent work, we conducted semi-structured interviews with farmers in the locations where they stored their seeds - either in their homes, home gardens or *milpas*, depending on the preference of the farmer. In order to deepen our understanding of the practices used by farmers for managing their diversity, we also participated in planting, harvest activities and seed selection, and we took samples of seeds under storage conditions. Interviews were carried out in both Maya and Spanish, depending on the language preference of the farmer. To understand the dynamics of the formal seed system, we also interviewed representatives of government programmes and research institutions that have participated in the introduction of improved planting materials.

The sampling unit for the surveys was defined according to previous studies by Pérez (1980) and Dzib (1987), who identified the farm household as the basic production unit and the foundation of social organization in Yaxcaba, where maize farming remains the most important economic activity. Making *milpa* is generally considered to be the purview of male heads of household, although in a few cases women heads of household (such as widows) may assume this responsibility. The sample included 62 farmer heads of household, approximately 10% of the total farmer households in Yaxcaba.
Results and discussion
Seed acquisition
Yaxcaba farmers have acquired their maize germplasm over time in a variety of different ways: through purchase; as gifts; through exchanges where one acquires new seeds from another farmer and provides an equivalent quantity of seed from one’s own harvest; as a loan of seed to be repaid in kind; or as “expropriated” seed obtained when passing by a field of another farmer and taken without that farmer’s permission (Table 1). The principal means of obtaining new seeds clearly consist of gifts and purchases (42.7% and 38.8% respectively), while loans of seed are the least important channel (1.12%). Louette (2000) and Aguirre (1999) concur in finding that farmers have diverse forms of acquiring seeds of their principal crops, with gifts, purchases and exchanges being particularly important.

Table 1. Ways in which farmers obtain their maize seed in Yaxcaba

<table>
<thead>
<tr>
<th>Genetic material</th>
<th>Mode of acquisition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Purchase</td>
</tr>
<tr>
<td>Local maize varieties</td>
<td>31.99</td>
</tr>
<tr>
<td>Improved maize stocks</td>
<td>6.73</td>
</tr>
<tr>
<td>Total</td>
<td>38.76</td>
</tr>
</tbody>
</table>

Seed flows
Several recent studies have described how farmers maintain a constant interchange of seeds, allowing them to conserve their preferred planting materials and assure their availability, suggesting that crop diversity is generated not only at the local level, but also results from the participation of other communities (Louette 2000). In Yaxcaba, however, the majority of seed stocks moving through informal channels appear to come from within the community (90.4%) and in much lesser proportion from nearby communities (5.8%) and more distant ones (3.5%). In other words, seed flows are greatest at the community level (Yaxcaba) with relatively limited regional influences both from nearby localities within the municipality (Cacalchen, Chimay, Kancabdzonot, Libre Unión, Santa María, Xan-la, Tahdzibichen, Tiholop, Tixcacal tuyup, Xpujuy and Yodzonot) and those more distant within Yucatan state (Figure 1). The informal system is the primary mechanism that Yaxcaba farmers turn to for recovering planting materials when they are lost in unfavourable years (principally due to drought or hurricanes).

Figure 1. Network of communities where Yaxcaba farmers have exchanged maize seed.
In Yaxcaba seed flows can be grouped into three broad categories (Table 2): materials transferred (as gifts, purchases, exchange, etc.) among related family members (38.8%), materials transferred between unrelated farmers (43.8%), and materials obtained from formal seed suppliers (17.4%). Seed flows are dominated by local landrace materials, principally those of long-cycle maize such as ‘xnuk-nal’ and the more precocious ‘xmejen-nal’ varieties, all of which are primarily restricted to informal channels. Of the seeds that flow primarily through formal channels, demand is greatest for short-cycle white maize, most of which is the variety V-528, known generically by farmers as ‘mejorado’ or ‘hibrido’ even though it is actually an open-pollinated variety.

Table 2. Seed flow channels in the community of Yaxcabá

<table>
<thead>
<tr>
<th>Genetic material</th>
<th>Routes of movement (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Family relations</td>
<td>Other farmers</td>
<td>Formal system</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Local varieties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow xnuk-nal</td>
<td>12.92</td>
<td>11.24</td>
<td>0.56</td>
<td>24.70</td>
<td></td>
</tr>
<tr>
<td>White xnuk-nal</td>
<td>9.55</td>
<td>12.92</td>
<td>0.56</td>
<td>23.00</td>
<td></td>
</tr>
<tr>
<td>Yellow ts’iit-bakal</td>
<td>0.56</td>
<td>0.56</td>
<td>0.56</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>White ts’iit-bakal</td>
<td>0.56</td>
<td>1.69</td>
<td>0.56</td>
<td>2.80</td>
<td></td>
</tr>
<tr>
<td>Piix Cristo</td>
<td>0.00</td>
<td>1.12</td>
<td>–</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Yellow xt’uup-nal</td>
<td>2.25</td>
<td>2.25</td>
<td>0.56</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>White xt’uup-nal</td>
<td>0.56</td>
<td>0.56</td>
<td>–</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Yellow xtrees</td>
<td>0.56</td>
<td>0.56</td>
<td>–</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>White xtrees</td>
<td>0.00</td>
<td>1.12</td>
<td>–</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Yellow xmejen-nal</td>
<td>6.18</td>
<td>4.49</td>
<td>0.56</td>
<td>11.20</td>
<td></td>
</tr>
<tr>
<td>White xmejen-nal</td>
<td>0.56</td>
<td>3.37</td>
<td>–</td>
<td>3.90</td>
<td></td>
</tr>
<tr>
<td>Yellow nal-t’el</td>
<td>0.56</td>
<td>0.56</td>
<td>0.56</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>White nal-t’el</td>
<td>0.56</td>
<td>–</td>
<td>–</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>Xhe ub</td>
<td>1.12</td>
<td>1.69</td>
<td>–</td>
<td>2.80</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>35.94</td>
<td>42.13</td>
<td>3.92</td>
<td>81.90</td>
<td></td>
</tr>
<tr>
<td>Locally adapted improved varieties</td>
<td>2.81</td>
<td>1.68</td>
<td>13.48</td>
<td>17.90</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>38.80</td>
<td>43.80</td>
<td>17.42</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Formal seed supply system

The formal seed supply system plays a measurable role in Yaxcaba, accounting for nearly one-fifth of the seed stocks that enter the community, by way of government programs (41.8%), projects sponsored by research centers and other institutions of higher learning (46.3%), and from farmers’ own visits to agricultural supply stores in urban centers (11.9%). Formal-system seed flows are dominated by improved materials, although on some occasions projects and programmes have distributed local materials (collected from the same or nearby communities) to Yaxcaba farmers as a gift, for purchase, or by a reciprocal agreement where farmers agree to return the donation of seed from their subsequent harvest. For instance, in 2000, some 2400 kg of maize seed from 3 improved varieties (v-528, v-532 and vs-236) was distributed to 45 Yaxcaba households by a government program known as “Kilo for Kilo”. We surveyed 20 of these households during the 2000-2001 season and found they received a total of 811 kg of improved maize seed, and they used about one-third of this total to plant 12.64 ha of fields. Yet this was only 14% of their total milpa acreage of 88.1 ha; they planted the remaining 75.5 ha (86%) to seed obtained locally through informal channels, demonstrating the enduring preference of Yaxcaba farmers for planting local landraces. The remainder of the seed distributed by the government programme was put to other uses, including for home consumption and feed for chickens, pigs and other domestic animals.
Seed storage

The seed selection practised by farmers in Yaxcaba involves a two-step process, beginning with a pre-selection made during the maize harvest. The pre-selection, which is undertaken by virtually all farmers, consists of separating out the best ears from those that are undersized, infested or damaged. The principal criteria for selection are the size of the ear and the quality of its husk coverage, with health of the ear and grain size also playing a role. Most farmers store all their preselected maize together, from which they periodically take ears for household consumption and other domestic activities. The final selection process involves two differing strategies using the same criteria of ear size and health, and husk coverage. A minority of farmers (7%) select and store separately the ears they plan to use as seed shortly after the harvest concludes in January or February, while the majority (93%) wait to select their seed ears until a few days prior to the start of the new planting cycle in May. However this arrangement may be altered when harvests are affected by natural disasters such as drought or hurricanes. During 2001, for example, when a persistent regional drought greatly reduced harvests, many farmers selected their seed ears shortly after harvest and stored them in the most secure places, thereby making sure they were not inadvertently consumed and were protected against pest infestation.

In Yaxcaba, fully 100% of farmers select and store seed from their maize harvest every year except in cases of crop failure. Among the predominant storage practices, about 87% of farmers store their seed ears with the husk, while the remaining 13% remove the husks or else store their maize seed as grain in nylon sacks. These latter approaches are predominantly employed with improved maize seed because it is not usually stored for extended periods. Studies of small-scale seed storage worldwide have reported that farmers utilize a variety of traditional methods and technologies for storing their seed stocks. These methods are effective in conserving seeds for short-term periods, and are economical because they make extensive use of locally available resources, such as wood, thatch, plastic bottles, cotton bags, nylon sacks and clay pots (Baniya et al. 1999; CONSERVE 2001). To store their maize seed, Yaxcaba farmers primarily utilize corncribs known as *trojes* or *kumche’,* constructed by 84% of farmers. *Trojes* may be round, square or rectangular, with the floor and sides made from wood poles extracted when felling forest for new fields or harvested from the forest margins surrounding *milpas*. The roof of a *troje* is most commonly thatched with *Sabal* palm leaves, readily available in Yaxcaba’s forest areas and in home gardens. Only a minority of farmers use laminated cardboard sheets or other roofing materials because of the added cost involved.

Farmers locate their *trojes* according to criteria and requirements based on their own personal experience. The majority of farmers (62.1%) prefer to construct their *trojes* in their *milpa* because (1) their *milpas* are located far from their homes and they find it easier to store their harvest there and carry it back to the house gradually as consumption rates dictate, and (2) by storing their harvest in the *milpa* it remains protected from possible depredation by pigs, chickens and other domestic animals. Other farmers prefer to construct their *trojes* in their home garden compounds in order to protect their harvest from wild animal depredation or from theft. In the case of a minimal harvest, farmers may even elect not to make a *troje* and instead store their maize seed in the kitchen or main room of their house (Table 3).

<table>
<thead>
<tr>
<th>Location</th>
<th>Criteria</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the <em>milpa</em></td>
<td>Long distance between <em>milpa</em> and home</td>
<td>34</td>
<td>51.5</td>
</tr>
<tr>
<td></td>
<td>Protection against domestic animals</td>
<td>7</td>
<td>10.6</td>
</tr>
<tr>
<td>In the home garden</td>
<td>Protection against theft</td>
<td>8</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>Protection against wild animals</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>House</td>
<td>Small harvest</td>
<td>10</td>
<td>15.2</td>
</tr>
<tr>
<td>Kitchen</td>
<td>Small harvest</td>
<td>4</td>
<td>6.1</td>
</tr>
<tr>
<td>Bodega</td>
<td>Ease of transport</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>66</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 3. Farmers’ criteria for locating their maize *trojes* (corncribs)
Conclusion
The informal seed system in Yaxcaba supplies more than 80% of the maize seed required by local farmers in an average year, and is complemented by the formal seed sector whose primary contribution has been the introduction of improved maize varieties. The effectiveness and success of the informal seed system has been demonstrated over time, even in the face of adversities such as hurricanes and drought. The adaptability of local seed storage methods and technologies has played an important role in enabling farmers to maintain local maize varieties that continue to be highly appreciated and accepted, while introduced improved varieties are more closely associated with official mechanisms and programmes of distribution.

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The use and distribution of seeds in areas of traditional agriculture

Roberto Valdivia F.
Centro de Investigación de Recursos Naturales y Medio Ambiente, CIRNMA, Puno, Peru

Introduction
The objective of agricultural development is to provide well-being to the producers and a high availability of food. The production and distribution of improved seeds have been one of the elements utilized for increasing production and productivity. This process, for a particular crop, starts by characterizing a genetic base and then selecting the best genotypes, applying the different techniques of crop improvement, spreading and distributing them as varieties or stable and homogeneous hybrids. In traditional agriculture, formal production and distribution of seeds many times have not been continuous and the producers have maintained their own strategies to reproduce their cropping systems every year.

Traditional agriculture depends mainly on its own resources and it is developed in a diversity of climatic and ecological conditions. The various conditions that Andean families face drive them to analyze how many of their different traditional strategies serve or can be revitalized to face the future. Under the current conditions, the agricultural sector does not seem to have an encouraging perspective.

The present study on the use of ‘varieties mixture’ is presented as a defense mechanism against variable conditions. The conformation of a ‘mixture’ begins with how the production is used and how the seed of the rural families is distributed. The experience of the conservation microcentre in Yunguyo (Puno, Peru) is used.

The distribution of varieties and their relationship with the family’s economy
When a new variety is developed and distributed, it is proven that the conditions in the different links of the chain of value are affected. It is positive while higher volume of production is available and the production is standardized. However, this tendency of incrementing the production affects the supply curve and the farmer’s income conditions. An example offered by the University of Oviedo (Spain) on wheat mentions that when increasing the quantity of produced wheat (because of the introduction of an improved hybrid), farmers are willing to offer more wheat at any given price. In other words, the supply curve moves toward the right (up), while the demand curve does not vary because the introduction of a new hybrid does not affect the quantity purchased by consumers of wheat products and the prices go down because of a higher supply. As a consequence of the process, at the end, the producers have fewer revenues since the commercial agents offer lower prices when there is a higher supply of the product.

The analysis in the example continues, if the development of a new wheat hybrid worsens the well-being of the farmers, why do they adopt it? The answer to this question takes us to the bottom of the problem; how the competitive markets work. As each farmer represents a small part of the wheat market, he sets the price of this product. This way, the reasoning seemed to point out that starting from any given price of wheat it would be better to use the new hybrid and sell more wheat individually. However, when all the farmers adopt this new hybrid, the wheat supply increases, thus lowering the price which in turn worsens the farmer’s economy.

This relationship in agricultural development (by increasing productivity), can be verified with what happened in the United States. In 1948, around 24 million people (17% of the population) made a living from agriculture. By 1993 only 5 million (2% of the population) made a living from agriculture. This change coincided with an enormous increase in the agricultural productivity. In spite of an 80% decrease in the number of farmers, American agriculture produced more than double the harvested crops and livestock in 1993 than in 1948. The increase of food supply caused a decrease in agricultural revenues, and this encouraged people to abandon agriculture. In the case of Andean
agriculture, there were also successes in increasing the productivity levels of certain crops; but mostly, the pattern of reproduction of seeds in a traditional manner was maintained. This happened because Andean producers have no better resources than their own technology, seed and labour.

A pathetic case that is happening in Puno, Peru is the one related to quinoa. There have been great efforts in improving the production of the quinoa grain by implementing technical support programmes. An important item here was the distribution of uniform and good-quality seeds. After several years of work, the local market is requesting not a uniform grain, nor one of first quality, but a clean grain of second-class quality, even if it is mixed. The food-processing companies use this product for different processes before it arrives at the final consumer.

**The dynamics of production and distribution of seeds in the traditional agriculture**

Producers of traditional agriculture, as in Andean agriculture, continually face the dilemma of “maintain traditional varieties for different objectives and/or replace them with genotypes with more capacity and production potential.” Furthermore, they also face a high risk because of the climatic variability and the reduced access to the market, given the conditions that their products offer. From Table 1 it is possible to appreciate the effect that a year of drought (1982–83) or a year of flood (1986) can have, and the number of times that each one of these events took place in the last century; this probably will not change in the future.

Under the described variable climatic pattern it is considered that, for this type of traditional agriculture, obtaining high yields is not the high-priority goal, but is still important. Steady production in time and space, as well as crops adapted to the characteristics of the Andean space, seem to be elements of greater weight. In this perspective, yield is very much linked with culinary quality, with the acceptance in the consumption and the possibility for good transformation. As it can not be obtained in a single genotype, a mechanical combination of different genotypes of ‘varieties mixture’ is adopted.

**Table 1. Area and crop production affected by drought (1982–83), flooding (1985–86) and different events recorded in the Peruvian Altiplano (Highlands)**

<table>
<thead>
<tr>
<th>Crops</th>
<th>Drought</th>
<th></th>
<th>Flooding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Affected area (ha)</td>
<td>Production lost (t)</td>
<td>Affected area (ha)</td>
<td>Production lost (t)</td>
</tr>
<tr>
<td>Tubers †</td>
<td>31 000</td>
<td>185 000</td>
<td>7 000</td>
<td>40 000</td>
</tr>
<tr>
<td>Quinoa</td>
<td>8 000</td>
<td>4 000</td>
<td>2 000</td>
<td>2 000</td>
</tr>
<tr>
<td>Barley</td>
<td>8 000</td>
<td>4 000</td>
<td>4 000</td>
<td>4 000</td>
</tr>
<tr>
<td>Other crops ‡</td>
<td>22 000</td>
<td>–</td>
<td>10 000</td>
<td>–</td>
</tr>
</tbody>
</table>

Source: INIA, PISA 1992; UNEP 1996
† Including potato, oca, olluco and mashua.
‡ Including natural grasses.

In the dynamics of the family system in the Peruvian highlands, after the harvest a diverse process of use and destination of the production begins (Figure 1). For the next planting, families use their own seed and they also purchase it, exchange or plant with a partner. This dynamic is completed with the flow of varieties in two periods: April-August (consumption) and September-November (seed). The movement of varieties begins when the family decides to sell small volumes in the nearer fairs (K’atos). In these places intermediaries buy them to take to fairs in more developed cities. In both the consumption and sale periods the commercialization is in reduced amounts and with a diversity of varieties. In consequence, when one acquires seed in the market (September–November), this is already “mixed” and is incorporated into the stock that the family owns.
In the dynamics above described, fairs play an important role. For the case of the microcentre of Yunguyo, in Puno (Peru), besides of existing very local fairs, three weekly fairs of great importance are developed. The fair of Yunguyo (Thursday and Sundays), concentrates the production of 72 rural communities and distributes them toward bigger cities in the highlands and in the coast of Peru. These fairs also have a high relationship with the fairs of the peninsula of Copacabana (Bolivia). The fair of Chaca Chaca (Thursday) is of a local nature. Varieties that are offered are the same as those in the Yunguyo fair. Especially at planting time, families acquire small seed stocks in this fair. Another fair of great importance is located in Desaguadero, where besides concentrating the production of the area, it also receives some of the production of oca from Oruro and La Paz (Bolivia). In the period of consumption, they are almost the same varieties as in Yunguyo, but in the time of planting, these are increased in number and volume.

The ‘seed mixtures’: the case of oca
For the highland of Peru, at present there is no official programme of production and distribution of seeds. Strategies and traditions of the rural families are developed; these families look to complement the acquisition of their seeds. In other words, according to the conditions of the year, they can use their own seed or look for seed in local, regional or extra-regional markets. In all cases, at planting time they have a group of varieties that are planted in the same parcel. A study on oca planting and harvest (Valdivia et al. 2001) showed that different structures of ‘seed mixtures’ of oca show different behaviour in time and space. Figure 2 is a schematic of the relationship that four types of oca mixture present with stability and productive adaptability. From this figure arises the question: what do the mixtures represent in the distribution and use of seeds? To answer this question, an analysis is presented below the figure caption.

In consequence, a production and seed-distribution programme for the Andes or in areas of traditional agriculture should be considered for the traditional management of their varieties. Improving the relationships of response to the time and the environment is important. However if only a few varieties are favoured, there is the risk of supply-demand problems as presented in the first part of this study. A study is needed to determine what is the biological response to the different microenvironments in an area of traditional agriculture, or if there is “complementarity of environments”. In the highlands, in any year, a town can have severe climatic restrictions that reduce the productivity of the area drastically. Yet, a few kilometers away, the conditions are different and the productivity is not as severely impacted. Then the producers appeal to these latter areas or to more distant places to get seeds and to restart their productive cycle.

Productions in mixture and their relationship with the market
The traditional producers maintain genetic variability in their fields and their harvests are a product of it. However, consumers are guided to acquire homogeneous products that are easily prepared.
What should farmers grow to better meet the market demands? The added value generated after the harvest is decisive, indicating that the dynamics of conservation of resources do not finish with the crop.

The diverse uses of the material that the rural families have should also be revalued or located in the current circumstances. An example is the use of the different natural colours of oca to produce oca marmalade of different colours. The added value generated from genetic diversity tends also to face a problem of competitiveness of the rural area against the industrial development in urban centres. As is shown, there is a high relationship between the different hierarchical levels involved from when a rural family decides to plant a crop, harvest it and commercialize it until it arrives at the final consumers.

**Figure 2.** Oca mixture: Stability vs. Adaptability Index, Puno, Perú (Valdivia et al. 2001).

M1 mixture: its structure is based on one or two varieties. They are the ones with better behaviour when the combination space-time is good. In other words, they are “good” in “good” environments. They are the most diffused ones and accepted by the producers. It includes 100% of Very Frequent varieties. (The study makes reference to varieties “Very frequent”, “Frequent”, “rare” and “very rare”, according to their presence or absence in the planting or harvest in families’ fields or in microcentre fairs in Yunguyo.) The families remember the varieties Jancc’o Luk’e, Waca lik’e and Kellasunte, used for at least 50 years.

M2 mixture: It is composed of 7 Very Frequent varieties (70%) and 8 Frequent (30%), selected randomly by the families themselves. It represents high stability, as the genotypes that compose it generate an excellent combination of genes that express a biological potential in production through the climatic changes. This group of genes offers a good strategy against variable climate among years. Therefore this is the more interesting ‘mixture’ to work with in the event of intervention and distribution of seed.

M3 mixture: Structured with 50% of Very Frequent varieties, 40% of Frequent and 10% of rare. While expressing high adaptability, the genotypes confer a good combination for the spatial changes. In other words it is better adapted to specific places, even registering the best average yields for the six studied regions (25 t/ha average; with ranges of 7 to 48 t/ha). It is in this mixture that the rare varieties begin to appear (those that are recorded occasionally in the parcels of the families, in their warehouses and in the fairs). It seems that these varieties may be concentrated in certain communities, and to these places we should appeal for their propagation in the vision of conservation of agrobiodiversity.

M4 mixture: With more than 12 varieties, it is adapted to different places but it is less stable in years and has the smallest yield compared with the other mixtures.
Finally, when the agricultural technology or the agricultural policies are analyzed, it is important to have in mind that what is good for the farmers is not necessarily good for the society altogether. The improvement of agricultural technology can be adverse for the farmers, but it is good for the consumers who pay less for their food. Also, a policy dedicated to reducing the supply of agricultural products can increase the revenues of the farmers, but the consumers will pay the burden.

**Bibliography**
Session II. Factors Affecting Seed Systems

Introduction

Alfredo Riesco
Consortium for Sustainable Development of Ucayali (CODESU), Lima, Peru

Introduction

This paper introduces the session on factors affecting seed systems. This is a revision of concepts and experiences that are expected to contribute to building a research agenda to enhance seed systems as a main tool for in situ conservation of crop genetic diversity. The analysis of the nature of seed systems is important to determine appropriate interventions for scaling up seed systems and supporting conservation in more efficient ways.

In order to identify the factors affecting seed systems and to estimate the magnitude of the effects, it is necessary to understand the value of the seed, the production processes and the actors involved.

Nature of seed systems

Seed is an input for agricultural production systems. Seed provides two joint benefits to the agricultural producers and to society: it is a consumable input and it is a source of genetic material. As a consumable input, it enters directly into the production function to obtain a product with an expected set of attributes; although seed quality can not be completely seen until harvest and, in some cases, until consumption. As a source of genetic material, seed the potential to improve quality, yield and resistance, which might be realized in the future, after research and development efforts.

The importance of seed comes from the preference and willingness of consumers to pay for final goods. According to economic theory, consumers try to maximize a utility function that depends on goods consumed, given a set of household characteristics, constrained by time, income and prices. As a result of this attitude, a demand function for final goods is identified and this demand may act as an incentive, through prices and marketing margins to orientate production decisions at several levels of the commercial chain. The demand for seed is derived from the demand for final goods.

On the production side, agricultural producers are assumed to act rationally: they will select a portfolio of crops and varieties to maximize the expected utility coming from net income, given their socioeconomic characteristics related to ability to decide, including access and capacity to process information. In making these decisions they confront a set of constraints including family labour, different types of soil, capital and production technology. Net income, in the objective function, depends directly on price of products and cost of inputs.

The selection of crops, varieties and production technology is the result of this maximization process. Therefore, the producer demand for quality and quantity of seed is also a result of this decision process. The decision may have different levels of risk, since there is no guarantee of yield and other attributes to be obtained. Within the community, however, farmers might know where the seed is coming from and have past experiences about its performance.

The demand for seed might be, in turn, an incentive for a set of activities related to seed production: breeding, management, replacement, certification and distribution. For example, the presence of pests and diseases stimulates demand for disease-free seed from the formal system. In some geographical conditions, the production of disease-free seed might be developed informally, as in the case of potato in the Andes, where seed free from bacterial wilt is produced at altitudes higher than 2800 m, and is sold to the lower parts of the valleys (Thiele 1999).

In the formal seed systems, these activities are conducted by commercial organizations independently of the agricultural producers of final goods. The decisions about what type of seed,
volumes, technology, strategies for distribution and communication, and plant varietal protection, are the result of a profit-maximizing process of the commercial firms.

There is an information flow that comes down from the consumer, to the farmers and then to the seed producer, according to price and marketing incentives. The flow of information depends on market integration (access to the market), profitability of different actors in the chain, infrastructure, organization of farmers and governmental support. Very often formal seed systems have no appropriate answers to the demand from most farmers. It has been argued that formal systems may supply genetic material that is inappropriate for small farmers because it requires high levels of fertilizers and pesticides.

In the informal seed systems, breeding, management, replacement and distribution are done by the communities themselves as part of the overall production decision. Hence, information from those who consume the final goods to those that provide the appropriate seed required by the production process are close, direct and accurate in these systems. As we all have found in the global in situ conservation project, very often rural families and their communities produce local crops and varieties for their own consumption, varieties that are practically unknown outside the communities. In this context, they need to produce the required seed.

**Concerns about seed systems**

In order to understand the factors affecting seed systems, we must consider that these are interrelated directly with production of final goods and with agricultural households. They also depend indirectly on consumption, preferences and marketing margins for final goods.

Some factors are related to the marketing of final goods. The size of the market is crucial for the development of seed systems of landraces. When a market is thin, information about the distinctive attributes of landraces is not readily available to the urban consumers, although they might be willing to pay a premium for some of those attributes.

Seed systems depend on size of local and national consumption for final products; migration from the countryside to the city, which creates market niches for final products, and possibilities for exports. Some landraces have “strong” attributes (superior traits) that compete with well-known substitutes. Market development and seed systems for these varieties are likely to be profitable, and would contribute to on-farm conservation very efficiently (Gauchan et al. 2003). But many other local varieties are expected to have a poor performance in the market.

Seed systems are also dependent on market integration. Very often, information about attributes of landraces for production and consumption is not fluid. The formal seed system has problems reaching scattered small producers, because of high marketing and other transaction costs. In contrast, the informal seed systems are closely connected with agricultural households that produce and consume final goods from landraces. Most often these agricultural households produce their own seed.

Distance and infrastructure are key factors for market integration. Depending on the distance to the market, Amazonian communities dedicate efforts and area to exotic crops and varieties, increasing the demand for seed of modern varieties and reducing the demand for seed of local varieties. This is the case of landraces of maize and beans in Central Amazonia in Perú (Collado et al. 2001). The same has been found in maize, beans and squash varieties grown by farmers in México (Van Dusen 2000), wheat landraces in Turkey (Meng 1997), and maize in Ethiopia (Benin et al. 2003).

In the semi-subsistence or semi-commercial indigenous communities of Peruvian Central Amazonia, families plant some areas of improved varieties mainly for the market. These varieties have been produced originally in the formal system, but have been propagated through informal channels. Families also plant commercial local varieties mainly for the regional urban markets (Pucallpa and Iquitos in the Amazonia), but also for market niches outside the region (Lima, the capital, at the west side of the Andes). They also plant non-commercial local varieties for consumption
within the rural communities in the region. The importance and diversity of local varieties for the families depend on the distance to the market and the ethnic group (Collado et al. 2001).

Some factors are related to the type of seed. A crucial issue for the performance of seed systems is the additional attributes of the seed as food for the household. Some seed involves two joint products: seed and food. This is the case of maize, peanuts or beans, different from cassava, chillies or cotton. Joint products give the seed a special additional value. When, under certain circumstances, a rural family has critical liquidity or food needs, they might sacrifice the seed and use it as food. This additional value might be a reason why, for the Amazonian communities, it is easier to give cassava, chillies or cotton seed as a present to neighbours, rather than seed of maize, peanuts or beans (Collado et al. 2003).

Another aspect related to the type of seed is bulkiness. There is a higher cost for handling cassava seed than for maize or beans. In order to plant 1 ha of beans or maize, between 20 and 25 kg of seed are needed. While 7000 stems are necessary to plant 1 ha of cassava, this material weighs about 680 kg. In terms of transportation and management, cassava seed is about 27 times more expensive than beans or maize. In this way, cassava seed flows are less aggressive than beans and maize.

Some factors are related to efficiency in the use of resources. Experience, management ability, education and leadership are human capital variables that will affect the performance of information flow, breeding, management and distribution.

Also, in relation to efficiency, a minimum size of operation is needed in the formal sector to continue in business. Commercial organizations will not produce seed of local crops and varieties unless the specific market has been developed to a profitable size. In the case of informal seed systems, multiproduct and multivariety farms are already in place as a result of production-consumption decisions of the household. Marginal efforts required to select seed are low enough and cannot be put aside because of the family food security during the next season. In the same context, the farmer’s attitude toward risk and uncertainty is also an important variable affecting informal seed systems. It is not clear yet if the Amazonian communities are risk-averse people, nor is the magnitude of risk aversion known, but we know in theory that this attitude is directly related to poverty.

Another set of factors affecting seed systems has to do with external intervention coming from development projects and private companies wishing to create business in the region. Usually these companies introduce exotic seed according to final market demand, often for exports. Farmers multiply the seed and distribute it further as long as the market exists. This is the case of Vigna sp., Phaseolus vulgaris var. Caraota and some varieties of cotton in Central Amazonia. Another exogenous factor is government intervention through the normative frame. Norms may limit the flow of seed from one region to another or from one country to another. Seed certification is also regulated by government.

There is a concern about keeping diversity in the long run, through maintenance of seed systems. Market integration and development will not solve the whole problem of in situ conservation. In the case of local varieties with “strong” attributes, information and marketing might be an important factor for sustainability and development of a seed system for them. In the case of local varieties with “weak” consumption attributes, with the development and integration of the market, competition for land and labour with other crops and varieties will tend to contribute to genetic erosion. This tendency might be overcome if the communities internalize the potential benefits of keeping diversity for yield improvement, resistance to pests and diseases and other quality parameters. Such a process requires strengthening farmers’ capacity for participatory plant breeding with a long-term perspective in mind (Hurvio and Sidibé 2003). But, will all the costs be borne by poor communities?

**Conclusions**

- Market for seed is a market derived from the product market. Incentives for seed production and management come from agricultural producers. Therefore, quality of seed has to do with consumption attributes of final products as well as with agronomic attributes;
• Information gaps, transaction cost and profitability of the commercial chain affect the development of seed systems. Informal seed systems are most appropriate when markets are thin or underdeveloped, and when formal seed supply does not satisfy farmers’ needs and expectations;

• Decisions about seed production and management are risky. Therefore research is needed to understand the expectations and attitudes toward risk of families and communities under study;

• Bulkiness of seed in crops like cassava affects their management and distribution. Transaction costs might be more than 20 times those of grains;

• Building capacities at the rural community level will help them to internalize the benefits of conserving genetic resources for improving yield and quality of products, even with those varieties that have “weak” attributes to compete in the market.

References


Experiences from Nepal

Bimal Kumar Baniya¹, Deepa Singh² and Bhuwon Sthapit³

¹Nepal Agricultural Research Institute, Kathmandu, Nepal
²Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Pokhara, Nepal
³IPGRI–APO, Pokhara, Nepal

Introduction

The purpose of this paper is to list some of the factors affecting seed supply systems and provide the experiences, contributions and findings from the global project: “Strengthening the scientific basis of in situ conservation of agricultural biodiversity on-farm” from Nepal.

Seed is the genetic material, which is the first link in the food chain, the source of life, future plants and even culture (Shiva et al. 1995). Louette (2000) defined “seed lot” as the kernels (grains) of a specific type of maize (crop) selected by one farmer and sown during one cropping season to reproduce that particular maize (crop) type. She further defined “variety” or “cultivar” as the set of farmers’ seed lots that bear the same name and are considered to form a homogeneous set. A seed lot, therefore, refers to a physical unit of kernels (grains) associated with the farmer, who sows it; a variety is associated with a name (Louette 2000). Baniya et al. (2000) raised the question that in dealing with seed, a clear distinction between seed and variety is needed. In most cases, they are used synonymously and many people have difficulty in distinguishing seed and variety. However, in dealing with the seed supply system in this paper, generally we use seed and variety interchangeably.

Individual farmers value diversity within and between their crops because of heterogeneous soils and production conditions, risk factors, market demand, consumption and uses of different products from an individual crop species (Bellon 1996). Bellon (1996) outlines a framework that assumes that the farmers have several concerns, including adverse climate, soils, labour or fertilizer shortage, poor yield or storage life, lack of appeal for home use or lack of marketability. He hypothesized that the farmer retains the variety that best meets each concern. The concerns themselves are dynamic, changing with new market structures, technology and government policies (Brown 2000).

Farmers manage rather than conserve on-farm crop diversity. Farmers do not usually view the on-farm crop in a static way, but rather as a dynamic part of their farming system that can be manipulated as part of their constant struggle to achieve sustainable livelihoods (Cromwell and Oosterhout 2000). Seed is used as the main management unit in seed supply systems. With the quantum jump in science and technology, scientists have developed modern crop varieties that have mostly broad adaptation, resistance to biotic and abiotic factors, high efficiency for use of inputs and are higher yielders than most of the landraces in high-input conditions. So, a few modern varieties have already replaced the landraces in the developed countries and the rate of replacement of landraces is very high in developing countries. However, some farmers are growing landraces because of factors—social, technological, cultural, biological, religious, political, economical, climatical, adaptiveness of varieties, available land type, etc.—which are directing them to maintain agrobiodiversity at a high level. The dynamics of seed systems enhance the continuing crop evolution processes (Brown 2000). The combination of different sets of the above-mentioned variables determines the seed supply system. On-farm conservation and seed system are closely linked where continuous human involvement is occurring in both processes.

Brown (2000) has analyzed the reasons for conservation of landraces. Farmers grow diverse landraces in often small patches amid modern cultivars. The question is why farmers grow these landraces without external supports? Brown (2000) has listed some of the reasons for continuous growing of landraces, as follows:

• Improved varieties may not be available or affordable;
• Improved varieties may not represent an improvement for a particular farmer or meet the farmer’s needs reliably;
• Landraces have aesthetic appeal;
• Division of land holdings within families;
• Marginal agricultural conditions associated with hill lands;
• Heterogeneous soils;
• Economic isolation;
• Niche market premiums;
• Cultural values;
• Special uses and preference for diversity;
• Access of seed;
• Effect of random events (e.g. hailstorm/flood) on genetic diversity.

To understand the dynamics of local crop diversity in farming systems, we need to relate farmers’
decision-making to the pool of varieties available for planting. The systematic force for allele
frequency change is farmer selection, both deliberate and inadvertent, mixing and hybridization.
Landrace seed selection by farmers for quality, flavor, size, appearance, market appeal, etc. comes
into play (Brown 2000).

Factors affecting seed systems
Some of the factors affecting seed systems can be as follows:
• Formal and informal seed systems;
• Types of farmers and social network;
• Socio-economic make-up of the community;
• Social concerns;
• Uses of genetic resources;
• Environmental conditions;
• Seed production and local institutions;
• Seed sources;
• Seed storage systems;
• Input availability or access to input;
• Policy and regulations;
• Market value of the variety.

Formal and informal seed systems
The formal system functions on the commercial scale and it is oriented to profit. Most of the formal
seed system is under the control of national and/or international and multinational seed companies.
The formal seed system is well established, is based on scientific principles and is committed to
providing quality seeds to the farmers. The success of the formal system depends on competition
by providing quality seeds. In Nepal, some seed companies, government agriculture stations and
private groups are the formal seed-supplying organizations, and they have fairly sound seed
networks for seed replacement of cereal and vegetable crops. They usually follow all the modern
seed production and distribution practices. However, the seed replacement rates of old seeds by
the certified seed of rice, maize and wheat were only 0.2%, 0.7% and 2.5% respectively in 1997/98
(Baniya et al. 2000).

In an informal seed system, the farmers produce, purify, store and use the seed locally. In Nepal’s
context, a large portion of the seed requirement of the major crops is met by the informal seed system.
The informal seed system fundamentally occurs through a social network where a set of persons is
connected through flow of information, goods or implementation of joint activities or other social
bonds of one kind or another (Subedi et al. 1999). Most of the processes are under the control of
the farmers and very little is known about the informal seed system. This system is predominant
in Nepal. The culture of the informal seed system is fundamentally different from the culture of
the formal seed system. Within the culture of indigenous peoples, we find viable alternatives to the current ethnic and environmental crises (Gonzales 2000). Research and development of agriculture are advanced in developed countries and thus formal seed system is very strong there, however both agriculture research and development are weak in developing countries and thus the informal seed system is predominant. Research and development are extremely weak in the least developed countries, and mostly the formal seed system does not exist there. But developing and least-developing countries are rich in genetic resources and their seed system is not well understood. So, the status of the country also affects the seed system.

The formal system focuses more on the interests of the seed company, and has more access to biotechnology and plant breeding techniques, so this seed system generally neglects the indigenous people. The market is dominated by a few suppliers with potentially serious implications for technology choice and price fixing. In Nepal, the majority of farmers fulfil their seed requirements through the informal system, which is met by retention, farmer-to-farmer exchange and local sales (Joshi 1995). Each year farmers decide how much seed to plant and where that seed comes from. The informal seed supply system is closely related with conservation of agrobiodiversity on-farm. In this system, farmers make decisions in the process of planting, managing, selecting, rogueing, harvesting and processing that affect the genetic diversity of the crop population (Baniya et al. 2003). These processes influence the geneflow and change the genetic constituent of a given crop. In the informal seed supply system, retention of the farmers’ own seed and exchange with neighbours are prominent practices. About 67–97% of rice area is planted with farmers’ own saved seed in the case of landraces (Baniya et al. 2000, 2003). Identifying strengths and weakness of farmer’s seed systems and providing incentives to strengthen informal seed supply systems needs priority attention, as it could serve to promote conservation of local landraces and to meet the farmers’ seed demand.

Types of farmers and social network

The types of farmers also affect the seed systems. Louette (2000) classified farmers in three groups: (1) mostly uses seed of own production and keeps more varieties, sows same varieties regularly and supplies seed of landraces to others; (2) uses own seed lots acquired in the community or seed introduced from other regions; the proportion of seed varies from season to season; suppliers of introduced seed are known as innovative farmers in the community and are aware of seed matters; (3) always uses seed from others owing to insufficient production; had less land; does not grow crop regularly and depends on others for seed; uses fewer number of varieties. Subedi et al. (2003) identified ‘nodal farmers’ who are in the rich category, maintain more variety diversity, search for new varieties, are more knowledgeable farmers in the seed system, have larger landholdings, are “diversity minded” and have a higher education (Rana et al. 1999). Nodal farmers play an important role in the seed flows through social networks and provide seeds to others. They also bring in materials from other farmers within and outside the community and provide seed to poorer farmers. Nodal farmers play an important role in dissemination of knowledge-based information as well. Nodal farmers more frequently participate in the local market (Subedi et al. 2003). Thus, the farmers of different groups affect the informal seed supply system in farming communities.

In the social network, different institutions and individuals play a significant role in the flow of genetic materials and associated knowledge. Among these local institutions, certain individual farmers in the community maintain a relatively larger diversity than other members. Farmers’ network is also a kind of social network where farmers have a network of affiliations and have been found to play a significant role in the flow of genetic material and the associated knowledge (Subedi et al. 2003). In this process, both material and non-material information—on morphological traits, management practices and the performance of the genotype in different conditions and their use values—also flows.
Socioeconomic make-up of the community
The socioeconomic conditions of the farmers also influence the seed supply system. Generally the rich farmers have more access to resources and information, have larger landholdings, are more educated, have land-use rights and have funds to manage the crops, and therefore they can exert a greater influence on the seed system. The rich farmers bring improved varieties from their relatives and other formal channels (Baniya et al. 2000). The landlords, persons with a high local position of authority, who have more contact with research and development organizations also play an important role in this system. Farmers with small landholdings produce less, even for their own consumption, and so generally depend on others for seeds.

Seed renewal
Most farmers are not concerned about the seed source, but some have a special preference for seed source and try to manage the seed from that particular source. Some farmers think that they must change seed lot of a variety for a particular land regularly to maintain or increase the productivity of the variety and they change seed lots accordingly. The frequency of seed renewal varies from one season to more than three growing seasons, depending on the nature of crops and location. For example, in Nepal 23% of farmers change seed lots every year in remote areas, but most change seed lots after one year in accessible areas, although in finger millet and taro the duration of seed change is more than three seasons (Baniya et al. 2003).

Uses of genetic resources
Farmers conserve the agrobiodiversity for different uses and/or manage their seed accordingly. Conservation of agricultural biodiversity on-farm can be assured only if they hold specific values either in socio-cultural, economic, ecological terms or preference of characteristics (Jarvis and Hodgkin 1997). The landraces can be conserved through value addition by breeding or non-breeding mechanism so that the farmers can obtain more economic benefits, which will promote the production and consequently the demand for seed of the particular landrace. Generally, the farmers perceive the genetic biodiversity as varietal biodiversity and, unlike in other developing countries, Nepalese farmers maintain a wide range of varieties for different purposes.

Landraces are mainly grown for food purposes and sometime also for economic, socio-cultural, religious and medicinal values. The crops are used to prepare different foods, and some landraces are used for a special purpose only. ‘Basmati’, ‘Kariya Kamod’, ‘Brambabusa’ and ‘Bhasa’ are used for different purposes. Some ‘Japonica’ type rice varieties in Nepal are used for beaten rice and alcohol preparation. Some rice varieties are used to prepare different special foods, e.g. the local rice variety ‘Anadi’ has a high protein content and is used exclusively as a medicinal by women who have recently given birth. ‘Sokan’, ‘Sotwa’ and ‘Anadi’ are used for medicinal purposes. ‘Anadi’ is a glutinous rice variety also used to prepare other foods. Another rice variety (Sathi) has religious value: it is offered to the goddess (Chathi maiya) on the special festival (Gauchan 1999; Rana et al. 1999) and is used for preparing sweets and dishes during the festival. ‘Khera’, ‘Sathi’, ‘Lajhi’, etc. are used for religious purposes. The local communities need these landraces and so the farmers grow them and manage the seed accordingly. ‘Basmati’ rice is a fine, aromatic and better eating-quality variety, so it has special value for the higher social and economic status groups. Aromatic and high-quality rice landraces such as ‘Jetho Budho’, ‘Bayarni’ and ‘Pahele’ are grown for commercial purposes and sell for a good price.

White grain maize and white finger millet varieties are also considered high-status landraces because they look like rice recipes and are offered to higher-status people for food. Here the value of the variety is in colour, which is associated with high social status.

A farmer selects seed from the particular population of a variety and identifies some different populations, and the breeders also use their landraces in formal breeding programme. So, most of the landraces have one or more favourable traits and farmers grow them for those specific qualities.
Similarly, in the case of other crops like taro and sponge gourd, the diversities are maintained for their adaptive traits and specific use values. The extent and distribution of these taro landraces are based on their multiple use values and the preference for local cuisine based on the plant parts (Rijal et al. 2000).

### Environmental conditions

Crops and varieties have specific adaptation and can be grown in particular environmental and soil conditions. Landrace populations of crops have survived centuries of selection for reliable production in subsistence agriculture, yielding a definite, known but probably limited benefit to the farmers that grow them (Frankel et al. 1995). If the landraces come from marginal environments, they are known to equal or exceed the performance of imported advanced cultivars in those marginal environments (Weltzgien and Fischbeck 1990). The special adaptation of landraces in harsh and heterogeneous environments is the prime factors for farmers’ maintenance of landrace diversity (Gauchan 1999). Farmers have different land parcels with different agroecological environments for which different varieties adapted to these environments are required. Thus, farmers maintain more than one variety based on the domain-specific characteristics of the varieties. Farmers also maintain the diversity of varieties, be they modern or landraces, to mitigate the risk of losing the crop owing to some unpredictable change in environment. Environmental
conditions are considered here at the narrowly based on-farm level only. Some examples from rice are as follows: specific agroecological factors such as marginal uplands, infertile soils, waterlogged lowland, rain-fed area, etc. influence farmers’ selection of particular landraces, cultivation decisions and management of the seed. Some landraces are suited only to unbunded upland areas with no irrigation, but most rice landraces are cultivated only in bunded lowland areas with the possibility of irrigation. For example ‘Mutumur’ and ‘Nakhisaro’ landraces are suitable in upland and poor soils with less use of chemical fertilizers, whereas ‘Bhathi’ and ‘Silhat’ rice landraces are grown in swampy land because of their unique adaptation to submergence situations, where other landraces are not adapted (Gauchan 1999). Again the fine and aromatic rice ‘Basmati’ is adaptive in lower wetlands and needs less fertile soils. Similarly, some landraces are suitable in cold and hot conditions, some are generally grown in the specific seasons and some can be grown in a wide range of agroecological conditions and soil fertility.

Seed production
Seed production is the main factor influencing the seed system in informal and formal systems. In the formal seed system, the seed production techniques and quality control system are well established and controlled by the authorities. But, in the informal seed system, farmers follow procedures developed by them, which differ from place to place and for the same crop, and different procedures are followed for different crops. Generally farmers establish strong seed-production systems for the premier crop of their area. For rice, roguing and seed selection with set criteria are the two special operations followed by farmers in seed-production procedures. Both operations are oriented to purifying their landraces to make them true to type and in some cases even to develop new genotypes. However, the selection criteria and time of plant or ear selection differ from place to place. Most farmers follow select seed before and after harvesting the crop. Some farmers designate a certain patch of land for seed production and use that area as a seed-production plot. Field and plant selections are based on a fixed set of criteria, which vary from place to place, crop to crop and farmer to farmer (Baniya et al. 2003). Some farmers provide more inputs to the seed-production plot and even maintain short isolation distances for maintaining seed quality (Baniya et al. 2003). Roles, responsibilities and decision-making of women farmers in rice seed production, seed selection, management and use are higher in the hilly region than in the lowland plains of Nepal. The direct involvement and decision-making of women farmers in variety/landrace choice, allocation of land parcels to variety/landrace, seed selection, storage, maintenance and further management indicate that women farmers have access to and control over genetic resources and are important stakeholders in the conservation and utilization of genetic resources on-farm (Subedi et al. 1999). Community-based seed production and marketing of the seed are effective measures to improve the local seed-production systems.

Seed sources
Informal and formal systems are the main sources of seed. A large percentage of cultivated area is planted with farmers’ own seed saved from the informal seed supply system, ranging from 32 to 79%; use of seeds from neighbours is high and from relatives is low (Baniya et al. 2003). The most common way of managing seed is by exchanging seed for seed or food grain, and gifts as well as purchases from different sources also are significant in rice crops of Nepal (Baniya et al. 2003). Farmers usually rely on diversity of other farms and communities to provide new seed when crops fail or seed is lost, or to renew seed that no longer meets the farmers’ criteria for good seed (Louette et al. 1997). Louette (2000) found that about 53% of seed lots were from farmers’ own harvest, about 36% of the seed lots were obtained from another farmer from the same area, and 11% were introduced from other regions. So, seed exchange within a community or among the communities is very important in the seed system. If a variety is grown in one locality only, the farmers must rely on their own stocks, and if there is no seed production, the variety/seed is lost forever.
Exchange, gift, purchase and free (from development organizations) are some of the processes of seed flow at household level. Seeds of modern varieties are exchanged more frequently than those of landraces (Louette 2000). Farmers have a well-established seed supply system, and they often operate in networks.

**Seed storage systems**
Safe storage of seed to use for the next season is one of the main challenges for farmers. Seed that is not exchanged or sold should be saved/stored for a more appropriate planting season. Improving storage units will help to preserve diversity more effectively thereby complementing the more formal *ex situ* system, which will also provide a back-up system for *in situ* field plots, in case of crop failure (Worede et al. 2000). The community gene/seed banks serve to maintain local germplasm for crop improvement and are a seed reserve system for emerging use. Mostly farmers keep seed in containers, materials and structures made from locally available materials. Farmers are very careful to store seed in safe places to maintain high seed quality. Types of storage structures vary with the amount of seed to be stored, its unique value and the local ethnic culture (Baniya et al. 2003). For seed security, farmers usually employ containers such as clay pots or rock hewn mortars that are sealed and buried in an inverted position in a secure place on the farm and in underground pits (Worede et al. 2000). When there is an emergency situation due to droughts, floods, landslides (natural calamity) or war, seed stored in a secure place is useful.

**Input availability/access**
The availability of agricultural inputs such as fertilizers, water, plant protection chemicals and, more importantly, seed to plant for the next season also affects a seed supply system. In the informal seed system adequate amounts of required inputs may not be available, which can halt the seed system. Seed security in terms of access to sufficient seed and access to seed of desired crop varieties is an important variable that encourages farmers to maintain a large number of crops and crop varieties on-farm (Cromwell and Oosterhout 2000). Many households reported that they could not grow some preferred landraces (‘Mutmur’ and ‘Nakhisaro’) because of the unavailability of seeds during the planting season (Gauchan 1999). So, there is a need to take measures to multiply the seed of desired varieties in sufficient amounts locally and distribute it to farmers. Efforts should be made to encourage different groups of a community to participate in seed production, storage and exchange locally. The generation of funds to support seed production, processing, packaging and distribution facilities locally and to make seed available to the farmers also is an effective way of strengthening seed systems. Construction of a few community seed banks will enhance the availability of seed of desired varieties locally.

Access to information on the source of seed, local knowledge, practices and use values are fundamentally not systematic, which may prove to be one of the factors affecting the farmer’s decision on choice of variety and ultimately the on-farm conservation. A Community Biodiversity Register (CBR), which is an inventory of this information, will aid in increasing the accessibility of local knowledge to the farming community as well as others. Project-based seed-production programmes in Nepal demonstrate the positive impacts on local seed production and distribution systems.

**Policy and regulations**
Agrobiodiversity is an important source for food security and livelihood in Nepal. Seed policy and regulations affect the seed systems of any crop variety. International agreements, national policies, and regulations in the seed sector can play an important role not only in directing on-farm diversity conservation but also in guiding the best use of the available genetic resources in sustainable way. Nepal has a National Seed Policy (2000), Seed Act (1988) and Seed Regulations (1997) in place. The seed policy has several liberal policy statements that permit the seed industry to strengthen the
private seed sector. However, a seed act and regulations are not sufficient to implement the seed policy properly. So, the present seed act and regulations are in the process of being amended by the concerned authorities. In Nepal, diffusion of technology and seed-promotion mechanisms, such as extension agencies, training, agricultural fairs and market promotion, by government and many non-government agencies, are mainly biased toward modern crop varieties, as are the policy act and regulations. It is not possible to produce the seed of landraces and sell it commercially. Neither extension advice nor inputs for the promotion of landraces and their seed are available. Thus, there are no legislation and support systems (certification and quality control) for seed multiplication of landraces in Nepal.

Nepal is a signatory of Convention on Biological Diversity (1992), is going to be a member of WTO/TRIPS very soon and has signed the International Treaty on Plant Genetic Resources for Food and Agriculture (2001). But, as we have no Plant Variety Protection or Breeders’ Rights and Farmers’ Rights yet, our seed system is very weak and not well controlled. There may be some problems in implementing farmers’ rights effectively.

**Market value of the variety**

Market value of a variety also influences the production system of that particular variety and consequently the seed supply system. Economic factors such as higher market demand and higher price also influence farmers’ decisions to maintain cultivars such as ‘Basmati’ (Gauchan 1999). Among various landraces, ‘Basmati’, ‘Mutmur’, ‘Nakhisaro’, ‘Sathi’, ‘Bhathi’, ‘Jhinuwa’, ‘Jethobudho’, etc. are most valued by the local community for their better cooking and aromatic qualities. Although they have market value, most landraces except ‘Basmati’ have low market demand and lower market price, and consequently are traded in limited volumes. The major reasons cited by the traders are inadequate availability of landrace products, small-scale production, less appealing colour and heterogeneity of grains (Gauchan 1999). ‘Basmati’ is a fine and aromatic rice with good cooking quality and high status and has high market demand, so it is being cultivated by many farmers despite pressures for adoption of modern varieties and commercialization. Coarse-grain landraces fetch a low price, so their market demand is low. Most consumers are not aware of the good qualities of the landraces, so they are not sold at good price. Lack of market incentives for rice landraces is a major problem for their continued cultivation on-farm. Marketing of landrace seed on a large scale does not exist in Nepal and the seed system of rice landraces is not strong.

**Conclusions**

From time immemorial farmers have been observing and selecting crops and crop varieties, saving and managing seeds for the next season. The long history of an informal seed system is being replaced by a well-established formal seed system; consequently the agrobiodiversity is eroding rapidly and the knowledge related to genetic resources also is disappearing. Informal seed supply systems have been developed through generations of experiences by farming communities to suit their environment and to meet their need for seeds for a variety of crops in a secure and sustainable manner (Shrestha 1998). The traditional seed supply systems have a great influence on the existing crop diversity. However, it is not possible to sustain the informal seed system as it is and there is a need for a new or modified seed supply system, which conserves high levels of agrobiodiversity and manages the local seed supply system effectively to provide quality seeds. All the factors affecting the seed supply systems must be understood and modified systems established based on the requirements of a given locality. Establishment of community-based seed-production and distribution programmes, community seed/genebanks at village level, more involvement of women in seed production and decision-making processes, balancing of breeders’ rights with farmers’/communities’ rights, etc. in the informal seed supply system can be the way to conserve genetic resources and improve the informal seed supply system. Increasing the capability of local people and mobilization of community-based organizations (CBOs) and groups to handle seed-related
operations also are equally important to strengthen seed systems. Project-based programmes can be the most effective strategy to understand, modify and strengthen the seed supply systems.

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A hybrid concept for understanding the functionality of seed systems in smallholder societies of the Peruvian Amazonia

Miguel Pinedo-Vasquez¹,², Robin Sears², Italo Cardama³ and Mario Pinedo Panduro⁴

¹People, Land Management and Environmental Change – PLEC, United Nations University
²Center for Environmental Research and Conservation, Columbia University
³Instituto Nacional de Investigaciones Agropecuarias - INIA
⁴Instituto de Investigaciones de la Amazonia Peruana – IIAP

One day in late August of 1998, a discoloured elongated green bean attracted our attention while we were walking in the mixed planted fields of Manuela Tapullima, a farmer from the Peruvian Amazon. Since we were documenting agrodiversity and agrobiodiversity, we asked her the name of the beans; she told us that it was called chiclayo verde japones (Japanese green beans). With a bit of humor and curiosity we asked her if the beans were provided by Alberto Fujimori, at that time president of Peru who originated from Japan. To our surprise, she told us that the beans indeed came from Japan but not by way of el Chino (as most farmers call Fujimori). She explained that she obtained the beans from a comerciante de semillas (seed seller) who lives in the city of Iquitos.

When we spoke with the seed seller he told us that his daughter worked on a farm on the island of Okinawa and she sent the seeds to him in 1994. He explained to us that since Manuela Tapullima was a very good semillera, a certified breeder, he gave her the seeds to test. She would determine if the seeds could grow and produce beans and if they were tastier and easier to cook than the local green beans. The seed seller explained that Manuela Tapullima experimented with that variety for two years and her results showed that the beans could be produced and consumed in the region.

Since 1997 the seed seller included the chiclayo verde japones among the many varieties of beans he sells to farmers. When asked if he gets his supply of this variety of bean from Japan he reported that he actually buys the seed each year from Manuela Tapullima and two other very good and reliable semilleros. He told us that he had met the semilleros when he worked for the programa de semilla certificada (certified seed programme) of the Ministry of Agriculture from 1982 to 1985.

Introduction

The narrative above serves to introduce the two classes of actors and their roles in production, breeding and supply in the seed trade business in the Peruvian Amazon: the comerciantes de semillas and semilleros. These entrepreneurial seed sellers and certified breeders are key players in the process of building and maintaining seed systems in a rural agricultural region of the Amazon where there has been little success with agricultural extension programmes.

Researchers have reported that in most developing countries governments have had limited success in building formal seed systems in rural areas (Tripp 1995; Thiele 1999). Nor have NGOs been able to fill the role in helping rural farmers maintain functional seed systems because their programmes are based on limited financial resources and are short term (Brush 1992; de Boef et al. 1995; Wiggins and Cromwell 1995). While both the state and NGO programmes have shown limited success in this area, we suggest that they have had significant indirect influence on the shaping of local seed systems. We have found that both information and technological resources from these programmes have been surreptitiously incorporated by farmers and entrepreneurs into local seed breeding and management systems resulting in what we call hybrid seed systems.

² We use the term certified breeders to refer to farmers who are recognized by seed sellers as the ones who engage in experimentation and innovation in the processes of producing high-quality seeds. The concept is based on the generic category of expert farmers used in the PLEC programme (Pinedo-Vasquez et al. 2002).
³ The term seed system refers to an interrelated set of process components including breeding, management, replacement and distribution of seeds (Thiele 1999).
Rather than condemning the behaviour of Manuela Tapullima and the seed seller, we use their case to examine how farmers are selectively adopting (and adapting) the technologies, tools and regulations that are brought to the region by extension agents of public and private organizations whose objectives were to build formal seed systems in the region. We focus on the more subtle influence, rather than on the success or failure, of those public and private seed programmes on local systems to analyze the enhanced functionality and composition of local seed systems in the Peruvian Amazonia. The three focal questions we address in this paper are: How are seed systems built? Who are the main players? and How are seeds and seeds technologies exchanged?

In the rural areas near the Peruvian Amazon city of Iquitos in the northeast section of the country, certified breeders and seed sellers participate in loose networks that are used by farmers to procure seeds within and outside the communities (particularly from the Iquitos markets). Both actors adapt existing knowledge to build and maintain seed systems in which traditional and modern technologies, tools and regulations are integrated for breeding, management, replacement and distribution of seeds. The actors incorporate some of the technologies and knowledge that are promoted by the hundreds of seed programmes run by NGOs and government agencies in the region since the 1960s. These hybrid systems are neither modern nor traditional, formal nor informal, and as such escape the formal categorization, and notice, of the conventional agricultural research and extension programmes.

The concept of hybrid seed systems not only draws attention to the knowledge and technology often overlooked by agricultural scholars and technicians, but also necessitates them to re-evaluate the role of seed sellers who are often thought of simply as middlemen and are often blamed and condemned by experts for proportionately introducing seed to rural regions that is contaminated by pathogens or of low genetic quality. We further argue that future seed programmes originating from the NGO and government agencies should carefully examine social, cultural and biological dynamics of the existing local systems before introducing new technologies and seed stock.

In this analysis we have used data collected on the multiple functions of seed sellers and certified breeders to demonstrate how the hybrid concept can describe the dynamic nature of local seed systems in rural agricultural areas. We incorporate a broad range of market and on-farm observational data that show how semilleros integrate both modern and traditional knowledge, rules and strategies into viable systems for producing, selecting and exchanging seeds. This case study should provide a new conceptual and analytical framework that can inform the design of seed policy for rural smallholder farmers in other areas of Amazonia and other regions of the world.

**Methods**

The data reported in this article were collected as part of the activities of the global programme on People, Land Management and Environmental Change (PLEC) of the United Nations University. In Peru, data collection began in 1997 and is ongoing. The study area comprises 6 small villages in the Muyuy sector situated 10 to 20 km upriver from the city of Iquitos, the largest urban center of the Peruvian Amazon. The villages lie on the banks of the Amazon River on the forested seasonal floodplain, or várzea, where fields and forests alike are inundated annually by the flooding whitewater river. This component of the PLEC research programme on the agrodiversity and agrobiodiversity of the region was specifically designed to understand the origin and function of local systems for breeding, storage and dissemination of agricultural seed.

Farmers, certified breeders and seed sellers participated in all phases of data collection following a research method described by Franzel (2000) and Biggs (1999). Since 1998, owners from 5 of the 18 shops found to be marketing crop seed have participated in the study and provide reports of their activities, the number of crops and crop varieties of seeds that they market, and the origin of the seeds that are brought to them. With the assistance of two students from the university in Iquitos,
our team recorded technical information on how these seed sellers control for quality and viability of the seeds, and we tested these methods.

On-farm participant observation methods were used to collect information on techniques and strategies used by semilleros, the certified breeders, to produce, select, store and exchange seeds. While all households in the 6 villages were surveyed for some information, 23 families have been participating in a more intensive manner. Among these, 12 semilleros have been providing continuous data since 1998 on the amount and quality of seeds per species and variety that they produce, store and sell to the seed sellers or other farmers. In addition, the semilleros have provided information on the mechanisms and strategies they use to exchange and procure seeds. Data collected from each semillero were cross-checked during group discussions and dialogues with the most knowledgeable members of each household and community.

Information on governmental and non-governmental seed programmes and incentives from 1970 to 2000 was accessed from the archives held in the municipal office of the agriculture ministry in Iquitos. A series of interviews with agronomists and other technical experts who had participated or are participating in formal seed breeding and dissemination programmes were also conducted using the actor and processes model (Cromwell et al. 2001). Results presented and discussed in this paper are part of the preliminary analysis of the data collected thus far.

Results
Two seed systems are recognized by local people in the study region: the mujo (seed lots) and pedido (requested seeds) systems, referred to here by their Spanish names.

The mujo system
In this system all processes—breeding, management, replacement and storage—are conducted in the villages by families to supply their own needs for planting. Farmers using the mujo system save out small portions of seed, ranging from 0.5 to about 5 kg, from the harvest for planting from one season to the next (Table 1). These seeds are selected based on their size and colour. The two most common receptacles for storing seeds are glass bottles and plastic sacks, and sometimes maize is stored on the cob. An important method for seed preservation identified in this study is the use of burnt motor oil. The technique consists of applying the used oil extracted from the engine of the peque-peque (a local outboard motor) to the outside of the storage receptacle. In the case of maize stored on the cob, the tassel end of the cob is dipped in oil, and in the use of plastic bags, the entire bag is given a thin coating before storage (Table 1). This practice is in line with what Bellon (1998) reports: most seed selection methods include several techniques and strategies that are part of the on-farm conservation practices of poor farmers.

Although most villagers reported that the mujo system was widely practised in Amazonia for managing their seeds lots, it is evidently being employed less and less in Muyuy sector. In 1998, only 37 of the 265 resident families (14%) of six villages surveyed were managing their seed lots using the mujo system (Table 2). This number dropped to 28, or 10%, in 2002.

In the mujo system women play a central role in breeding, selecting and storing seeds. In 19 of 23 participating families using the mujo system, women were the seed managers and were in charge of classifying, supervising and storing seeds to assure that the supply was not contaminated by pathogens or infested by insects. Residents reported that the reason for this is that women have the curiosidad (curiosity) and dedicación (dedication) required in the processes of testing, producing and storing seeds for planting that most men in the villages do not possess or express. Farmers also mentioned that women are more capable than men of producing seeds of high quality for planting. We observed that women are more careful to collect the seeds at the appropriate time during the harvest, which is an important factor in the village certification schemes that control seed quality. Thus, women play an important role in providing the family with planting stock and in maintaining the neighbourhood certification scheme of producing quality seed.
While the seed lots managed by women in this system are relatively small and mainly directed to supply seeds to the family, farmers do exchange seed with other families for products, favours and in a few cases for money. All 23 families have exchanged their seeds for favours such as working in their fields and helping with house construction. Five used their seeds to exchange for products such as fish, sugar and kerosene. Only two sold their seeds to other farmers for cash.

Several reasons explain why the majority of farmers in these villages are not managing their seeds using the *mujo* system. One of the main reasons described by farmers is that most women migrate to the city as adolescents and do not have the opportunity to be trained by their mothers in these techniques and strategies. Farmers mentioned that there are no longer as many women in the villages who are capable of managing the seeds as there were in the past. Farmers also explained that the *mujo* system is not as critical to the family as it was in the past since it is easier to obtain seed from the city today by making a *pedido* to the *comerciantes de semillas*.

Table 1. Average amount of seed of five annual crops that were stored by six farmers in the *mujo* system from 1998 to 2002

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Storage technology</th>
<th>Storage unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Carolina</td>
<td>Bottles (glass)</td>
<td>Seeds</td>
<td>1.8 kg</td>
</tr>
<tr>
<td></td>
<td>Aguja</td>
<td>Bottles (glass)</td>
<td>Seeds</td>
<td>1.2 kg</td>
</tr>
<tr>
<td></td>
<td>Blanco</td>
<td>Plastic sacks painted with burnt oil</td>
<td>Espiga†</td>
<td>34 espigas</td>
</tr>
<tr>
<td></td>
<td>Enano</td>
<td>Bottles (glass)</td>
<td>Seeds</td>
<td>2.4 kg</td>
</tr>
<tr>
<td></td>
<td>Inti</td>
<td>Plastic sacks painted with burnt oil</td>
<td>Espiga†</td>
<td>22 espigas</td>
</tr>
<tr>
<td>Maize</td>
<td>Shishaco</td>
<td>Ears, end dipped in burnt oil</td>
<td>Ears‡</td>
<td>36 ears</td>
</tr>
<tr>
<td></td>
<td>Polvosara</td>
<td>Bottles (glass)</td>
<td>Seeds</td>
<td>1.7 kg</td>
</tr>
<tr>
<td></td>
<td>Pocpoc</td>
<td>Bottles (glass)</td>
<td>Seeds</td>
<td>0.4 kg</td>
</tr>
<tr>
<td></td>
<td>Duro</td>
<td>Ears, end dipped in burnt oil</td>
<td>Ears‡</td>
<td>48 ears</td>
</tr>
<tr>
<td>Beans</td>
<td>Ojo negro</td>
<td>Plastic sacks painted with burnt oil</td>
<td>Vainas§</td>
<td>130 v</td>
</tr>
<tr>
<td></td>
<td>Pindayo menudo</td>
<td>Bottles (glass)</td>
<td>Seeds</td>
<td>1.8 kg</td>
</tr>
<tr>
<td></td>
<td>Garbanzo</td>
<td>Plastic sacks painted with burnt oil</td>
<td>Vainas§</td>
<td>147 vainas</td>
</tr>
<tr>
<td></td>
<td>Ucayalino</td>
<td>Bottles</td>
<td>Seeds</td>
<td>3.4 kg</td>
</tr>
<tr>
<td></td>
<td>Regional</td>
<td>Plastic sacks painted with burnt oil</td>
<td>Vainas§</td>
<td>98 vainas</td>
</tr>
<tr>
<td>Peanuts</td>
<td>Rojo</td>
<td>Plastic sacks painted with burnt oil</td>
<td>Vainas§</td>
<td>272 vainas</td>
</tr>
<tr>
<td></td>
<td>Blanco</td>
<td>Bottles</td>
<td>Seeds</td>
<td>4.6 kg</td>
</tr>
</tbody>
</table>

† An average of 11 espigas of Blanco yields 1 kg of seed, 8 espigas of Inti yields 1 kg of seed.
‡ An average of six ears of Shishaco maize yields 1 kg of seed, 4 ears of Duro yields 1 kg of seed.
§ An average of 33 vainas of Ojo negro is equal to 1 kg of seed, 37 vainas of Garbanzo is equal to 1 kg of seed, 23 vainas of Regional beans is equal to 1 kg of seed, 64 vainas of Blanco peanuts is equal to 1 kg of seed.

Table 2. Number of families practising the *mujo* system in the six villages surveyed during the period from 1998 to 2002

<table>
<thead>
<tr>
<th>Village</th>
<th>Total households</th>
<th>1998</th>
<th>2002</th>
<th>Households practising <em>mujo</em> system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1998</td>
</tr>
<tr>
<td>Cañaveral</td>
<td>47</td>
<td>54</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Mazana</td>
<td>36</td>
<td>48</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Santa Ana</td>
<td>58</td>
<td>43</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Yarina</td>
<td>23</td>
<td>19</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Dos de Mayo</td>
<td>82</td>
<td>78</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Mazanillo</td>
<td>19</td>
<td>26</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>265</td>
<td>268</td>
<td>37</td>
<td>28</td>
</tr>
</tbody>
</table>
The *pedido* system

The actors

The *pedido* system is a hybrid system of selection, breeding, management, replacement, storing and supplying of seeds to rural farmers. The system engages two types of actors involved in three main stages. The actors are (1) certified breeders (*semilleros*) and (2) seed sellers (*comerciantes de semillas*). The *semilleros* are expert rural farmers who practise crop breeding and seed storage on their own. They have been identified by the seed sellers as experts and are widely recognized as such by other farmers. The *comerciantes de semillas* tend to be entrepreneurial individuals residing in urban areas, perhaps originally from a village, who buy and sell seed stock to farmers. Their role, however, is much more complex than that of a simple trader or middleman. The background of the seed sellers, the *comerciantes de semillas*, is an important part of this story and is described next.

The many government and NGO seed programmes implemented in the Peruvian Amazon since the 1960s employed many local people, mainly as part of the service staff. The members of the technical staff of these seed programmes were mainly urban people trained in agricultural schools. Because of the sometimes rigid conceptual and logistical framework from which they operated, the technicians often failed to establish trusting relationships with the rural farmers. Driving boats, preparing plots for planting, and interviewing farmers who would be benefactors of credit and seed programmes, the service employees—who were sometimes recent migrants from rural villages—informally learned techniques and strategies for seed production, selection, storage and dissemination to farmers. They identified the expert farmers in the villages and established and maintained good relationship with them as well as the technical staff.

Often, when their employment terminated, these individuals began to engage in producing and trading certified seeds on their own accord using the knowledge and technologies learned from their involvement in the programmes. Some have gone on to build the hybrid seed systems we are describing here. All of the 18 seed sellers interviewed in Iquitos had participated in some capacity in the formal seed programmes: 12 were formerly employed in government seed certification programmes, 3 were former employees of the agrarian bank that managed a credit programme for promotion of certified seeds, and 2 formerly worked in a development programme run by CARE that provided seeds to farmers.

The *pedido* process in detail

The three stages of the *pedido* system begin with acquisition of new varieties of seed by the *comerciantes de semillas* and negotiation with breeders to work with it; second, on-farm testing by breeders of the viability, growth and yield in the local environment, on-farm breeding and certification; and third, delivery of the certified seed back to the seed seller. The beneficiaries of the *pedido* system are the rural farmers who purchase certified seed from the *comerciantes de semillas* at the start of the planting season. The seed seller also plays an important role in safely storing the seed stock between harvest and planting. The *pedido* system is schematically portrayed in Figure 1.

Step 1. Acquisition of new seed stock. The first step involves seed sellers investigating the possibilities for obtaining new crop varieties or seed sources. Once the source of an interesting variety is identified, the seed seller makes a request, the *pedido* that gives the system its name, to obtain a small amount of the seed from their associate at the source. For some type of exchange negotiated, the associate delivers or sends a small amount of the seed (less than 2 kg for maize) to the seed seller.

Our data show that seed sellers provided an average of six new varieties of annual crops per year to breeders to test in their fields. Most of the varieties of annual crops supplied to *semilleros* by seed sellers come from relatively distant regions in Peru and neighbouring countries (Table 3). They also provided hybrid seeds of maize, beans, watermelon, melon, peppers, tomatoes and other vegetables that are produced and sold in the USA, Europe and Brazil.
Table 3. Places of origin of seeds of rice, maize, beans and peanuts purchased by the 18 seed sellers during the period from 1998 to 2002

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Carolina</td>
<td>Upper Amazon (Yurimaguas)</td>
</tr>
<tr>
<td></td>
<td>Aguja</td>
<td>Ecuador (Upper Napo River)</td>
</tr>
<tr>
<td></td>
<td>Blanco</td>
<td>Coast of Peru (Chiclayo)</td>
</tr>
<tr>
<td></td>
<td>Enano</td>
<td>Upper Amazon (Jaen, Cajamarca)</td>
</tr>
<tr>
<td></td>
<td>Inti</td>
<td>Ucayali River (Contamana)</td>
</tr>
<tr>
<td>Maize</td>
<td>Shishaco</td>
<td>Upper Amazon (Lamas)</td>
</tr>
<tr>
<td></td>
<td>Polvosara</td>
<td>Marañon river (Lagunas)</td>
</tr>
<tr>
<td></td>
<td>Pocpoc</td>
<td>Brazil (Tabatinga)</td>
</tr>
<tr>
<td></td>
<td>Duro</td>
<td>Brazil (Marcos &amp; Tabatinga)</td>
</tr>
<tr>
<td></td>
<td>Costeño</td>
<td>Central Coast of Peru (Huaral, Lima)</td>
</tr>
<tr>
<td>Beans</td>
<td>Ojo negro</td>
<td>Putumayo river (Estrello)</td>
</tr>
<tr>
<td></td>
<td>Ucayalino</td>
<td>Ucayali river (Contamana)</td>
</tr>
<tr>
<td></td>
<td>Huallagino</td>
<td>Huallaga river (Yurimaguas)</td>
</tr>
<tr>
<td></td>
<td>Manteca</td>
<td>Brazil (Tabatinga)</td>
</tr>
<tr>
<td></td>
<td>Pindayo menudo</td>
<td>Ecuador (Upper Napo river)</td>
</tr>
<tr>
<td></td>
<td>Garbanzo</td>
<td>Colombia (Leticia)</td>
</tr>
<tr>
<td>Peanuts</td>
<td>Angelito</td>
<td>Upper Amazon (Puerto Maldonado)</td>
</tr>
<tr>
<td></td>
<td>Bolisho</td>
<td>Upper Amazon (Puerto Maldonado)</td>
</tr>
<tr>
<td></td>
<td>Singasapa</td>
<td>Central Coast of Peru (Ica)</td>
</tr>
<tr>
<td></td>
<td>Blanco</td>
<td>Upper Amazon (Tingo Maria)</td>
</tr>
<tr>
<td></td>
<td>Costeño</td>
<td>North Coast of Peru (Chiclayo)</td>
</tr>
<tr>
<td></td>
<td>San martinense</td>
<td>Upper Amazon (Tarapoto)</td>
</tr>
</tbody>
</table>

Figure 1. A schematic of the hybrid pedido system of seed management.
The seed sellers have built a network of seed suppliers that allows them to obtain seeds (including programme-certified seeds) from many sources, including from Japan as in the case of the green bean featured in the opening narration of this paper. Because of the interaction of seed sellers with people in many sectors of society, the sources of knowledge, technology and seeds are varied: travelers, rural teachers, relatives working overseas, individuals working in development and conservation programmes, farmers and other agents.

Seed sellers continue to expand their networks for getting seeds of annual crops from neighbouring countries, particularly from Brazil. Semilleros reported that the seeds of maize, rice and beans from Brazil are much better than the ones from other regions of Peru, particularly those from the coast of Peru. They reported that it takes only two generations to produce fertile seeds of the Duro hybrid variety of maize that comes from Brazil while it takes five for the Costeño hybrid variety.

Step 2. Seed testing, breeding and certification. In the pedido system, genetic diversity and seed quality are the main trade characteristics used by semilleros and comerciantes de semillas for selection. In all the villages of Muyuy sector the seed sellers have developed certification schemes for the seeds produced, selected and sold by semilleros. This process is locally called neighbour certification and involves semilleros testing the growth and yield of plants from the new seeds (basic seeds4) in local conditions. The seed sellers recognize this system and complement it with additional concepts, rules and standards for seed certification they learned from the formal seed programmes with which they may once have worked. In the agreement negotiated in the pedido system, it is expected that the breeder will follow the rules and uphold the standards established by the seed seller.

In the beginning of this second phase the seed seller provides a portion of the seeds to a few certified breeders (the semillero) and makes a request (another type of pedido) of them to test, breed and produce a certain quantity of certified seed. Both parties agree on the quantity of certified seed to be returned to the seed seller and then how much he or she will purchase over and above that quantity. The seed seller provides information to the semilleros on the basic characteristics of the environment where the seed originated (e.g. locale, elevation, soil humidity). As reported elsewhere, we found that the semilleros strongly consider the relationship of the environment to the crop varieties in the process of breeding new varieties (Gaur et al. 1980; Hühn et al. 1993). The semillero breeds the new varieties using a suite of techniques that include some learned from extension agents of seed programmes or others suggested by the seed sellers. They commonly use interbreeding schemes or plant seed plots within or separated from their fields.

If the seeds are viable through breeding for at least two generations the semilleros produce semilla resistente5, or seeds optimized to local site conditions (soil, humidity, etc.), of the new variety. If the semilla resistente produced by the semilleros is suited to local environmental conditions and resistant to local pests and disease then the certified seeds are sold to the seed seller for market distribution. Both parties negotiate throughout the process and agree on the conditions of sharing the benefits in the event that the breeding experiment yields good results. They will provide the basic information on the growth characteristics and requirements that the seller will then pass along to buyers.

We have observed that semilleros also have experimented with varieties of commercial seeds of different crops available in markets of the USA, Europe and Japan. All certified breeders that participated in this study reported low yields from most commercial seed and that these produce fertile seeds for only one generation. In the case of commercial maize seed brought from temperate regions most plants do not produce fruit, probably for physiological reasons related to daylength.

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4 Basic seeds are those of new varieties of crops that are brought to the villages by villagers or outsiders (particularly members of NGOs and government agencies).
5 Semilla resistente is what agricultural experts call registered seeds.
Semilleros also indicated a familiarity with the limitations of planting hybrid seeds and have experimented with several methods of adapting and changing the agronomic characteristics of the commercial hybrid seeds. The most common method used is interplanting the hybrid seed with local varieties. The interbred seeds are given a name that reflects its origin as in the case of the chiclayo verdura japones described at the beginning of this paper. Both semilleros and comerciantes de semillas then use that name.

A similar process of testing and certification by resident expert breeders is followed for new seed management technologies. Seed sellers or farmers themselves may have learned about or seen an intriguing technique while visiting another village or talking with associates in the city and they wished to try it. An example of this is the technique of using burnt motor oil to protect seeds from predators. In this case, two farmers from the village of Muyuy were told by a farmer from the Napo region that burnt oil is very good for controlling insect infestation of maize seeds stored for planting. This technique was first tested by semilleros who then demonstrated the results to other farmers. In another case, the semilleros tested a technique for protecting seeds of beans, peanuts and rice. They modified the burnt oil technique by using plastic bags to store the seed, coating them with the oil. They found that this technique for seed storage greatly increases the time for keeping seeds before planting. Maize, beans and peanuts can be stored for more than a year when burnt oil is employed compared with a similar method using an extract of hot chillies pepper (Table 4).

<table>
<thead>
<tr>
<th>Seed</th>
<th>Maximum storage time (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Burnt oil</td>
</tr>
<tr>
<td>Corn</td>
<td>28</td>
</tr>
<tr>
<td>Beans</td>
<td>22</td>
</tr>
<tr>
<td>Peanuts</td>
<td>15</td>
</tr>
</tbody>
</table>

Step 3. Buying and selling certified seed. The third step in the pedido system involves strategies for buying and selling seeds produced by the certified breeders. Seed sellers maintain the quality of their seed by buying only from the certified breeders, the semilleros. They employ several strategies for selling and buying seeds from other farmers. In most cases when a semillero produces viable seed, the seller advertises in communities that they have a new variety for sale for planting during next season. Seed sellers always tell farmers that they have a limited amount of seed and that the seeds are only available upon request (again, the pedido, this time by a farmer to the seller). When farmers make a request they tend to negotiate separate prices for the portion of seed for planting and another price for seed they will produce and in turn sell back to the comerciante. Such dynamic relationships among seed sellers, certified breeders and farmers make the pedido system the best channel for moving seeds in and out of the communities.

A comparison of the mujo and pedido systems

The pedido seed system has distinct advantages over the mujo system. There is great advantage in the capacity for individuals of the two local groups, the semilleros and comerciantes de semillas, to learn, integrate and innovate the knowledge and technological resources brought from different places such as the NGO and state seed programmes or neighbours. Although there is always the risk of introducing new pathogens and contaminating the local seed resources, local people have demonstrated that they are capable of developing alternative methods to avoid these problems.

Another advantage of the pedido seed system is in the capacity of the two actors to supply the increasing demand for seed by rural farmers in both quantity and crop diversity. The seed stocks of
all crop varieties offered by seed sellers were tested and produced by certified breeders in the *pedido* seed system. Seed sellers recognize the need to always maintain the diversity of seeds. Data collected from the interview of the 18 seed sellers show that they store and sell a great diversity of crops and varieties to farmers (Table 5).

The *pedido* system also provides more security for seed storage from harvest to the planting season in a system that yields viable and high-quality seeds. These and other factors are the main reason why most farmers procure seeds in the *pedido* system more than in the *mujo* system. The number of families that obtained maize seed through the *pedido* system in 1998, 2000 and 2002 was more than 10 times that of those obtaining seed through the *mujo* system (Table 6).

### Table 5. Number of species and varieties of annual crops sold by 18 seed sellers in Iquitos to farmers in 1998, 2000 and 2002

<table>
<thead>
<tr>
<th>Crops sold</th>
<th>1998</th>
<th>2000</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varieties</td>
<td>26</td>
<td>34</td>
<td>42</td>
</tr>
<tr>
<td>Species</td>
<td>7</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

### Table 6. Number of farmers in the Muyuy sector who obtained maize seed for planting through the *pedido* and *mujo* seed systems

<table>
<thead>
<tr>
<th>Year</th>
<th>Pedido</th>
<th>Mujo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>265</td>
<td>46</td>
</tr>
<tr>
<td>2000</td>
<td>265</td>
<td>39</td>
</tr>
<tr>
<td>2002</td>
<td>268</td>
<td>33</td>
</tr>
</tbody>
</table>

### Conclusion

Where the lack of continuity and instability of seed programmes in the Peruvian Amazon has resulted in limited success in the establishment of formal seed systems, we found that local actors, through their complex and dynamic relationships, moved to fill the need for the rising demand for quality seed. Knowledge and technologies introduced by the many short-term seed programmes of government agencies and NGOs were integrated into a traditional seed system, the *mujo* system, through complex networks and relationships among farmers, traders, travelers, rural teachers, urban entrepreneurs and agricultural technicians. In this region we found that the process of testing new seed varieties and technologies has neither entirely eliminated the traditional *mujo* system nor resulted in the development and adoption of a formal seed system. Rather the blending of techniques, knowledge, concepts and rules by farmers and entrepreneurs has led to the development of the hybrid *pedido* system where elements of the traditional and modern, the formal and informal are integrated by local actors who possess specialized knowledge in breeding and business.

The innovative and dynamic nature of this hybrid system stems from factors such as the continual exchange of seed supply and introduction of different varieties, and the enterprising farmers who engage different sets of knowledge, rules and techniques in the process of selecting, saving and exchanging seeds that incorporate people and resources from inside as well as outside the communities. The respective roles of the local actors, and their relationships based on trust and respect, allow for continual renovation of quality and diversity of seed.

Our analysis of the seed systems in smallholder societies of the Peruvian Amazon suggests a complex pattern that makes it difficult to clearly differentiate the formal from the informal categories of seed systems so commonly cited in the agricultural literature. Such links between the formal seed programmes and local seed breeding systems have facilitated access to seeds and seed technologies by rural farmers and a mechanism of control of seed quality (including standards for seed certification) used by formal seed industries. The level of specialization and expertise required for the control of quality, diversity and quantity of seeds supplied to rural farmers to plant from one season to the next is provided by these two highly specialized and experienced groups of local people.

This study shows that by examining the subtle influence of programmes external to the village, rather than by focusing on the limitations of formal seed programmes (Van de Fliert 1998; Waage 2001), researchers can better understand local processes and recognize where the value lies in formal programmes.
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On-farm seed systems and crop genetic diversity

Didier Balma¹, T. Jérémy Ouedraogo¹ and Mahamadou Sawadogo²

¹INERA, Département Productions Végétales, Ouagadougou, Burkina Faso
²UFR-Sciences de la Vie et de la Terre, Université de Ouagadougou, Ouagadougou, Burkina Faso

Introduction
Nowadays a dual system of seed supply is leading agricultural activities in developing countries, with a formal system of organized seed production and an informal system based on small scale farmers’ retention of seed from previous harvest, storage, gifts and exchange of this seed within and between communities. That is why we have to avoid debates on this kind of duality and focus on what we, as genetic diversity people, are concerned with when we are talking about on-farm seed systems. As Douglas (1980) stated, formal seed supply systems, characterized by vertically organized production and distribution of tested seed and approved varieties, using strict quality control, are similar throughout the world and have been well documented. We must be most concerned with seed supply source characterized by local seed reproduction by small-scale farmers themselves, using local seed selection, production and conditioning practices that constitute the main bottleneck of traditional farming. Farmers’ seed supply is a complex and dynamic system of interrelated activities and components that can be compared to the principal components of the formal seed system: breeding, seed production and distribution (Almekinders et al. 1994).

This paper analyzes traditional seed supply systems of food crops through a review of the in situ project implemented in Burkina Faso in 1997 with the initiative of IPGRI. The constraints arising from combining elements of the traditional and formal seed systems in the integrated seed systems are discussed.

Material and methods
Vegetal material
Six crops were selected for the following reasons: sorghum, pearl millet, groundnut and cowpea are the four most important crops in Burkina Faso; okra (Abelmoschus esculentus) is considered to be a women’s crop in the country, and Frafra potato (Solenostemon sp.), is considered to be the most endangered tuber crop in Burkina Faso.

Study sites and households
The three sites were chosen taking into account low rainfall and high fluctuation of rainfall, which can have a high impact on crop diversity resulting from genetic erosion in the area. Every village tested had at least five to six crop species and three or more varieties per crop, as well as the presence of NGOs and farmers’ organizations. These farmers had to be permanent and full-time farmers having knowledge of the wild relatives of crops.

On one hand we studied three farmers in every test village who had organized themselves as a single group to cultivate one community field for producing seed based on the best varieties of the whole village, and on the other hand we considered community field schools for participatory varietal selection to produce seed subsequently.

Method of sampling and data analysis
Community fields for seed production were established taking into account the cultivable land availability in every test village and applying field plot isolation techniques for open-pollinated species (for example pearl millet in our case). To avoid any pollen grain flow, techniques using intercalary fields sown with different species or moving forward the dates of sowing were applied.
Two sessions for weeding out to preserve seed purity and cleanness were held for each individual farmer or community field: the first session took place just before the flowering stage and the second one after harvesting pearl millet and sorghum and during hulling for cowpea, okra and groundnut.

An evaluation of seed purity and cleanness following by phytosanitary observation was made using a 30 square yield sampling method (10 lines x 10 steps).

A field study and survey from 1997 to 2002 in 3 sites of the in situ project in Burkina Faso involved 54 households totalling 907 household members. The aim was to investigate social factors affecting farmers’ variety selection and utilization in traditional seed systems. Key information discussions were based on a participatory approach, focus group interviews based on semi-structured questionnaire, and open questions about farmers’ seed system production and supply systems. Data analysis was based on GIS (ARC-VIEW, Flora map, Diva), Shannon Weaver Index (SWI) diversity.

**Results**

Much of the information obtained indicated that traditional seed systems are extremely heterogeneous (Figure 1) according to socio-cultural, ethnic and socioeconomic values but highly dynamic and slightly similar according to seed-production techniques for improved crops and landraces. The majority of farmers made seed selection directly from the field during harvest. Generally farmers were reported to prefer traditional varieties because of their better adaptability in local agroecosystems, such as pest and disease resistance.

![Influencing factor](image.png)

**Figure 1.** Factors influencing farmers’ decision-making in seed production. Each bar in a set of three for a factor represents a study site.

Most farmers used their own seeds, and seeds of new varieties were mostly obtained from local sources (local seed-exchange mechanisms, local market, NGOs, extension agencies, etc.).

In evaluating the seed quantity conserved by households from 1997 to 2002 (Figure 2 and 3) we realized that 20% - 48% of farmers increased (doubled or trebled) their seed quantity to guarantee two or three sowings in case of a bad beginning of the rainy season. The threshold for increased seed quantity was reached in 2000-01. It appears that the farmers cannot produce more maybe because of the restrictions of the conservation tools, which are not yet improved; maybe because of the lack of seed prospects and markets. Some farmers (40-46%) have not yet increased the seed quantity they
conserve. A few farmers (around 5–10%), who are very traditional, have remained far behind their colleagues who are increasing their seed quantity.

In most cases the storage bottleneck comes from seed-borne diseases and insect damage. Observations made from 1999 to 2002 reveal that the farmers’ saved seed is of poor health status every year and the quantity of seed that failed to meet the minimum for seed certification or direct use for sowing is quite high despite the decrease of seed lost during the same period (Figure 4). This decrease of seed lost is due to the in situ project’s influence on farmers, and that is the proof that improving seed production and seed supply systems on-farm calls for educating the farmers about

![Figure 2. Evolution of pearl millet seed quantity conserved by farmers in the site of Ouahigouya: K=Konfé; Y=Yampa.](image1)

![Figure 3. Evolution of cowpea seed quantity conserved by farmers in the site of Thiogou: ND=Nacoula Dominique; BM=Bancé Moumouni; LO=Larba Oumarou; NT=Nam Tokira; ZH=Zoungrina Hamado; GD=Guigma Dabousiniego; DI=Dipama Issa; BV=Bouda Vonogo; SI=Segda Idrissa; IB=Ilboudo Bebtigba.](image2)

In most cases the storage bottleneck comes from seed-borne diseases and insect damage. Observations made from 1999 to 2002 reveal that the farmers’ saved seed is of poor health status every year and the quantity of seed that failed to meet the minimum for seed certification or direct use for sowing is quite high despite the decrease of seed lost during the same period (Figure 4). This decrease of seed lost is due to the in situ project’s influence on farmers, and that is the proof that improving seed production and seed supply systems on-farm calls for educating the farmers about
seed health, i.e. use of disease-free seed and treatment during vegetative stage, storing seed with proper free moisture content (Kashyap and Dehan 1994).

Factors leading traditional seed sources and diffusion
There are several sources from which a small-scale farmer can obtain seed: his or her own harvest, farmer-to-farmer, the local market, formal sector, NGOs and recently local seed banks. The farmer’s own seed has the advantage of known quality and well known by the farmer. When the farmer did not save seed because of disaster like a drought season, degenerated seed, wars, farmer’s overconsumption, plant diseases and pests or when he wants to plant a new variety, he or she has to look for other sources. For that the best source is the local one because local seeds have the advantage that the variety or plant populations are usually known to be adapted to the agroecological and socioeconomic conditions of a given area. Farmer-to-farmer seed exchange mechanisms are mostly based on traditional social networks and family relations and can be very effective in the diffusion of new varieties (Franco and Schmidt 1985; Maurya et al. 1988; Almekinders et al. 1994).

Discussion and conclusions
Reports on local production and selection practices demonstrate the presence of capable farmers-breeders in the farming community. Burkina Faso pearl millet and maize farmers harvest seed from the centre of the field to maintain “purity”. They harvest millet spikes and sorghum panicles from a range of plant parent types, taking into account the uniformity of grain colour and spikelet dehiscence. Seed renewal was practised more often in the case of improved varieties than in the case of traditional ones. This means that the repeated local renewal of the seed by farmers is a key process in the functioning of local seed systems (Almekinders et al. 1994). Farmers’ agrobiodiversity allows the cultivars to continuously interact with each other, and with their agroecological, socioeconomic and socio-cultural environments. The duality between men-farmers’ and women-farmers’ criteria of selection is one of the main factors affecting the process through variety choice, seed production and selection practices. We refer to the different members of a farming household who influence the utilization of varieties and the seed selection. Farmers’ variety selection and utilization purposes deal with a variable environment and have multiple production objectives which all affect his or her

Figure 4. Evolution of cowpea seed lost in the site of Thiougou. Variety: 1=Nacoula Dominique, 2=Bancé Moumouni, 3= Larba Oumarou, 4= Nam Tokira, 5= Zoungrana Hamado, 6= Guigma Daboulsiniesgo, 7=Dipama Issa, 8=Bouda Vonogo, 9= Segda Idrissa, 10= Ilboudo Bebtigdba, 11= Moyenne.
choice of crop and selection of genotypes. That is why any breeding programme can not be achieved without taking into account the preferential choice of men-farmers and the preferential choice of the women-farmers and socio-cultural factors. In the formal breeding programmes the most important objective is, by far, high yield and stability, adaptation to new production techniques and conditions, market demand, various technologies and consumption purposes, while yield stability is a particularly important objective for farmers producing at the subsistence level.

Landraces were grown more often than improved varieties because of their culinary qualities and their adaptability to local technology. In the drought-prone areas, some traditional varieties are important because they combine good yields with earliness. The improved varieties were grown only because of their high yields, earliness and market security. As emphasized by Almekinders et al. (1994), however, they combine a high degree of yield stability with a relatively low yield potential. Increasing pressures on land through population growth, and the subsequent pressure of city life and agricultural business, have caused rapid shifts in agricultural production conditions toward use of modern technologies. Positively speaking, traditional seed systems have been shown to be dynamic, and have a high level of flexibility and courtesy in meeting the local demands and capacity of farmers. However traditional seed systems do have limitations. Also, traditional methods of seed production and storage conditions can be improved, especially where storage conditions are unfavourable with regard to farmers’ capacity to store a large quantity of seed.

In the Sahelian areas like Burkina Faso, availability of local seed can be severely affected by drought or other natural disasters which reduce yield and quality levels. When large areas are affected by poor yield the local seed market and social structures may fail to operate. Seed-exchange systems may be narrow and, as emphasized by Sperling and Loevinsohn (1993), farmers generally do not exchange seed of a new variety until it has been multiplied and tested for several seasons. But in a severe disaster situation they may fail to do that. There is a need to create a training guide for integrated formal and informal seed systems which enhances farmers’ capacity-building.

**Lessons learned**

In the Sahelian areas of Burkina Faso, which are characterized by a high frequency of drought seasons, conserving a high diversity of crops can be an alternative for survival. The management of this diversity means the farmer has a certain mastery over seed supply and production. This is the only way to guarantee food security for poor farmers from year to year. The frequency of drought seasons determines the level and the nature of seed supply. A significant quantity of seed is maintained by farmers, moreso since the *in situ* project was implemented. As we have seen, the seed supply system on-farm is a diverse and complex topic (community-based quality seed production, community-based seed fairs, participatory varietal selection based on farmers’ criteria, mass training of farmers, farmers’ seed certification, collection of genetic material, local genebank and seed bank management, setting up of seed flow mechanisms and markets, capacity-building), and as a result no training guide can cover every detail of the discipline involved.

**References**

Almekinders CJM, Louwaars NP and de Bruijn GH. 1994. Local seed systems and their importance for an improved seed supply in developing countries. Euphytica 78:207-216.


Multi-level seed movement across producers, consumers and key market actors – seed marketing, exchange and seed regulatory framework in Hungary

István Már¹, Á. Gyovai¹, Gy. Bela² and L. Holly¹
¹Institute for Agrobotany, Tápiószele, Hungary
²Institute of Environmental Management, St. István University, Gödöllő, Hungary

Introduction
The small-scale farming system has an established tradition in Hungary, and neither the socialist regime nor the agricultural crises that followed succeeded in reducing its function. The average size of small farms is 4.8 ha; 12.71% of cooperatives and 94.81% of private holdings have less than 10 ha area.

According to the census of farmers (2000) most of the households (697 336) have home gardens, and the total of 41 193.66 ha implies an average garden size of 591 m². The primary goal of these gardens is to add additional income to the families’ budget. As the result of the burst of plant breeding activity the landraces were displaced from large- and middle-scale farming systems and continued to be cultivated mainly on small-scale, traditional farms in marginal areas. Beyond the important role that home gardens and small plots play in supplying healthy foodstuffs for families, and also additional income, they are the most significant space for crop biodiversity conservation in Hungary.

Research methodology
From the overall activities done within the framework of the Hungarian on-farm research project, one is targeted at revealing the mechanisms acting for or against the seed system, primarily those with high impact on biodiversity conservation.

In 2001, the Institute for Agrobotany in joint partnership with IPGRI initiated research focused on the economics of biodiversity conservation and sustainable use. During 2002, a pre-defined questionnaire was used to collect information from more than 300 households located in three regions targeted by the project (Dévaványa, Örség and Tiszahát) to reveal the actual social and economic status of households with potential roles in conservation. Selection of study sites for the economic research, and through this the informal seed system research, was done by taking into account several criteria. The first was to set up a link between the on-farm conservation research and National Agri-Environmental Programme (NAEP). Hungarian Environmentally Sensitive Areas (ESAs) are areas with low agricultural productivity but high environmental value. In the context of the NAEP, the main goal of the ESA system is to protect natural areas, such as those inhabited by endangered plant and animal species, through supporting extensive production methods. In the three research sites, the ESA system provides opportunities for: (1) application of extensive production methods oriented toward environmental protection (Szatmár-Bereg region), (2) habitat development for endangered species (Dévaványa region), and (3) ‘mosaic’ farming with small plots (Örség-Vend region). The farmers who have fields located within the ESA boundaries are eligible for support and payments according to the package of farm management rules tailored to the ecological potential and protection needs of each region. However, no support system as yet exists for conservation of landraces and agricultural biodiversity found in home gardens and on small farms. Biological and economics research on this project is therefore designed to investigate, document and analyze the ecological, social and economic importance of this diversity for those involved in policy formulation.

The settlements chosen are located within the pilot sites of the NAEP and also are located in areas where collecting missions had been conducted and a number of traditional varieties had been identified. The sites differ by major contrasts in terms of agroecology and market infrastructure,
associated with differences in farming system and land-use intensity. All of these sites belongs to the high-sensitivity category and are included as primarily important regions in the National Agri-Environmental Program. Other information taken into account to characterize the informal seed system was recorded during the collecting missions organized in the period 1997–2002. By revisiting the targeted regions we have obtained useful information, mainly on management practices (seed storage, seed selection, land management, trends in landownership, etc.).

**Short description of study sites**

**Dévaványa region**

Dévaványa region is located in the centre of the Hungarian Great Plain. The area is flat and the natural conditions (climate, soil) are generally suitable for intensive crop production. There the landscape is a mosaic of cultivated lands and grasslands where the soil conditions are less suitable for cultivation. These different soil conditions justify a combination of both intensive agriculture and extensive grazing at the same site. In Dévaványa region the goal of NAEP is the protection of the rich wildlife.

This region is the most urbanized among the sites selected. With one exception, each of the five settlements included in the site represents a town with an area of 12 387 up to 30 398 ha. The population size of the settlements ranges from 5334 to 15 874 inhabitants. Here migration is not an important factor, but the number of inhabitants is stagnating. The infrastructure is well developed.

**Szatmár-Bereg region**

Szatmár-Bereg is in the northeast of Hungary, on the Ukrainian border. The characteristics of the area are similar to the Dévaványa region. The landscape is a mosaic of grasslands, forests, arable lands and moors. Aside from the beautiful landscape, the region has several important natural endowments. There are plans for the future establishment of a national park. Today the NAEP promotes nature conservation in this ESA.

In Szatmár-Bereg, villages are relatively small, both in area (1600–2819 ha), and population (488–939 inhabitants). All of the six villages face the problem of an aging population. The explanation for this pattern is straightforward. The region is a less-favoured area for agricultural production and is located far from the economic centre of the country. There have been few investments in infrastructure or employment-generation, and the unemployment rate is high (15–30%). A particular disadvantage for economic development of the region is its low road density.

**Őrség-Vend region**

Őrség-Vend region is located in the southeast of Hungary, on the Slovenian border. This region differs from the other two sites in many ways. The agricultural landscape is heterogeneous, including knolls, valleys, forests, grasslands and arable lands. Poor soil conditions render intensive agricultural production methods impossible. Here, NAEP supports extensive production methods to preserve the landscape for future generations.

In this study site the 11 villages are extremely small (520–3356 ha), and the smallest villages have only 58 to 267 inhabitants. The problem of a declining and aging population is even greater in these communities than in Szatmár-Bereg. Moreover, the unique forms of settlement in this region—‘szer’ and ‘szórvány’—make it difficult to design the public utilities necessary to support villages. Most villages are far from towns, and road density is very low.

**Selection of households**

The first step in selecting households was to determine a sampling frame. Village authorities were unwilling to provide a list of households in the settlements because of concerns for personal privacy. Existing databases from the Ministry of the Interior were too costly to obtain. The list was therefore compiled by combining information from detailed maps drawn by the NAEP and the database of
Hungarian Central Statistical Office TSTAR. Since little was known about the characteristics of the households in the survey sites and the extent of their involvement in agricultural production and home gardens, a brief screening questionnaire was designed in order to better target the sample in a second stage. Since a minimum final sample of 100 per site was thought necessary for data analysis, and the response rate to a mail survey was expected to be low, the team decided to include 600 households per site (1800) in the first stage. All administrative units within the sites were sorted based on population sizes and the initial sample was distributed proportionally.

These two information sources (household interviews and field interviews) provided data and information (Table 1) to assess the links within the formal and informal seed systems.

### Table 1. Percentage distribution of respondents by type of agricultural participation

<table>
<thead>
<tr>
<th>Region</th>
<th>Home garden only</th>
<th>Field only</th>
<th>Home garden and field</th>
<th>No home garden, no field</th>
<th>Landrace growing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dévaványa</td>
<td>49.57</td>
<td>4.20</td>
<td>21.84</td>
<td>24.36</td>
<td>32.77</td>
</tr>
<tr>
<td>Szatmár-Bereg</td>
<td>45.00</td>
<td>1.66</td>
<td>46.66</td>
<td>6.66</td>
<td>50.00</td>
</tr>
<tr>
<td>Örség-Vend</td>
<td>30.90</td>
<td>1.81</td>
<td>54.54</td>
<td>12.72</td>
<td>35.18</td>
</tr>
<tr>
<td>Average</td>
<td>41.82</td>
<td>2.55</td>
<td>41.01</td>
<td>14.58</td>
<td>39.31</td>
</tr>
</tbody>
</table>

### Results

In the project sites during the field interviews 22 villages were visited and at the end of the field mission we had responses from a total of 332 households. The data in Table 2 show the diversity of species and varieties kept by the households, and also the differences in diversity between home gardens and arable fields.

### Table 2. Genetic diversity of the project sites

<table>
<thead>
<tr>
<th>Region</th>
<th>Dévavnya</th>
<th>Örség</th>
<th>Tiszahát</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of settlements</td>
<td>5</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>No. of households visited</td>
<td>112</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>Total no. of species (home garden)</td>
<td>211</td>
<td>470</td>
<td>234</td>
</tr>
<tr>
<td>Total no. of varieties (home garden)</td>
<td>1763</td>
<td>3059</td>
<td>2044</td>
</tr>
<tr>
<td>Total no. of species (arable land)</td>
<td>125</td>
<td>193</td>
<td>53</td>
</tr>
<tr>
<td>Total no. of varieties (arable land)</td>
<td>373</td>
<td>518</td>
<td>164</td>
</tr>
<tr>
<td>No. of bean growers</td>
<td>83</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>Total no. of bean UDs†</td>
<td>142</td>
<td>211</td>
<td>224</td>
</tr>
<tr>
<td>No. of farmers growing local bean varieties</td>
<td>27</td>
<td>55</td>
<td>56</td>
</tr>
<tr>
<td>No. of local bean varieties (FUDs) †</td>
<td>46</td>
<td>109</td>
<td>119</td>
</tr>
<tr>
<td>No. of maize growers</td>
<td>48</td>
<td>64</td>
<td>82</td>
</tr>
<tr>
<td>Total no. of maize UDs</td>
<td>60</td>
<td>75</td>
<td>97</td>
</tr>
<tr>
<td>No. of farmers growing local maize varieties</td>
<td>4</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>No. of local maize varieties (FUDs)</td>
<td>4</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

†UD = unit of diversity; FUD = farmer unit of diversity.

From the perspective of an agricultural management system the Dévaványa region belongs to the most intensively managed agricultural regions of the country. In the other two regions, in contrast,
the farmers manage their fields in a much more extensive matter (low-input system). The data recorded in the field show the same pattern, namely the average ratio of diversity on arable fields vs. home gardens was 41% (the highest in Dévaványa 60%, the lowest in Tiszahát 23%). Also, in the number of varieties on arable lands vs. home gardens we have found significant differences: 21% in Dévaványa, 17% in Örség and only 8% in Tiszahát region.

In each region the cultivation of beans is very common. Most farmers used to grow beans to cover their own annual consumption and to get some additional revenue for the family. In winter, beans are one of the most important, and the cheapest, vegetal protein sources. As beans are a labour-intensive crop, they are grown mainly in home gardens; in Dévaványa 74%, in Örség 91% and in Tiszahát 89% of the respondents used to grow beans. Only a small amount is produced on arable lands, generally high-yielding varieties (HYV) adapted to intensive conditions. On average 46% of cultivated varieties are traditional varieties. For these farmers the primary seed source is the local market and seed exchange among relatives, and/or relatives and neighbours. In Dévaványa 26% of farmers cover 42% of their needs from the local informal seed exchange network. This ratio is 60% (72% of needs) in Örség and 72% (81% of needs) in Tiszahát. Seeds procured from the formal sector are in a ratio of 47% (43% of farmers) in Dévaványa, 19% (18% of farmers) in Örség and 14% (14% of farmers) in Tiszahát (Table 3). A relatively high number of farmers (on average 18%) have not defined their seed sources by varieties and by time.

<table>
<thead>
<tr>
<th></th>
<th>Dévaványa</th>
<th>Farmers</th>
<th>Örség</th>
<th>Farmers</th>
<th>Tiszahát</th>
<th>Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Relatives and neighbours</td>
<td>52</td>
<td>37.0</td>
<td>20</td>
<td>24.1</td>
<td>143</td>
<td>68.0</td>
</tr>
<tr>
<td>Seed companies</td>
<td>67</td>
<td>47.0</td>
<td>36</td>
<td>43.4</td>
<td>41</td>
<td>19.0</td>
</tr>
<tr>
<td>Local market</td>
<td>7</td>
<td>5.0</td>
<td>2</td>
<td>2.4</td>
<td>8</td>
<td>4.0</td>
</tr>
<tr>
<td>Several seed sources†</td>
<td>3</td>
<td>2.0</td>
<td>21</td>
<td>25.3</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Unknown</td>
<td>13</td>
<td>9.0</td>
<td>4</td>
<td>4.8</td>
<td>17</td>
<td>8.0</td>
</tr>
<tr>
<td>Total</td>
<td>142</td>
<td>100</td>
<td>83</td>
<td>100</td>
<td>211</td>
<td>100</td>
</tr>
</tbody>
</table>

†Several seed sources = sources for seed procurement not defined by time period and variety.

The cultivation of maize varieties, and especially of local traditional varieties, is completely different from the cultivation of bean. Because of several seed regulations the local maize varieties cannot be used on large fields. The hybridization programmes had a crucial role in the spread of HYVs, adopted first by large-scale farmers and cooperatives and later by smaller-scale farmers. Today all farmers have access to registered seeds and the network of shops and traders is well developed so that there are no distribution problems. In parallel with the expansion of the formal seed trade in local farming communities, the informal system weakened. Access to local seeds and knowledge about specific production practices are difficult and are realized through personal contacts. Seed sales in local markets are exclusively controlled by the National Institute for Agricultural Quality Control, so that the functioning of a local-informal seed system is not legalized. Usually, in the local markets the seeds of traditional varieties are sold as foodstuff for food or feed.

In such conditions in Dévaványa the seeds provided by the informal seed network represent 15%, in Örség 27% and in Tiszahát 26%. Most of the farmers, on average 64%, procure their maize seeds only from the formal sector (Table 4).
Table 4. Seed sources for maize – number of units of diversity (UDs) procured from different sources and number of farmers using specific seed sources

<table>
<thead>
<tr>
<th></th>
<th>Dévaványa</th>
<th></th>
<th>Órség</th>
<th></th>
<th>Tiszahát</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UDs</td>
<td>Farmers</td>
<td>UDs</td>
<td>Farmers</td>
<td>UDs</td>
<td>Farmers</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Relatives and</td>
<td>5</td>
<td>8.3</td>
<td>12</td>
<td>16.0</td>
<td>25</td>
<td>26.0</td>
</tr>
<tr>
<td>neighbours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed companies</td>
<td>48</td>
<td>80.0</td>
<td>49</td>
<td>65.0</td>
<td>57</td>
<td>59.0</td>
</tr>
<tr>
<td>Local market</td>
<td>4</td>
<td>6.7</td>
<td>8</td>
<td>11.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Several seed</td>
<td>1</td>
<td>1.7</td>
<td>1</td>
<td>1.3</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>sources†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>3.3</td>
<td>5</td>
<td>6.7</td>
<td>9</td>
<td>9.0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5.0</td>
</tr>
<tr>
<td>(emergency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>allowance)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100</td>
<td>75</td>
<td>100</td>
<td>97</td>
<td>100</td>
</tr>
</tbody>
</table>

The seed replacement strategy plays an essential role in long-term cultivation and conservation of locally adapted plant varieties. The seed replacement strategy differs by crop and region. In the case of bean 74% (Dévaványa), 83% (Órség) and 89% (Tiszahát) of farmers replaced seed less than six times or had practised no seed replacement for their varieties during the last two decades. In the case of maize the figures are slightly higher: 92% in Dévaványa, 94% in Órség, 84% in Tiszahát (Table 5).

Table 5. Seed replacement – number of farmers replacing varieties periodically

<table>
<thead>
<tr>
<th>Replacement</th>
<th>Dévaványa</th>
<th></th>
<th>Órség</th>
<th></th>
<th>Tiszahát</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bean</td>
<td></td>
<td>Bean</td>
<td></td>
<td>Bean</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>No seed replacement</td>
<td>26</td>
<td>31.3</td>
<td>10</td>
<td>21.0</td>
<td>56</td>
<td>56.0</td>
</tr>
<tr>
<td>At least 3, but &lt;6 times</td>
<td>36</td>
<td>43.4</td>
<td>34</td>
<td>71.0</td>
<td>27</td>
<td>27.0</td>
</tr>
<tr>
<td>More than 6 times</td>
<td>1</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>No defined replacement strategy</td>
<td>20</td>
<td>24.1</td>
<td>4</td>
<td>8.0</td>
<td>15</td>
<td>15.0</td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>100</td>
<td>48</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Both formal and local-informal seed systems have a tradition in Hungary. Economic transformation, social structure and cultural change have affected both systems and their institutional setting. In the last 15 years, the seed system changed considerably because seed companies were gradually privatised and the agricultural sector was liberalized. In the near future, the European Union will require other minor changes in the Hungarian institutional structure and legislation.

The market for seeds is an open market, and anyone is entitled to trade in seeds, provided that a seed has been certified by the Hungarian Agricultural Quality Control Authority. At present there are 936 companies in the formal seed sector, quite a number of which trade in seeds. The size and
The functioning of seed systems differs for the study crops (maize and beans). The maize seed industry is vertically integrated and concentrated, with a few multinational companies sharing total sales. The bean seed industry is not so concentrated and is relatively small. In 2001 the harvested area of maize was 1,258,120 ha, of which 29,017 ha was for seed propagation. After quality control and certification, a major share of the planting material (seed) (59%–32,471 t) was exported, mainly to western European countries. The propagation area for bean (including green bean) was just 97 ha in 2001, and the total harvested production is not enough to satisfy domestic demand, so that bean imports are required. In such a way the production of local traditional varieties is targeted to cover mainly farmers’ own consumption and only a relatively small quantity is sold on the market. For maize this amount is 100% for own consumption, for bean the average is 92% for own consumption and 8% for market (Table 6).

<table>
<thead>
<tr>
<th>Table 6. Use categories of local varieties – number of farmers and FUDs per use categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own consumption</td>
</tr>
<tr>
<td>No.</td>
</tr>
<tr>
<td>Dévaványa</td>
</tr>
<tr>
<td>Bean FUD</td>
</tr>
<tr>
<td>Farmers</td>
</tr>
<tr>
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**Conclusion**

Fierce competition on the seed market after liberalization took place in the local-informal seed system. In the case of certain species (e.g. bean) the local informal seed exchange and trade is more extensive than in the tightly controlled commercial species (maize, wheat, sunflower, etc.). Since trading of local varieties is forbidden, there are no precise market data about the frequency of their use. The farm household survey completed in 2002 in the above-mentioned regions gives only an overview on the main seed sources, the frequency of seed replacement and the use categories of varieties grown by the farmers.

The Hungarian seed market is small. Investment in breeding for the specific conditions of a certain production niche is uneconomic, and the few Hungarian research institutions involved in this kind of work are not financially viable. Only very few registered seeds traded in Hungary are bred from local varieties. The use of high-yielding varieties produced by multinational companies and registered by the authorities is the norm.

One possible prospect for the future is that the local informal seed system might be legalized and supported by government, to encourage the establishment of a well-integrated seed sector.
Seed savers’ organizations and participatory breeding activities might be supported as part of the National Agri-Environment Programme, along with the investigation of labelling approaches to protect an organic production process or production quality.
Session III. Genetic diversity consequences of seed systems

The seed system and genetic diversity

A. H. D. Brown
CSIRO Plant Industry, Canberra, Australia

Introduction
To consider the interactions between genetic diversity and the seed system we might first ask: What properties do farmers want their seeds to possess? With so much depending on seed quality, farmers are likely to look for seeds that are:

- Viable, undamaged, ripened, cleaned, with high germination capacity;
- Healthy, free of disease and weed contaminants;
- Economical, since seed is an outlay to yield a livelihood;
- Productive, locally adapted to their conditions and their purposes;
- New or improved, ideally with new characters to meet old problems;
- “Pure”, i.e. true-to-type or types.

This is already a long list and its length raises the question of when genetic diversity within a variety per se, or genetic divergence between varieties, might rank as additional criteria in a farmer’s choice of seed. Some possible answers as to when genetically diverse seed may be the farmer’s preference are: (1) to match a diversity of uses; (2) to meet the demands of a very heterogeneous or marginal environment; (3) to keep alive any varieties inherited as family heirlooms; or (4) to keep open contingencies to provide for future options.

In this discussion of the seed system, we focus on the nature and the sources of “seed” (true seed and vegetative propagules). Several sources typically comprise the farmers’ seed, ranging from their own saved lots, to those obtained locally from family, neighbours, village sources, local and distant markets and from the formal seed sector. Measures of the proportions of these different inputs and their genetic relationships to one another form a basic description of the “seed flow” in the system. The outstanding and challenging features of this complex system are that it is hierarchical in space, it is likely to be variable or stochastic or fluctuating in time, and is dynamic in being subject to systematic trends (arising, for example, from innovation, changing agricultural systems, rural development, climatic change, etc.)

The measurement of genetic diversity itself is no less challenging. The concepts of diversity to be included are:

- Richness—i.e. how many different kinds are present in a population? This is the basic measure of diversity despite the difficulty of standardizing it to comparable sample sizes;
- Evenness—or similarity in frequency of variants, i.e. how likely are two items (individuals, fields, landraces, etc.) to differ? In the seed systems, this is an important indicator of how accessible variants are to any one farmer. Also another interpretation of unevenness of frequencies is dominance of the most common type. High dominance implies large areas of genetic similarity and hence higher genetic vulnerability;
- Divergence—i.e. how related are populations? This is usually based on measuring phenotypic or genetic resemblance. Increasingly in the future DNA sequence comparisons could give us more precise estimates of historical relationships (Hey and Machado 2003);
- Adaptedness—how ecologically diverse are the environments in which the population or landrace can grow? One problem with this measure is that it is biased toward generalists, whereas specialists are clearly as important to consider.

The features of the seed system that are likely to affect the survival of genetic diversity in the short term are as follows:
• The system comprises a complex of processes that range in scale from the highly localized to the very widespread;
• The system is labile in time, subject to cultural, political, economic and environmental change;
• It is highly stochastic from both (a) fluctuations in time and space, and (b) catastrophes and calamities;
• Farmers can be the agents of strong selection both between and within varieties (farmers’ managed units), particularly when much seed is sourced from a relatively few key farmers, or when diverging gender perspectives on seed selection promote diversity;
• The kind and mode of producing of propagating material—whether clonal, sexual (autogamous, or open-pollinated)—affects the organization of diversity;
• The mode of introducing new diversity—whether by mixing, blending, or replacement of older populations with new varieties;
• The size of the seed production system and whether the source populations represent the diversity in the crop;
• The proportions of the two components from the formal and informal sectors, and extent to which their roles diverge or overlap.

Population genetics of the seed system

The first step in analyzing the genetic diversity consequences of the seed system is a quantitative estimate of the population structure of a landrace, namely the network of partially or variably isolated subpopulations, their sizes and their connectivity, that make up the plantings of that landrace in a region. The linkages among components of the network arise from the seed supply system, or “seed flows”. Ideally we would also like to know the genetic relationship among these members, and in particular the degree of relationship between the name of a landrace and its genetic make-up. However it is unlikely that such precise genetic information is critical to analyzing diversity trends in the system; analyses are possible based on farmer names, varietal characters and seed flow rates. Names are the farmers’ management label, although imperfectly related to genes. Unrecognized divergence between seed lots with the same name, or undetected geneflow between named landraces, may merely alter the apportioning of diversity, increasing that within seed lots and lowering the diversity between such units.

Knowledge of the breeding system of plant populations is crucial to any understanding of their genetics. The breeding system forms the ways in which genes are transmitted to the next generation of seeds. Furthermore, the breeding system is fundamental in producing the raw material of the seed system. Different breeding systems have very different effects on the genetic structure of the species; and on the operation of evolutionary forces. The principal kinds of breeding system are vegetative (clonal) or sexual, and if sexual then either self- or open-pollinated. In open-pollinated species, the breeding system includes the nature of pollination (wind-blown, insect-borne, etc.) and the paternity of fruits (i.e. whether the pollen is from a single or multiple sources). Although spoken in categorical terms, it is important to realize that the breeding system is itself flexible and may vary between and within plants, populations and environments. In many domesticated species, it is open to human manipulation (e.g. maize, date palm). It is therefore both a tool for, and a limitation on, how farmers can manage diversity in seed systems.

In forming the link between one generation and the next, the seed system itself can set in train the operation of evolutionary forces (that maintain or change the genetic make-up of plant populations). These forces are:
• Finite population size, genetic drift and bottlenecks - arise from a limited number and limited size of the populations that are sources of seed;
• Migration - seed exchange (and pollen flow);
• Recombination - subsequent to actual hybridization between populations, or introgression;
• Mutation - new changes in the DNA sequence, or in the genome;
Selection - or differential reproduction of genotypes arising from deliberate or inadvertent choices by humans, or from differential responses of plants or populations to the environment.

We now briefly consider each of these in connection with the seed system.

Finite population size
The likely extent of genetic drift in allele frequencies and loss of alleles from the population are measured by the “effective population size”. This is an abstract standardizing parameter and is defined as the size of an idealized hypothetical population that would give rise to the same increase of inbreeding (or loss of heterozygosity, or variance in allele frequency) that is happening in the actual population under study. At the molecular level, the effective population size plays an underlying role in limiting genetic diversity. Molecular diversity arises continually through mutation, and is ultimately lost due to the finite size of the population. At equilibrium, larger populations on average are thus expected to have more molecular diversity than smaller ones.

Two general points can be made about the effect of finite population size on genetic diversity. First, genetic drift and bottlenecks in population size have a more immediate impact on allelic richness than they have on diversity evenness. Rare variants get lost first. Second, effective population sizes have to be very “small” over a period if they are to be the sole agent of substantial genetic erosion. However, when combined with selection, small sizes can seriously erode the unselected diversity. Population sizes of just a few plants are uncommon in field crops, but are prevalent for many species grown in home gardens for special uses.

Finite size in seed systems can have effects at two levels. First, it is usual to analyze the sampling effect of finite size upon the genetic variation within a landrace and ask whether the number and size of seed sources for that landrace are so low as to lead to serious loss of diversity through genetic

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**Box 1. Statistic for diversity comparisons—“Effective number of landraces” in an area.**

Suppose in a farm or village a survey reveals that six landraces and the observed frequencies \(\{p_i\}\) are

\[
\{0.5, 0.25, 0.1, 0.05, 0.05, 0.05\}
\]

The concept of the effective number of entities (landraces, origins, etc.) in an area is the number \(n_e\) of entities with identical frequency \(= 1/n_e\) that would give the same probability of identical ancestry as when any two random genes are compared for their origin

\[
n_e = 1 / \left[ \sum p_i^2 \right]
\]

For the above vector of frequencies, actual number of landraces here is 6; the effective number is 3.03.

**Example:** Landrace composition of farmers’ own seed of faba bean in nine villages of Orzagh site, Morocco (data of Sadiki et al., these proceedings).

<table>
<thead>
<tr>
<th>Average</th>
<th>Good year</th>
<th>Medium year</th>
<th>Bad year</th>
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<tr>
<td></td>
<td>9 villages</td>
<td>9 villages</td>
<td>7 villages¹</td>
</tr>
<tr>
<td>Proportion of farm's own seed</td>
<td>0.93</td>
<td>0.82</td>
<td>0.40</td>
</tr>
<tr>
<td>Actual number of landraces</td>
<td>5.10</td>
<td>5.00</td>
<td>4.60</td>
</tr>
<tr>
<td>“Effective number” of landraces</td>
<td>3.49</td>
<td>3.53</td>
<td>2.54</td>
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</table>

¹ These averages exclude two villages that planted only purchased seed.
² In the two villages where no local landraces were planted, the effective number was defined as zero.

**Conclusion:** In the poor year, farmers had less of their own seed to plant, with a lower richness of landraces, and lower evenness of frequencies.
drift. In addition, however, finite size and sampling issues are involved at a second level, namely “between-populations”. At this level, we are concerned about the number of distinct landraces in an area. In this vein, it will be important to know whether the seed system is such as to provide farmers with a diminishing number of choices of variety. The richness and evenness in frequency of the number of landraces will be important to follow; and an estimate of “the effective number of landraces” (see box), as well as the actual number, will be useful for summarizing trends.

**Migration**
Migration is the movement of seeds or pollen among populations or subpopulations that differ in their gene frequencies. Again, it is necessary to think of migration happening on two levels, because we need to distinguish migration between fields of the same landrace from migration between different landraces. In genetic theory, migration is a powerful homogenizing force. It spreads diversity about and, if unchecked by selection, counters genetic divergence. The fact that landraces, for example of maize, maintain their distinctiveness in the face of geneflow and while possibly sharing some of the genes, is testimony to the effectiveness of farmer selection.

In informal seed systems, migration takes place at different spatial scales: local, regional, national and beyond. The theory of migration among (diverging) subpopulations in model systems stresses that uneven migration rates reduce the effective population size of the system. Thus it is important to gather estimates of seed flows and how they vary in time with different seasons, and how they vary among the components of a seed network. The effect of migration on diversity also depends on whether the migrants completely displace the local population, or whether they merely mix with the local varieties, or whether they actually hybridize and fuse with the local population.

**Recombination**
With hybridization among different populations comes the opportunity for recombination and the generation of new genotypes. The species breeding system in relation to farmers’ management of possible hybrid seed determines whether recombination proceeds. The example of farmer maintenance of distinctiveness between open-pollinated maize landraces growing together has already been mentioned. Inbreeders are also subject to recombination, and their low rates of outcrossing can have an impact much larger than one might expect. In contrast to maize, farmers may be less aware of rare outcrossed progeny in inbreeding populations and they may escape detection.

**Mutation**
The low rates of occurrence appear to rule out mutation as a major agent of genetic change in the short term. However, mutation may be involved in loss of viability of seed in medium to long-term storage. Mutation is also of concern in the *in vitro* propagation of clonal species. But perhaps of more potential importance is the evidence of the labile nature of plant genomes owing to the activity of transposable elements. In addition, in many species humans may have deliberately selected mutable systems because they generate new distinctive colour patterns on seeds, stalks and flowers that act to mark their varieties. Mutable systems not only act on the genes affecting colour, but presumably on other genes in the whole genome. Hence it is important to keep mutation as a plausible if relatively unimportant cause of genetic changes in the seed system.

**Selection - the key force**
Despite the potential roles of other evolutionary forces in affecting diversity in seed systems, it is clear that selection is the key force with an overwhelming effect on diversity. The farmers’ deliberate and unconscious selection that is integral to the seed system is the main force determining the use and survival of diversity. IPGRI’s *in situ* project provides a methodology for investigating particular cases, and a catalogue of examples that test, illustrate and reinforce this claim (see the accompanying reports).
This leads to the question: What is to be our process to greater understanding of the seed system’s impact on genetic diversity? Clearly the first essential phase is descriptive. In describing the system we need to include:

- The crop species biology (e.g. mating system, plant longevity, seed storage dynamics, etc.);
- Its population genetic structure in an area (the number of varieties, diversity within and between them);
- Its identified seed sources, nodes and measured seed flow rates (means and variances in space and variation in time);
- Both farmer and natural selection regimes: by whom, for what purpose, how intense, how effective?

The second phase is to synthesize and integrate these elements to yield overall statements and predictions about genetic diversity in the system. One approach is to invoke the most plausible of available models (e.g. “island-mainland”, “stepping stone”, “isolation-by-distance”, “metapopulation”) and compare the data with the key parameters of such models (e.g. migration rates). A second approach is to build a computer model of the system and simulate its behaviour in time, introducing fluctuations (as suggested by the observed variability in processes) and periodic major disruptions. This kind of modeling has been helpful in estimating the survival probabilities of endangered wild plant populations. In this way we can aim to appraise the current trends, and the resilience of the seed system, and determine the critical parameters for survival of diversity.

Reference
Seed systems and genetic diversity in home gardens: a Cuban approach

Z. Fundora-Mayor¹, L. Castiñeiras¹, T. Shagarodsky¹, V. Moreno¹, M. García², C. Giraudy³, O. Barrios¹, L. Fernández-Granda¹, R. Cristóbal¹, V. Fuentes⁴, A. Valiente⁵ and F. Hernández²
¹Fundamental Research Institute on Tropical Agriculture “Alejandro de Humboldt”, Ministry of Agriculture, Boyeros, Cuba
²Ecologic Station Sierra del Rosario, Biosphere Reserve Sierra del Rosario, Ministry of Science, Technology and Environment, Pinar del Río
³Environment Unit, Ministry of Science, Technology and Environment, Guantánamo, Cuba.
⁴Institute for Tropical Fruits Research, Ministry of Agriculture
⁵Botanical Garden of Cienfuegos, Carretera del Central “Pepito Tey”, Ministry of Science, Technology and Environment, Cienfuegos, Cuba

Introduction

Conservation of traditional cultivars, that constitute an important genetic patrimony—on farms or at the community level through their use within the households or because of their usefulness at the markets (Iwanaga 1995; Eyzaguirre and Iwanaga 1996)—is an approach that is becoming very important. This conservation requires an informal seed system where the farmers can have control over their own seeds (Fernández 1994). A seed-production system, in agreement with a sustainable agricultural system, would be based on traditional practices and greater intervention by farmers.

A seed system at the farm level varies according to the species, the ecological conditions of the region under study, and the socio-cultural features of the “curators” or “custodians” of this precious treasure (Kashyap and Duhan 1994), and refers to the different ways that farmers access seeds (Jarvis et al. 2000). One of the essential characteristics of this system is that during seed production, the varietal type is not an exact replica of the previous one, but there always exists certain selection, which does not necessarily result in the maintenance of its type (Mushita 1993). In other cases, there is no selection, and the development of certain heterogeneity in the cultivars is permitted, which will vary in accordance with the mode of reproduction in the species (Martin and Adams 1987; Williams 1996). Climatic events and cultural and ethnic factors present during seed production can also affect the maintained diversity (Tuxill 2002). Understanding the form of seed production used by the farmers, mainly with their traditional varieties, is essential for establishing a strategy for in situ conservation of crop species, having farmers as protagonists (Jarvis 2002). This knowledge is important because it will permit a deeper understanding of the sustainability of these agricultural systems.

In Cuba, farmers’ organizations take several forms, from co-operativization of the production to complete autonomy over the working tools and crops (Castiñeiras et al. 1999; Fundora et al. 2000). Some urban and suburban alternatives have been developed as well, such as organoponics and seed farms in the Municipalities (Companioni et al. 1996). Nevertheless, there is not much known about seed production within the traditional systems in the Cuban countryside.

In this article, the characteristics of seed production in home garden systems and farms are described, and the factors that are involved in the whole process are discussed as they relate to the genetic diversity preserved.

Methods

A sample of 39 home gardens (conucos) and farms was studied, covering three areas in Cuba: Guantánamo, in Yateras and Guantánamo Municipalities (14), Pinar del Río (13), and Cienfuegos, in Cumanayagua and Cienfuegos Municipalities (12).
The following data were registered by species: cultivar source (cultivar flow); selection patterns used by the farmers during seed production; container type and place where seed is stored; durability of the reproductive material in storage, and cultivar status. Data were collected by means of a general semi-structured interview, during the periodic visits to the home gardens between 1998 and 2000, following the procedures established by Castiñeiras et al. (1999, 2000), and also using the aspects discussed in exchange and capacitating workshops performed with the farmers (Shagarodsky et al. 2001).

Data were coded on a nominal scale, varying according to the whole spectrum for each variable; frequency analyses were performed, estimated as percentages from the total of species in the gardens.

Results

Seed systems in Cuban home gardens and farms

Between 54 and 80% of the cultivars in the majority of the species within the studied home gardens were reported as traditionals, which have belonged to the garden’s owners and their family for a long time (more than 20 years) (Figure 1). The proportion of traditional cultivars is higher in home gardens from Pinar del Río, followed by those from Guantánamo and, lastly, Cienfuegos; the remainder were the species reported as wild, whose seeds are not managed, or those that are “tolerated” within home gardens. Nevertheless, in some cases these species are in a way managed, like the living fences (Gliricidia sepium, Eritrina sp. and Bromelia pinguin); some spices (Eryngium foetideum and Plechtranthus amboinicus); medicinals (Ocimum sp., Vetiveria sizonoides, Pluchea carolinensis, etc.), and some potential fruit trees like Coccoloba uvifera.

For the infraspecific variability, Pinar del Río presented the greatest richness (Figure 2), with traditional cultivars ranging between 23 and 100% of the total, in the 14 species with infraspecific variability that were common to all areas. Species with the greater richness in traditional cultivars were Phaseolus lunatus (100%); Psidium guajava, Cucurbita sp., Xanthosoma sagittifolium, Phaseolus vulgaris and Zea mays, among others.

Figure 1. Number of cultivar types present in home gardens: 1=Wild; 2=Traditional; 3=Advanced; 4= Advanced/traditional; 5=Unknown; 6=Wild/Traditional; 7=No information.
It is important to point out that, despite the proportion of advanced cultivars not being generally high, there are a few cultivars of species in certain some home gardens, and all came from breeding programmes in the formal sector (nurseries and from the Seed Production Enterprise of the Ministry of Agriculture), so those species have a very narrow genetic base. This suggests a strong displacement of traditional cultivars, as a consequence of the adoption of those cultivars, and a high genetic vulnerability of those systems. This fact could be appreciated in one of the selected home gardens in Cienfuegos, where the owners had progressively replaced all traditional cultivars (from their fathers) with modern ones, registering almost 100% erosion. Nevertheless, the coexistence of advanced and traditional cultivars within the conucos is an undeniable necessity for farmers’ subsistence, because they are continually introducing new materials to obtain better production or simply to have greater variability.

**Origin of the genetic material in the home gardens and farms: genetic flow**

Differences in cultivar flow were observed between Pinar del Río and Cienfuegos, and were less marked between Pinar del Río and Guantánamo (Figure 3). Almost half of cultivars reported by the farmers have been in the conucos since their establishment, either by inheritance or by the splitting of the original farm for a growing family, and were transmitted from one generation to the other; species taken from the woods are present in the same proportion. The latter include most of the fruit crops and other perennial species, and primitive cultivars of Dioscorea sp. and Xanthosoma sagittifolium; wild spice species like Lycopersicon esculentum var. cerasiforme and E. foetidum; wild medicinal plants like Solanum americanum and Solanum torvum, and living fences like G. sepium, Jatropha curcas and Erythrina berteroana, among others.

Also observed was considerable exchange among relatives (generally parents, uncles, grandparents, etc.), or between near or relatively far away neighbours. In most cases the exchange with neighbours was limited to nearby areas in the same region, and in extreme cases, from neighbouring provinces and municipalities within the limits of the sampled area. In Pinar del Río province, the references with regard to the cultivars’ flow among neighbours were neither frequent nor specific; they always referred to “neighbours of the area”, “the town” or “from La Habana”. The places cited in each region were always very near to each other and the conucos and farms.

![Figure 2. Percentage of species with infraspecific variability. Numbers 1 through 12 represent individual holdings.](image_url)
In Cienfuegos only three species were brought from very far away places, like garlic (*Allium sativum*), from the neighbouring Sancti Spiritus province, probably from the formal sector, since this it is a typical area for extension work with this crop; wild cotton (*Gossypium arboreum*) from Villa Clara province, and cocoa (*Theobroma cacao*) from the easternmost part of Cuba.

It is interesting to note that in the home gardens from Guantánamo region, several farmers, mainly the most isolated ones, related that certain species came from places as far away as Haití or China. This is the case of *Allium chinense* and yams (*Dioscorea* sp.), said to being brought from Haití, and other *Allium* species from China.

From 4 - 19% of the cultivars come from state nurseries or farms, or from shops established by the Ministry of Agriculture (MINAG) for the sale of seeds from advanced cultivars; in some cases they come from areas of self-consumption of sugar cane and cattle forages. This flow may be direct, or through exchange with neighbours, in the event of the loss of their own reproductive material or for the purpose of trying new genotypes. Sometimes the advanced material has been on the farm for some time, but originally was brought from the formal sector. This happens with those cultivars that are for sale, like sweet potato (*Ipomoea batatas*) and banana and plantains (*Musa* sp.). Finally, for some species, cultivars come directly from the markets (*Pisum sativum, Carica papaya* and *Brassica oleracea* var. *capitata*).

In those species, in general, several cultivars are managed, and among them are both traditional and advanced ones, bought by neighbours and passed over to the particular home garden, or bought directly by the owner.

**Selection practised by farmers**

The data reveal an appreciable diversity of selection patterns used in Cuban home gardens, suggesting a certain interest of farmers in experimentation and improvement of cultivars in their *conucos* and farms. This was especially so in the Guantánamo area, which had the biggest diversity—between 7
and 12 different patterns—suggesting a greater level of concern about the species that they cultivate following a traditional pattern of behaviour.

Regarding the types of selection of the reproductive material used (Figure 4), these were markedly different in all the evaluated areas. There was an outstanding percentage of species which did not undergo any selection during seed production, coincident with the species very little managed (they are wild or traditional cultivars). Among them are medicinals like *Plantago major*, *Costus spicatus* and *Pavonia typhalea*; spices like *L. esculentum* var. *cerasiforme*, *Bixa orellana* and certain fruit species, like *Citrus* sp. and *Pouteria sapota*. For traditional cultivars, farmers only separate seed to be used in sowing future crops; for advanced cultivars they select what they cannot produce themselves in Cuban conditions, e.g. *Brassica oleracea*.

The selection patterns most frequently used during seed-production management are simple in the three areas under study, involving selection (1) only in the field, before or after the harvest, or (2) only in the warehouse or house, after the harvest. In a reduced proportion of species, more complex selection patterns are used that involve two selection stages: in the field and in the warehouse. Criteria for selection are for different plant parts (whole plant, fruit, seed, etc.), and for different purposes (vigour and health of the plants, high yields, better-formed fruits that conform to the

![Figure 4. Selection patterns for seed production in Cuban home gardens. Selection patterns: 1=No selection; 2=Field x fruit; 3=Field x plant; 4=Field x seed; 5=Warehouse x fruit; 6=Field x fruit and seed; 7=warehouse x seed; 8=Field and warehouse x seed and fruit; 9=Warehouse x fruit and seed; 10=Field and warehouse x seed; 11=Warehouse and field x fruit; 12=Warehouse and field x plant and fruit; 13=Field x plant and fruit; 14=Field and warehouse x plant; 15=Field x fruit and warehouse x fruit and seed; 16=Field x seed and plant; 17=Field and warehouse x fruit and seed; 18=No information.](image-url)
desired type, and well-developed seeds, among others). Examples of species where simple selection patterns are practised are some grains: *Phaseolus vulgaris* and *P. lunatus*, where in general the criteria used refer to the vigour and health of plant, fruit and seed, and seed form, type and colour; roots and tubers: *Colocasia esculenta*, *Xanthosoma sagittifolium* and *Ipomoea batatas*, where the criteria refer to the health and vigour of corms and stalks respectively, as well as the degree of development and vigour of buds and insect resistance. In this last case, selection is carried out in the fields.

More complex patterns were observed in species reproduced by sexual seeds; the selection starts in the field, for plant and fruit characteristics, and is completed in the house/warehouse, addressed preferably to the type, status of formation and seed health. This is the case of *Zea mays*, whose selection is strongly influenced by women’s decisions; the youths and children also participate in the home gardens. Selection of reproductive material and its conservation were always independent of selection for material dedicated to consumption, or for sowing in the next season.

In some cases (as for that of *Cucurbita moschata* in Guantánamo), farmers do not make any selection, instead maintaining a mixture of seeds, suggesting the possible existence of great intrapopulation diversity in some of the recorded samples. This, on one hand, assures the stability of the production, and the readiness of a rich source material for any empiric selection that farmers want to make; on the other, the production of fruits is quite variable in quality, size and forms, due to the allogamous nature of this species. However, in Cienfuegos, the different accessions are maintained separately.

**Conservation and longevity of the reproductive material**

From 2 - 60% of the present species in the studied home gardens are not subjected to conservation (Figure 5); this proportion includes the species that are not managed at all, and are considered as wild, or those very little management, whose reproduction happens in a natural and spontaneous

![Figure 5](image-url)
way around the adult plants, e.g. *Coffea arabica* and *Pouteria sapota*. Also in this group are those that are sown successively during the year and therefore do not need any storage practices or conservation. It may be that this is a consequence of the loss of viability of the reproductive material, due to mishandling. Nevertheless, a considerable number of species are subjected to conservation processes, using various forms according to the necessities and available materials, and depending on the type of reproduction.

There is considerable variety in containers used for the storage of reproductive material at the home gardens, with almost any available container being used and numerous and varied forms of placing it. The most used containers are glass bottles of any type, mainly for grain storage (*Phaseolus* sp., *Cajanus cajan*, *Zea mays* and *Oryza sativa*), which are placed under the most diverse conditions: room or cold temperatures, depending on the circumstances of each family. Glass bottles are frequently used to store vegetable seeds like *Lycopersicon esculentum* and *Capsicum* sp., and for some spice plants. Also very frequently used are transparent or opaque polyethylene bags. In the case of the grains, cans or sealed tanks are also used, or the seeds are mixed with oil or petroleum to avoid the attack of insects.

Corms and cormels from roots and tubers, like *Dioscorea* sp. and *Xanthosoma sagittifolium*, are stored on the floor, or in *barbacoas* (a high place, generally near the roof, that is used to store different products), where humidity does not exist. The bulbs of *Allium sativum*, are stored in aired places, at room temperature. The seeds of some fruit crops are stored for short periods in dry places.

Another common storage form is the conservation of the seeds on the plant, as for *P. vulgaris* and *G. max*, and in *Z. mays*, where kernels are stored with the bracts, hung in an aired place; sometimes seeds are stored in their own infrutescens, as in *Eryngium foetidum*, *Petroselinum crispum*, *Sorghum bicolor* or *Nicotiana tabacum*.

In general, longevities of the reproductive material greater than 1 or 2 years were not reported in storage, and mainly in grains and vegetables in any type of containers, especially in glass bottles.

**Factors that converge during the production of the reproductive material and their influence on the maintenance of diversity**

Among the observed factors in Cuban home gardens that can affect the composition and genetic diversity, especially during the process of production of the reproductive material, are: the coexistence of traditional cultivars with the introduced advanced varieties; the genetic flow observed among home gardens and farms within an area, among the areas and between them and the environment; the selection patterns used by the farmers; the form of conservation of the reproductive material; State plans for development and the climatic factors that converge in the area where the *conuco* is located. Ortega (2002) has mentioned some of these factors causing genetic erosion in Chalco region, México. Many reports about the diverse factors that affect genetic diversity have been published in México (Collado et al. 2002; Tuxill 2002; Yupit Moo et al. 2002).

In Cuba, the coexistence of traditional and advanced cultivars does not seem to have serious effects on the genetic diversity in self-pollinated and clonal species; the genetic exchange among them, as far as it has been able to be proven, is null or almost null. However, in the case of facultative self-pollinated plants, which have a high cross-pollination percentage, or in species totally cross-pollinated, it has been possible to check, from the morphoagronomic point of view, that numerous intermediate forms exist among the cultivated and traditional types, and between both and the wild ones. Such it is the case of *Capsicum* spp., where a complex of species is present in Cuba, since there are no isolation practices for their management in the gardens. In a preliminary way, this has been observed using molecular variants of the studied material (Barrios, pers. comm.). Handling practices and selection of the reproductive material favour on occasion the appearance of intermediate types, so cultivars suffer genetic drift by selection toward the permanency of those types. This drift is reinforced by the cultivation of few plants of each cultivar, which produces a bottleneck effect. In this case, although change in the genetic material exists, a favourable microevolutive process to the accumulation of adaptation genes occurs.
Another example is maize (Fernández, pers. comm.) where, in spite of the existence in those *conucos* and farms of highly heterogeneous populations, because of the natural heterozygosis of the cultivars of this species, and also of the sowing and handling practices, varietal types have stayed unchanged for generations. Hodgkin (2001) has cited the instability that involves such conservation using reduced populations, but at the same time, he pointed out that, in a certain way, farmers have been able to conserve those particular types. Finally, in pumpkin, the observed practice of maintaining mixed seeds from several types or cultivars as the reproductive material and selecting at the field the best fruits with the desired attributes, and in the following cycle mixing the obtained seed again after sowing, assures they yield stability, but slowly the original cultivars may drift toward a new form.

On the other hand, since most of the species/cultivars in Cuban *conucos* and farms do not undergo conservation processes, and they are reproduced with short intervals during the same year, selection events multiply, and they favour the changes in the genetic material, which is reinforced with the frequent introduction of new cultivars (Hodgkin 2002). Bennet-Lartey et al. (2002) reported genetic types coming from the local markets that are traditional cultivars originating in another area; so, this way they enrich the genetic diversity of these orchards.

When sowing material comes from conservation, frequently it has lost its viability and vigour, and as a consequence it is lost as a genetic combination, and is replaced. This substitution frequently happens within the same area as the orchard, and with much less frequency from distant areas inside the subregion or from other subregions of the country. It rarely happens from other countries (Fundora et al. 2000). This suggests that the type of exchange observed produces a genetic pool of cultivars with relatively uniform variety patterns in each area, from which it would be important to identify which would be the important unique types for conserving as genetic entities; this way population size would not be a limitation for conservation, because they would be considered bigger units than a single orchard or garden. This has been reported in other countries of the continent (Gómez 2002), and it is considered a real possibility in this conservation type (Hodgkin 2002). The participation of modern cultivars in this flow could carry serious consequences if they contribute genes that may alter considerably the genetic composition of the population in wild species (Zizumbo et al. 2002).

In Cuba, the limited understanding by the authorities of the formal sector about the importance of traditional agrobiodiversity could cause farmers to be more concerned about the fulfilment of plans linked to the commercialization of the crops, dedicating most of their efforts to that end. For this reason it is important to develop more initiatives in some of the studied areas, for the awareness of both government officials and private farmers, about the importance of the maintenance of this diversity in their production systems.

Finally, Cuba is located in an area of natural disasters, where tropical storms frequently occur, which seriously affects, among others, the agricultural sector of the country. Storms have eroded severely the diversity, just as the extended droughts have done. National restoration plans for these systems in all cases are limited to cultivars formally registered in the country by the Ministry of Agriculture (almost all advanced cultivars), but unfortunately they do not include the restoration of the affected traditional diversity. Thus, there is an urgency to structure initiatives that consider ensuring the permanency of this diversity for future generations. Tuxill (2002) mentioned extended droughts as an important factor that affects the genetic diversity in Yucatan *milpas*, and Collado et al. (2002), in Perú, mention the soil type and the irrigation as decisive causes of a bigger or a smaller diversity. Other climatic situations, like heavy mists in some of the areas, can contribute to the development of fruiting in certain species, conditioning the erosion of them, and modifying the composition of the diversity.

References
SEED SYSTEMS AND CROP GENETIC DIVERSITY ON-FARM


Banana and plantain seed systems in the Great Lakes region of East Africa: a case for a clonal seed system

E.B. Karamura, D.A. Karamura and C.A. Eledu
IPGRI/INIBAP, Kampala, Uganda

Introduction
Bananas remain the single most important starchy staple in the Great Lakes countries of East Africa, with 10-30% of all arable land under the crop. Per capita consumption of the staple is estimated at 400-600 kg, the highest in the world. Over 30 million people in the region depend on the crop for food security and income. In this region, the crop is grown as a perennial system and gardens as old as 150 years are very common in Uganda and the Kagera region of Tanzania. This perennial system thus creates a “tropical forest” system over large expanses of land and helps to conserve the soil systems on which it is growing. Moreover the crop readily lends itself to intercropping (with pulses and tree crops) and to mixed farming with livestock, all of which facilitate efficient nutrient recycling while at the same time helping to balance what is otherwise a largely carbohydrate diet (Karamura et al. 1998).

At the household level, banana plays a lead role in sustaining the livelihoods of the communities of the region (Table 1). In Uganda, for example, it is increasingly replacing coffee as a cash crop, given the price fluctuation and the coffee wilt problems that are quickly rampaging the region.

Table 1. Ranking of cash crops by site farmers (Karamura et al. 2003)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Ranking by site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ibwera, Tanzania</td>
</tr>
<tr>
<td>Coffee</td>
<td>1</td>
</tr>
<tr>
<td>Banana</td>
<td></td>
</tr>
<tr>
<td>Cooking</td>
<td>2</td>
</tr>
<tr>
<td>Brewing</td>
<td>3</td>
</tr>
<tr>
<td>Dessert</td>
<td>–</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>–</td>
</tr>
<tr>
<td>Beans</td>
<td>5</td>
</tr>
<tr>
<td>Maize</td>
<td>4</td>
</tr>
<tr>
<td>Cassava</td>
<td>7</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>6</td>
</tr>
<tr>
<td>Sorghum</td>
<td>–</td>
</tr>
<tr>
<td>Pineapples</td>
<td>8</td>
</tr>
</tbody>
</table>

In some areas farmers report that they are progressively replanting their coffee gardens with bananas. Despite their importance, banana-based cropping systems have experienced a steady decline over the last several decades. Yields have dropped from 10 t/ha in 1970 to 4–5 t/ha by 1990 (Karamura et al. 1998). Over the same period the region experienced serious pest and disease outbreaks that seem to have taken a toll on the crop. Black Sigatoka (*Mycosphaerella fijiensis* morelet), the banana weevil (*Cosmopolites sordidus* Germar.) and a host of soil-borne nematode species combined to reduce yield, and production levels were only maintained by increasing acreage. Moreover, without the capacity to use off-farm inputs such as fertilizers and pesticides, pest/disease control measures remained limited to cultural practices that are usually labour-intensive and unreliable, even though environment-friendly.

Given the important roles played by bananas in the livelihoods of the communities and the threats that are besieging the production system, it is necessary to understand the seed system of the
crop, as a basis for developing management strategies that will ensure its sustainability and improve the livelihoods of communities.

**Banana/Plantain Seed Systems in the Great Lakes region**

All naturally occurring cultivated banana and plantains are seed sterile, the majority being triploids. This makes a fundamental difference between this clonally propagated crop and the other grain seed systems, which have definable cycles. In the case of bananas, the “seed” is a clonal bud off the underground stem (=corm) which farmers detach and plant in new fields. Consequently banana seed has extremely limited variability and buds (also called suckers) tend to be exact duplicates of the mother mat or clone. This, however, has implications for the sustainability of the system because while everything else around the plant (soil texture, nutrients, water, temperature and other microclimatic factors) has been changing over centuries, the banana genetic make-up may not have changed as much. In planning the long-term development of banana–based economies, it is important to take into account the limitations posed by this limited variability in the case of a clonal system.

In general two banana seed pathways are recognizable: the traditional and non-traditional seed systems, although at the farm level, the two pathways usually merge into one another.

**Traditional pathways**

By far this is the most widespread and age-old system whereby farmers deliberately select and collect seeds from friends, neighbours or relatives far and near and plant them in their own gardens. The selection of seed follows well-defined criteria across the region (Table 2). In the two of the three countries involved in the study, the first four most important criteria—bunch size, palatability or taste, period taken to maturity and resistance to pests and diseases—were the same across the sites. In general the criteria reflect the communities’ food security, income-generation and socio-cultural objectives which are the pillars of the livelihood structure.

### Table 2. Banana cultivar selection criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Tanzania (Farmers (%))</th>
<th>Uganda (Farmers (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chanika</td>
<td>Ibwera</td>
</tr>
<tr>
<td>Bunch size</td>
<td>29</td>
<td>35</td>
</tr>
<tr>
<td>Palatability/taste</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>Maturity period</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Resistance to diseases</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Plant vigour</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Rationing ability</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Marketability of bunches</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Drought tolerance</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Large fingers</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Softness of cooked food</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Adaptability to soil</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Longevity</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Gold et al. 2002.

Traditional pathways are characterized by high cultivar diversity per farm and the stand may have as many as 20-30 different cultivars grown in complex mixtures. Once a cultivar is selected and introduced, it is normally grown near the main house or kitchen from where the mat is observed
for several ratoon crops with respect to bunch size, food quality, response to pests and diseases, etc. before it is transplanted to an appropriate site in the garden for production and conservation.

Another characteristic of the system is its low-input / low output behaviour. In general, sucker seeds collected from neighbours, relatives and friends are not cleaned and consequently carry along to the next farm a lot of soil-borne pests and diseases. The system appears to have survived as a kind of “barter trade” whereby planting materials are exchanged without cash money involved. Thus any attempt to improve it would need to take into account that farmers traditionally do not buy banana planting material.

**Non-traditional pathways**
As is illustrated in Figure 1, the distinction between traditional and non-traditional is not distinct because at the farm level, the non-traditional merges into the traditional. However non-traditional banana seed systems are characterized by high-input/high-output culture. The investment in terms of cash to purchase seed, establish weaning sheds, and put up irrigation schemes can only be afforded by a few. Therefore this system is driven by market objectives, cash returns and commercial focus. However, it is characterized by low genetic diversity as it tends toward monocultivar farming and genetic erosion is an unfortunate outcome. Appropriate policy guidelines need to be put in place to ensure that commercialization of the seed system does not lead to enhanced genetic erosion of the crop.

**Who is involved and what roles do they play in banana / plantain seed systems?**
In order to understand the dynamics of any seed system, it is important to identify the key players—the stakeholders of the system and their roles. Apart from roles, it is also important to identify their objectives for growing and conserving banana diversity. Such information will form the basis for developing relevant and community-owned strategies for strengthening the conservation of genetic diversity. In the Great Lakes Region, the key players are the farming communities and their grassroot platforms, the civil society organizations, the public sector institutions, the upcoming private sector and the policy-makers at various levels.

**Farming communities and grassroot platforms**
Banana cultivation in this region has become intertwined within the socio-cultural fabric of the communities. Some cultivars are used to pay bride price, or celebrate the birth of children; others
are used to mourn death of a relative; yet others are used as stimulants, medicine and as perfumes. Until recently banana leaf bases were used as thatch for houses, and banana fibre is variously used in a host of handicraft and household decorations. This is not to mention the pivotal food security and income-generation roles that bananas play in the region.

Given the foregoing, communities have a critical role in ensuring that all their needs for bananas can be met. The communities have to select and breed cultivars and ensure that their members’ needs are met. They therefore institute seed selection, seed maintenance and sharing mechanisms which in totality enable the communities to respond to the needs and challenges they meet. In the Great Lakes region, communities have established community genebanks whereby new introductions are given to different farmers who multiply them and give to others in that community. Such materials (seed) may be introduced to the community by the research system, NGOs or from other benchmark sites, following PRA studies. Once in the community the introductions normally follow traditional seed pathways.

**Civil Society Organization (CSO)**

Included here are religious organizations, non-governmental organizations, community-based organizations and farmer associations whose focus is not strictly profit-making. These organizations support and facilitate capacity-building and information through the organization of diversity seed fairs and agricultural shows. They also support and strengthen community infrastructure and help the communities to access new technologies from the national and international research systems. When the CSOs do their job properly they strategically win the trust of communities and this trust can be exploited positively to strengthen seedflow systems. In the Great Lakes Region, where banana is the dominant crop, all the CSOs in one way or another are involved in banana-related projects. The CSOs provide a lynchpin between farming communities on one hand and public sector organizations and policy-makers on the other. It is very important therefore that any development plan should exploit the CSOs key position as this may assist to bridge the gap between grassroot platforms and policy-makers.

**Public Sector Organizations**

These include the national agricultural research systems, including research institutes, universities and extension services. They access, evaluate and disseminate new technologies to the communities and with CSOs they facilitate capacity-building and information dissemination. It is this group of stakeholders who are responsible for variety release, registration and certification. In addition they are responsible for overseeing the phytosanitary and quarantine issues. Through the execution of these responsibilities, they collect vital information for the initiation of policy processes. In the majority of cases changes in the seed system are usually initiated by the public sector organizations which makes it imperative for them to participate in any seed system development plans.

**Private Sector**

Within the region, the private sector has not played the same role as in Latin America and the Caribbean. A few private companies have set up tissue culture laboratories to produce clean seed at a cost. They target the upcoming commercial growers whose impact is still limited. Nevertheless it is important that the private sector be aware of the importance of clean seed as well as the need to conserve crop diversity. If well informed, the private sector would make critical decisions with regard to investment in new technologies, infrastructure and associated dissemination of technologies.

**The future**

Globally the banana/plantain seed system is little studied, let alone in the Great Lakes region of East Africa. There is a need to clearly articulate the descriptors of the seed system, particularly because it is clonal seed of the perennial crop, without clear supportive policies. There is also a need to clearly
characterize threats and opportunities as a basis for developing strategic research objectives. Such studies can help elucidate the factors that propel the clonal seed system, identify information and technology gaps and answer questions on the long-term sustainability of the crop system.

Nevertheless, as it is, the system appears to be internally resilient. It has strong roots in the tradition; does not depend on financial capacity or organized/intricate formal market structures and still maintains high levels of diversity, propelled by the diversity of utilization needs. However the inability to sufficiently ward off genetic erosion factors—selective pest/disease pressures and declining soil fertilities—plus the failure to exploit diversity to increase household livelihoods may pose a formidable challenge. Ultimately it will be critical to balance the system by carefully integrating traditional and non-traditional systems where non-traditional systems respond to the diversity needs of communities while at the same time incorporating diversity into a market economy.

References
Seed exchange and supply systems and on-farm maintenance of crop genetic diversity: a case study of faba bean in Morocco

Mohammed Sadiki¹, Mustapha Arbaoui¹, Lamia Ghaouti¹ and Devra Jarvis²
¹Institut Agronomique et Vétérinaire Hassan II (IAV), Rabat, Morocco
²International Plant Genetic Resources Institute (IPGRI), Rome, Italy

Introduction
In any country, seed systems comprise the formal and informal seed sectors. The importance of each of these components depends on the crop and production systems. The informal seed system prevails in agroecosystems with subsistence economics, providing most of the seed used for crop production. Seed systems in the informal sector are mainly in the hands of farmers and rural communities and are maintained to satisfy their own seed demand.

In this sector, farmers select and store part of their harvest for future planting, exchange seed with relatives and other farmers, and trade seed in the local marketplace. It is a major dynamic factor that promotes crop evolution, influences genetic diversity and provides an important potential way for maintaining genetic diversity. Local seed exchanges are built upon seed requirements and needs of farmers, particularly small-scale farmers and the resource-poor. These local seed exchanges play an important role in the distribution of local genetic diversity and the shaping of its structure. The farmers need a number of different varieties of seed for different crops, usually in small amounts, at the right time and at an affordable cost. Varieties or landraces maintained in local seed systems are often best fitted to the local specific agroecological conditions (drought, access of water, tolerance to pests and diseases, etc.).

While the informal seed system has a powerful local character it is not necessarily limited to a small geographical area. Indeed, informal local seed systems are large networks of local networks operating at different geographic scales (villages, communities, provinces, etc.), which are interconnected and allow circulation of plant material in different geographic units. The number of landraces and farmers’ varieties grown at a given locality, their genetic similarity, and the areas they occupy over time and space are influenced by seed exchange and supply sources. These networks are an important mechanism of geneflow by which new genetic material is introduced into populations. Seed exchange networks, including seed production and supply systems, vary owing to diversity of climate, crops, farming systems, culture and economics. In the informal sector the seed or products of landraces or traditional varieties may not be traded much on markets and may be exchanged outside of official channels. The timing of seed exchange is particularly seasonal (just before planting), and may occur in limited geographical areas (a few farmers, a few villages).

Finally, very little secondary data are variety-specific, and even when they are, a basic tenet of work is that information on named varieties is likely to be inconclusive with respect to farmer-managed units of diversity. Our understanding of the ways in which the seed exchange mechanisms work, how they affect the level of crop genetic diversity on-farm, and how local seed systems are organized and promoted is still limited and vague. From previous farm household data there is an understanding of how individual farmers exchange seed and products, but few conclusions can be drawn at either the community level or higher levels of aggregation. There is a need to understand how seed systems affect the agricultural biodiversity of communities and regions. A basic underlying hypothesis is that reasons for maintaining local genetic diversity through continuous cropping and management of local varieties on-farm are both structural (soil, technical, economic, sociological) and circumstantial (drought, biotic stresses) (Arbaoui 2003; Ghaouti 2003). The objectives of the present paper are to:
• Identify and quantify the seed flows in local networks;
• Determine the relation between the seed system and the spatial and temporal distribution of genetic diversity of the faba bean crop on-farm;
• Evaluate the potential of seed systems to support *in situ* conservation of genetic diversity on-farm and to formulate options.

**Materials and methods**

The characterization of the local seed exchange, supply and distribution system for faba bean crop has been conducted in two communities—Ourtzagh and Ghafsai—located in the province of Taounate, in the centre-northern part of Morocco. This province extends over 5585 km² with 425 000 ha arable area of which 77 500 ha are planted to grain legumes, including more than 60% faba bean. The province is located in the largest area of traditional faba bean production of the country. Production systems vary according to farms but cereal/faba bean rotation is the most frequent system. The annual rainfall, generally concentrated between October and April, averages 560 mm, in the south of the province and 800 mm in the northern part. The study concentrated on nine villages in Ourtzagh and seven in Ghafsai, representing one-fourth of the total villages in the two communities.

A survey was conceived by a multidisciplinary team based on previous work regarding the estimation of the amount, distribution and on-farm management of local genetic diversity of faba bean crop in this area. A team composed of scientists, development and extension agents and students conducted the survey. The survey was two-fold: farm and market. In each village, the survey addressed individual farmers based on a questionnaire structured into aspects related to socioeconomic data of the farm, production systems practised, management and use of seeds, seed flows in the local networks (particularly quantification of seed produced on-farm, seed going off the farm, and that entering the farm from different sources), and relation with the market. The market survey concerned the seed transactions, seed supply sources and storage.

Individual farmer surveys were performed on 97 farmers in 15 villages (66 farmers in 9 villages of Ourtzagh community and 31 farmers in 6 villages of Ghafsai). A market survey was conducted simultaneously at three local markets visited by the farmers of the two communities (Sidi Lmakhfi, Galaz and Ourtzagh).

Drought has been identified as one of the most important environmental constraints influencing on-farm management of crop diversity in this area and therefore of seed management. The information was collected for three types of seasons defined on the basis of rainfall: a good year (high and good-quality production), medium year (average yields), and bad year (low yields and weak production quality).

Previos research investigations within the on-farm project provided basic information for this study; in particular, those data dealing with the amount and distribution of genetic diversity were used in this study (Sadiki et al. 2001; Sadiki 2002; Belqadi 2003).

**Results and discussion**

**Distribution of diversity**

The number of different local varieties found in an area or a field is an important parameter for the survey of the structure and the genetic diversity of the local varieties (Brown 2000).

Table 1 shows that the majority of farmers (70%) of Ourtzagh community use at least two varieties in the same cropping season. Among these, 31% produce two varieties, 26% have three varieties and 11% cultivate four varieties. The distribution of the number of varieties on-farm is different in Ghafsai community, where around 63% of the farmers use a single variety, 23% exploit two varieties, 10% plant two varieties and only 3% of the farmers of this community get their faba bean production from four different varieties in the same season.

The determination of nature of varieties planted by farmers each season allows an enhanced understanding of diversity structure and distribution. Table 2 shows the main characteristics of the seven varieties found and planted by farmers of the two communities. These are farmer-named varieties, consistently recognized throughout the region. Farmers described and identified them during the survey. These 7 varieties are included in the 14 varieties described in the northern region.
of Morocco (Belqadi 2003). None of the farmers interviewed planted certified seed of improved selected modern varieties.

Local varieties 3, 4, 5 and 7 are the most frequently used by farmers in the region. Hence, 62.4%, 41%, 38% and 25.8% of the farms plant varieties 4, 5, 7 and 3, respectively. On the other hand, farmers using varieties 1 and 2 do not exceed 6%.

Variety 4 is planted on nearly half of the area devoted to faba bean in this region. Although variety 7 is less frequent than variety 5, it covers a larger area (32.5% compared with variety 5 with 17.5%).

Source of seed supply

Farmers surveyed in different villages of the two communities depend on various supply sources to acquire faba bean seeds (Table 3). All faba bean cultivars used in the region are local farmer-named varieties. Among the surveyed farms, 88% produce their own seed. Nevertheless, not all farmers produce all their seed needs. Indeed, among these farmers, only 17% depend solely on this source. The rest use more than one seed supply source for each season. About 69% of farmers buy their seeds at local market (souks) from other producers, and 13% from dealers. The seed sold by the suppliers generally originates from the region; however, seed also can be introduced from outside the region. These data indicate only a relative independence of farmers in respect of the market for seed supply.

More than 62% of the farmers get seeds from two origins. Among these, 74% utilize both their own produced seeds and seeds from the market. Only 23% of farmers plant seeds from a single origin. Among them 61% (corresponding to 15% of the farmers interviewed) use only their own seeds and 13% get the seed exclusively from the market or exclusively from neighbours and relatives. Finally, 13% of the farmers depend on three sources of seeds.

The relative importance of each seed supply source depends heavily on the yearly fluctuations of the amount and quality of production.

Table 1. Distribution of farmers according to number of varieties planted in the same season in the communities of Ourtzagh and Ghafsai

<table>
<thead>
<tr>
<th>Community</th>
<th>Number of faba bean varieties planted on the same farm in the same season</th>
<th>Percent of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ourtzagh</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Ghafsai</td>
<td>1</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2. Descriptive list of faba bean varieties named and cultivated by farmers

<table>
<thead>
<tr>
<th>Variety No.</th>
<th>Variety name</th>
<th>Seed weight (g)</th>
<th>No. seeds/pod</th>
<th>Percent of farmers</th>
<th>Percent of area planted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L’fift R’bai (Lakhdar ou Labiade)</td>
<td>&lt; 0.8</td>
<td>4–5</td>
<td>2.2</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>T’lati (Lakhdar ou Labiade)</td>
<td>1.5–3</td>
<td>2–3</td>
<td>3.2</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>T’lati Beldi Laghlid (Lakhdar ou Labiade)</td>
<td>1.5–3</td>
<td>2–3</td>
<td>25.8</td>
<td>0.8</td>
</tr>
<tr>
<td>4</td>
<td>R’bai Laghlide (Lakhdar ou Labiade)</td>
<td>1.5–3</td>
<td>4–5</td>
<td>62.4</td>
<td>47.2</td>
</tr>
<tr>
<td>5</td>
<td>Moutouassate Beldi (Lakhdar ou Labiade)</td>
<td>0.8–1.5</td>
<td>4–5</td>
<td>40.9</td>
<td>17.5</td>
</tr>
<tr>
<td>6</td>
<td>S’dassi (Lakhdar ou Labiade)</td>
<td>0.8–1.5</td>
<td>6–8</td>
<td>10.8</td>
<td>1.2</td>
</tr>
<tr>
<td>7</td>
<td>S’baï Labiade (Lakhdar ou Labiade)</td>
<td>1.5–3</td>
<td>6–8</td>
<td>37.6</td>
<td>32.5</td>
</tr>
</tbody>
</table>
Table 3. Faba bean seed supply sources in the villages of the two communities Ourtzagh and Ghafsai in the Taounate region, 2003

<table>
<thead>
<tr>
<th>Seed supply source</th>
<th>Percent of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produced own seed</td>
<td>88</td>
</tr>
<tr>
<td>Bought from neighbouring farms and relatives</td>
<td>18</td>
</tr>
<tr>
<td>Bought at local market (souks) from other producers</td>
<td>69</td>
</tr>
<tr>
<td>Bought at local market (souks) from dealers</td>
<td>13</td>
</tr>
<tr>
<td>Borrowed seeds</td>
<td>1</td>
</tr>
</tbody>
</table>

Seed flow

The seed flow was described for each village of the two communities in terms of proportion of contribution of each seed supply source. The composition of the seed flow was analyzed in terms of proportion of each local variety in the seed originating from each source at the village level following a good production season, a medium season and bad season respectively.

Following a good production year, villages produce 94% (95% in Ourtzagh and and 93% in Ghafsai) of their seed need. Their own seed contains both newly produced and stored seed from previous years. Many farmers store seeds for 2–5 years (depending on farmers and villages) as part of their strategy to cope with environmental stresses—particularly drought—leading to low and weak production. The rest of the seed is bought at the local market. Only 4 villages out of the 16 produce less than 92% of the seed they plant following a good year. Tisemlal village in Ghafsai and Zdharouf in Ourdzagh produce the lowest proportion of their seed requirement. After a medium production year, 86% of the faba bean seed planted comes from seed produced on-farm. This is 8% less than following a good year. After a bad year, only 35% of the seed comes from the on-farm production, essentially from the storage of previous years or from farmers with a clear strategy of seed production who can secure their need even when the season is not favourable. Four villages (Khons, Zdharouf, Boudahil and Lhwanet) acquire the seed totally from the market after a dry year. Most farmers (75%), purchase part of their seed needs from the market when the previous season conditions prevent seed production. These data show clearly the significance of the effect of drought on the seed source. Consequently, drought has an important impact on the diversity, by influencing seed composition over time.

Nevertheless, drought does not affect the spectrum of varieties cultivated in each village. A comparison of variety profiles following different seasons shows that the same varieties are grown in each village. However, the frequency of each variety in the flows (proportion of seed of each variety in the total amount of seed used in a village) changes according to type of season as well as the source of seed supply. Consequently, this might influence structure of population and intrinsic genetic diversity within population of the same landrace. Additionally, the frequency of varieties changes in terms of area planted.

Nevertheless, depending on villages, a number of farmers change seed after a number of years as part of their seed strategy for different reasons. The seed renewal frequency varies highly depending on farmers. Table 4 shows that 42% of farmers do not change seed as a rule. This proportion is higher in Ourzagh community (56%). In the two communities, 68% farmers regularly change the seed according to seven deadlines. Among these farmers, only 13% change seeds every year while only 1% change it every 7 years. Thus, farmers change seed lots according to fixed deadlines to maintain consistent production on their field. However, most farmers keep producing the same varieties, yet the proportion of each variety might change, particularly following drought periods.

Drought is an important factor influencing seed renewal frequency overall. Indeed, farmers who are accustomed to producing their own seeds on-farm are constrained to buy seed from the market or purchase it from neighbours when the previous year’s production is not satisfactory. Therefore, seed introduction to the village increases particularly in dry seasons when the local production is low and the seed quality weak. Such conditions oblige the farmers to renew their seed.
Table 4. Distribution of farmers according to faba bean seed renewal frequency in the communities of Ourtzagh and Ghafsai

<table>
<thead>
<tr>
<th>Frequency of seed renewal (number of years after which seed is purchased)</th>
<th>Ourtzagh community</th>
<th>Ghafsai community</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No change</td>
<td>56</td>
<td>13</td>
<td>42</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

References
Genetic diversity and on-farm seed system in Ethiopia

Tesema Tanto
Institute of Biodiversity Conservation and Research (IBCR), Addis Ababa, Ethiopia

Introduction
Farmers’ varieties (landraces) are well adapted to different specific physical and biological environments. There is empirical evidence that they are tolerant of certain biotic and abiotic stresses. They are sources of different desirable quality traits for modern scientific research as well. Conversely, farmers’ varieties (FVs) do not respond to high-input agriculture (HIA), which limits their value to subsistence farmers and marginal production areas.

In Ethiopia over 90% of the food crops grown and sold are FVs. Most farmers producing FVs sell their produce to consumers and traders in the local market. Disposal of products in a local market normally includes substantial farmer-to-farmer exchanges. Commercial marketing organizations and grain traders at all market levels do not make a distinction between FVs and improved varieties. There is, however, a general feeling by farmers that FVs have a higher nutritional value than improved varieties.

Crop genetic diversity and the need for conservation
Crop diversity provides a tremendous array of benefits to humanity. It is the source of food, fuel, fibre and medicines, which also provides the raw material for industrial products. It contributes to the maintenance of ecological systems. Crop diversity primarily benefits the local communities living closest to the habitats. However, vast indirect benefits also accrue to urban populations, national economies and the global community at large (Mugabe et al. 1997).

Crop evolution involves two fundamental processes: the creation of genetic diversity and selection (natural and artificial or conscious). These evolutionary processes must continue in order for agriculture to remain viable. Even though agricultural science, notably plant breeding has altered and enhanced these processes it has not changed its fundamental nature. Ever since humans started domesticating plant species, crop improvement has relied on the available genetic variation on which both natural and artificial selections act. It was the rediscovery of Mendelian genetic laws in the 1900s that gave plant breeding a scientific basis and led to the release of genetically uniform improved varieties. At the time only a few scientists realized that FVs were being lost from agricultural fields and with them genes of immense value to subsequent generations. This became clearer when the spectacular synergistic effects of high-yielding varieties (HYVs), particularly of wheat and rice, and cheaper nitrogen sources led to the so-called Green Revolution. The action taken to curb this irreversible loss of crop genetic resources was to store landraces in genebanks, i.e. ex situ conservation.

Farming systems trend and its implication for in situ on-farm conservation of FVs seed
 Discussions were held with elders (men and women) to assess the changes that have occurred over the last three decades and the implication of these changes on FVs seed conservation. At Harbu, both men and women groups indicated that there have been significant changes in climatic conditions in the area. Rainfall amount and distribution have reduced. In 1984/85 a drought occurred in the region and a number of localized droughts have occurred since then. Consequently, production of some of the preferred FVs of sorghum has declined. Farmers introduced some drought-tolerant types of sorghum FVs and their production expanded. Thus, the composition of FVs grown over the last two to three decades decreased. At Ejere, the area covered by wheat FVs has declined over the last 10 to 20 years and area under improved wheat varieties has expanded. This is also true for maize FVs in Decha. At this location, production of hybrid maize has expanded over the last 5 years, although there was a setback in the 2001/02 production season due to high input price and collapses in maize seed price. This signals the threat to FVs and the need to conserve them.
Over the past three decades the human population has tremendously increased and this has resulted in great pressure on grazing land and on deforestation for crop production. Moreover, farm sizes have been reduced and this entails the need for greater productivity from a given unit of land to meet food and cash needs of the household. A substantial proportion of conservator and non-conservator farmers at Harbu, Ejere and Decha realized that areal coverage of FVs has been declining. Farmers stressed that some FVs have either been lost or are on the verge of extinction.

Seed source, selection and maintenance
Farmers have developed systems of ensuring a sustained supply of seeds. The basic seed source for FVs is their own seeds saved from a previous harvest and this source is more common at Decha and Harbu than at Ejere. Seeds are also obtained through exchange, gift from relatives or friends and through purchase from markets. Recently crop conservation associations (CCAs) actively engaged in providing seeds from community gene banks (CGBs) on credit to members (Figures 1 and 2). NGOs operating in the area also provide seeds to farmers. For example in Kalu Woreda, CONCERN Ethiopia, a NGO, procures and distributes FV seeds to farmers. In Ejere, seeds of improved varieties are made available through the service cooperatives and extension package programme. The amount of improved seeds distributed is much lower in Harbu and Decha than in Ejere. At these two sites farmers depend more on informal (traditional methods) seed production and maintenance to ensure a supply of seeds.

Revolving seed system
To ensure adequate seed supply by each community genebank, some 136,942 kg of 64 farmer varieties multiplied in each district/woreda or purchased from conservator farmers of the respective sites were made available additionally in this system (see Table 1).

Farmers were given seed on a loan basis for conserving/multiplying materials that were likely to disappear or be abandoned but might have potential value, and for multiplying such seed for distribution to local farmers in the region. This was determined based on the additional inputs (labour and various costs) incurred in such a task. Their activities have been guided and closely supervised by the IBCR scientific and field staff, including local agricultural extension agents collaborating with the institute.

More than 3883 farmers shared seeds developed in this way, and multiplied these materials for further distribution for the following planting season. Many of the crop plants that are locally
adapted were jointly selected with farmers and did relatively well, all with no external inputs like commercial fertilizers, pesticides, herbicides, etc. They were expanded into vicinities close to the project areas of the above regions where frequent crop failures have occurred due to prevailing droughts, thus filling major gaps in the availability of locally adapted seed for planting under such stressful conditions.

Seed lenders charge exorbitant interest rates and exploit farmers who have lost their seeds owing to various factors and are unable to maintain their seeds. The prices of planting seeds become very expensive at planting time. For example at places like Harbu, South Wello, the price of sorghum seed is more than twice the price of grain for consumption and the ratio between grain and seed prices could be as high as 1:10 during planting time. Loans of planting seed from the community genebanks protected the farmers at the conservation sites from seed lenders and the exploitation of other suppliers.

### Table 1. Amount of farmers’ varieties of different crop seeds under revolving seed system

<table>
<thead>
<tr>
<th>Region</th>
<th>Zone</th>
<th>Crop Conservation Association</th>
<th>Number of farmer varieties</th>
<th>Amount in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amhara</td>
<td>North Shewa</td>
<td>Ankober</td>
<td>2</td>
<td>2 360</td>
</tr>
<tr>
<td>Amhara</td>
<td>North Shewa</td>
<td>Insaru Wayu</td>
<td>5</td>
<td>1 320</td>
</tr>
<tr>
<td>Amhara</td>
<td>South Wello</td>
<td>Kallu</td>
<td>3</td>
<td>8 668</td>
</tr>
<tr>
<td>Amhara</td>
<td>South Wello</td>
<td>WereiLU</td>
<td>8</td>
<td>9 815</td>
</tr>
<tr>
<td>Oromia</td>
<td>East Shewa</td>
<td>Lume</td>
<td>7</td>
<td>36 300</td>
</tr>
<tr>
<td>Oromia</td>
<td>East Shewa</td>
<td>Gimbichu</td>
<td>4</td>
<td>36 300</td>
</tr>
<tr>
<td>Oromia</td>
<td>Bale</td>
<td>Agarfa</td>
<td>3</td>
<td>3 169</td>
</tr>
<tr>
<td>Oromia</td>
<td>Bale</td>
<td>Goro</td>
<td>5</td>
<td>1 953</td>
</tr>
<tr>
<td>SNNPR</td>
<td>Keffa Sheka</td>
<td>Decha</td>
<td>5</td>
<td>12 978</td>
</tr>
<tr>
<td>SNNPR</td>
<td>Keffa Sheka</td>
<td>Chena</td>
<td>6</td>
<td>14 650</td>
</tr>
<tr>
<td>Tigray</td>
<td>Eastern zone</td>
<td>Hawzen</td>
<td>11</td>
<td>6 993</td>
</tr>
<tr>
<td>Tigray</td>
<td>Eastern zone</td>
<td>Ganta Afeshum</td>
<td>9</td>
<td>2 436</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>136</td>
<td>942</td>
</tr>
</tbody>
</table>

Source: IBCR Terminal Report

**Incentives to farmers growing their own traditional seed**

Seed markets offer a strong incentive for *in situ* conservation of farmer varieties. FVs sold for seed purposes, as compared with grain price, fetch premium prices depending on the season and the locality. Community genebanks play an important role in the FV seed supply system and in stabilizing the FV seed market, as well as in keeping farmers attracted to the *in situ* on-farm conservation programme. A distinct market for FVs at the national (as opposed to the local) level has not been developed. Producing FVs as organic products is relatively easy since most smallholders growing landraces (>90%) do not use fertilizers and other inorganic inputs on their annual FVs such as sorghum or durum wheat. This experience was extended to farmers at East Shewa site to organically produce durum wheat for supply to the nearby milling industries. This shows that there is considerable potential for organic production of a variety of other crops including oilseeds and pulses. Furthermore, the project has managed to develop links between Ejere and Cheffe-Donsa (Adaa) farmers growing durum wheat varieties with the flour-milling companies serving the confectionery industries. The milling companies used to import the durum wheat variety but are now contracting farmers to supply the grain, with an estimated annual demand of 10 000 quintals (1000 t).
**Women's participation in the local seed system**

The project enhanced the involvement of women in *in situ* on-farm conservation and in household decision-making. It was possible to increase women's participation from no participation to 20% depending on specific local and cultural condition of the *in situ* site. In the male-headed household, women have participated in a number of farm activities including seed selection and decision-making on which FVs to grow. Considering their influence on the conservation activities, more attention was given to housewives in training and decision-making concerning the type of FV to be conserved.

Women farmers have rich indigenous knowledge about FVs. They use their own criteria in selecting and classifying FVs and comparing them with improved varieties. Some of the important traits/criteria that women farmers consider in valuing FVs include yield potential, baking quality, taste, grain colour, market value, feed quality and other qualitative characteristics.

**Local seed system and on-farm crop conservation**

Ethiopian farmers play a key role in creating, maintaining and promoting crop genetic diversity through identifying and promoting varieties obtained through exchange; promoting the intercrossing of cultivated crops with wild or weedy relatives, which results in new characteristics; identifying and propagating new, mutant types which occur in their fields, or hybridization between wild and/or cultivated types, or cultivars obtained through exchange; making available their knowledge and skills in identifying, collecting/rescuing and utilizing plants which they have helped develop and maintain for generations.

*In situ* (on-farm) crop conservation of FVs/landraces on peasant farms provides, therefore, a valuable option for maintaining a local seed system. More importantly, it helps to sustain the evolutionary systems that are responsible for generation of genetic variability. This is especially significant in regions of the country subject to drought and other stresses, because it is under such environmental extremes that variations useful for stress-resistance breeding are generated. In the case of diseases or pests, this allows continuing host-parasite co-evolution. In addition, under these conditions, access to a wide range of local seed systems provides the only reliable source of planting material. *In situ* conservation enhances the continued diversity-based agriculture as opposed to monoculture by ensuring intraspecific and interspecific diversity of crops.

Farmers themselves perceived an advantage in continuing to grow diverse traditional crops and their participation in conservation of a traditional seed system proved to be self-sustaining (sustainable). Nationally and internationally, the potential uses of diversity include, among others:

- Ecologically the on-farm conservation of the traditional seed system with its associated traditional knowledge is sound practice since it allows the evolutionary process of the crop conserved to take place in association with biotic and abiotic stresses that a crop plant can encounter;
- The farming communities have a continued source of genetic material produced by a dynamic evolutionary system;
- Farmers in the target regions and elsewhere have a more secure source of locally adapted traditional seeds that otherwise might be eliminated by genetic erosion;
- National and international breeders can develop new crop varieties that have a greater range of genetic material from these diverse and potentially useful basic crops;
- National and international crop scientists have a unique living laboratory to understand the biology and ecology of crop genetic resources and the seed system.

**Social impact of local seed supply system**

Seed is the basic input in agricultural production system. Lack of locally adapted seed, particularly in drought-prone and food-insecure communities, is crucial especially as production is only subsistence. The seed supply system developed by the Crop Conservation Associations has provided the opportunity for farmers to take seed loans from the community genebank with minimum interest
rates (10-25%) depending on local conditions every year. Some 4000 farmers can get seed by loan every year for planting purposes. Lack of seed has been alleviated because of the current system. This, in addition to a being constant source of locally adapted seed supply, has been able to generate resources that help them improve their livelihoods for all their family members. These situations assisted the farmers from in displacement to other areas where they could have a better life.

**Farmers' opinions on seed of their varieties**
During the initial period of the project, the farmers were hesitant and strongly argued to start the programme in their field. However, later on after some consecutive harvests of the landrace/FVs, they established confidence because of the following observed advantages of landraces (farmers’ varieties) over the improved varieties:
- Resistance to stress condition and pest outbreaks;
- No loan and no credit for purchase of fertilizer and different inorganic inputs while planting landraces;
- Free ‘produce of seeds’ without absorption effect of fertilizer nutrients and pesticides;
- Encouragement for organic farming and indigenous farming practices;
- Better productivity advantages under low-input production condition in marginal areas;
- High productivity advantages were obvious while using crop rotation and other organic farming techniques;
- Better local price advantage, especially for planting seed;
- Constant interaction among farmers and good exchange of ideas among each other;
- Good maintenance of alternative seed supply system through the CGBs;
- With respect to qualitative characteristics, the farmers’ opinions were summarized as follows, although some of these advantages need scientific confirmation;
  - The flour of local seed produces many enjeras compared with the same amount of flour of the improved varieties;
  - The landrace cultivars have good taste for both human diet and animal feed. The farmers observed some poisoning effect of some straw of improved varieties on their cattle;
  - Better diet satisfaction of the farmers’ varieties;
  - Medicinal value of their varieties;
  - More tillers per plant and seeds per spikes;
  - During the project period, the farmers said that they were in a position to reintroduce their landrace varieties, which had been lost before the onset of the *in situ* project.

**Economic advantages of farmer varieties seed**
The ability of landraces to survive under stresses is promoted by their inherent broad genetic base. This is often not the case with the uniform, new or improved cultivars that, despite their high yield potential, are less stable and not as reliable as sources of seed under the adverse growing conditions generally present in many of the drought-prone regions of Ethiopia.

Programmes for evaluation and enhancement of FVs are needed to promote more extensive utilization of crop genetic resources that are already adapted to these regions. In addition, under such extreme environments, locally adapted seeds provide suitable base materials for national crop improvement programmes. There is, therefore, an outstanding need to maintain landraces growing under these conditions in their dynamic state, and the Institute of Biodiversity Conservation and Research best achieved this through on-farm or community-based conservation programmes.

At the conservation sites, the project has reduced the rate of genetic erosion and restored local seeds or landraces in regions where they were wiped out by severe drought or otherwise consumed by farmers during the famine years or replaced by new, exotic or improved (high input) varieties. The other aspect of the project was the enhancement of the yields and other desirable characteristics of landraces, and their utilization for food, to ensure a sustainable, more secure and reliable seed supply.
IBCR scientists and farmers have already identified a few elite seeds (e.g. white and purple seeded durum wheat) with the potential for use in the food industry (especially for pasta and pastries), which at present largely depends on imported food grain, and farmers are multiplying those for local/urban consumption. To support a sustained, more elaborate landrace enhancement activity some 175 durum wheat farmers’ varieties were evaluated/characterized. Through this process additional entries were identified for the durum wheat landrace on-farm selection activities, as well as the enhancement work undertaken collaboratively with Debre Zeit Research Centre, along with the older durum wheat composites at Ejere. Similarly, in South Wello Region, 66 sorghum farmers’ varieties and other pulse crops that are locally adapted types with potential for high yield and other desirable characteristics were identified and distributed to the local farmers.

Conclusions and recommendations
The seed loan system developed has strengthened the more sustainable revolving seed system schemes, which have to a large extent provided incentives to farmers. This system provides farmers with a fallback mechanism and has enabled them to be more seed secure.

The growing demand for farmer varieties seed in the local markets, their multiple benefits including low inputs, better adaptation to marginal conditions and superior culinary, nutritional and straw qualities have all contributed positively to sustainability in the project areas.

A key component of the seed system is the creation of links to the markets in the private sector. To this end, it is worth mentioning that the project has managed to develop links between Ejere and Cheffe-Donsa (Adaa) farmers growing durum wheat varieties with the flour-milling companies serving the confectionery industries. This commendable initiative needs to be enhanced through further diversification of markets and replication in the other project sites and regions.

The participation of local communities and awareness created makes the seed system initiative more sustainable in a social context. The local farmers are keen to produce farmers’ varieties because of their merits including performance in marginal areas with little or no requirement for chemical fertilizer inputs.

The seed system is based on a revolving seed supply with an inbuilt interest-generation mechanism on seed loans. Moreover, market and non-market incentives are being developed for better pricing devices for farmers’ varieties grown in a chemical-free environment. Looking for the right market niches for organic products is one of the ways forward.

Recommendations
More agroecological zones of the country have to be covered for effective local seed supply systems, especially in drought-prone areas.

The research and enhancement aspects of farmer varieties seeds have to be strengthened to effectively utilize the existing farmer varieties in crop improvement programmes and in local seed supply systems.

Some policy issues that disregard the use of farmer varieties in the extension packages have to be revised because of their importance in less food-secure and drought-prone areas.

Community genebanks with seed loan schemes secure the local seed supply system. Therefore, this effort has to be expanded in more agroecological regions of the country.

The farmer varieties across the country have to be identified and enhanced in order to promote these local varieties to add value because of socioeconomic, nutritional and ecological advantages.

The availability of locally adapted planting seed is a security for farmers; the identified and enhanced farmer varieties of crops in each region have to be purchased in each locality and made available both as planting seed and as grain, especially in drought-prone and food-insecure regions of the country.
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Management of maize varieties in a traditional agricultural system of México

Dominique Louette
SHIS (Lago Sul), Brasilia DF, Brazil

Introduction
This paper discusses the basic assumptions of most genetic resources conservation projects: that a local variety is well defined in space, as the result of local management, and that varieties are genetically defined units, as there is concern about geneflow or contamination by other varieties. This study examines, in a traditional agroecosystem in México, the structure of diversity in maize and analyzes the effect of farmers’ seed management strategies on this structure. Its objective is to specify the mechanisms responsible for the structure and dynamics of diversity. Analyses of phenotypic and phenological characteristics, combined with data on seed sources, demonstrate the effect of introduced varieties on the diversity of maize cultivated in a traditional community. The amount of seeds used to reproduce the variety, and the management of those seeds in space and time, call into question the genetic definition of a landrace. This work shows that local varieties exist as part of an agricultural system which extends beyond a single place and that the dynamic nature of these systems precludes “freezing” local varieties into a static system.

Methods
Cuzalapa watershed
This work was implemented in the indigenous community of Cuzalapa in the Sierra de Manantlán Biosphere Reserve (SMBR), on the West Coast of México (Figure 1) which is most likely one of the zones where the genus Zea originated (Benz and Iltis 1992).

Figure 1. Reserva de la Biosfera Sierra de Manantlán (RBSM) and the Cuzalapa valley.
The Cuzalapa watershed covers mountainous land of irregular topography. The agricultural zone is characterized by a hot subhumid climate, with a mean annual temperature of 22°C and mean annual precipitation of 1500 mm, concentrated from June to October. Fields are generally located near rivers on alluvial soils of moderate fertility.

Each year, about 1000 ha are sown in Cuzalapa, 600 ha of which are irrigated (Martínez and Sandoval 1993). Maize is the dominant crop in the valley. Nearly half of the survey farmers cultivate maize in association with squash on an average of 2 ha per farmer during the rainy season. Maize is also planted under irrigation in the dry season, intercropped with beans for the majority of the survey farmers, on an average of 2–3 ha per farmer. With relatively traditional cultural practices, compared with those found outside the Sierra de Manantlán, mean maize yields reach 2.8 t/ha (unshelled) during the rainy season and 2.1 t/ha (unshelled) under irrigation. Cuzalapa is representative of many indigenous, poor and isolated rural areas in México.

“Seed lot” and “variety” defined
The terms and concepts used in this work are based on farmers’ own practices and concepts. In this context, the term “seed lot” refers to the set of kernels of a specific type of maize selected by one farmer and sown during one cropping season to reproduce that particular maize type. A “variety” or “cultivar” is defined as the set of farmers’ seed lots that bear the same name and are considered to form a homogeneous set. A seed lot, therefore, refers to a physical unit of kernels associated with the farmer who sows it; a variety is associated with a name.

A maize variety is defined as “local” when seed from that variety has been planted in the region for at least one farmer generation (that is, for more than 30 years, or if farmers state that “my father used to sow it”). By contrast, an “exotic” variety is characterized either by the recent introduction of its seed lots or by episodic planting in the valley. Exotic varieties may include landraces (farmers’ varieties which have not been improved by a formal breeding programme) from other regions and commercial improved varieties recently or repeatedly reproduced by farmers using traditional methods.

Measuring morphological diversity
The structure of phenotypic diversity was studied both within a variety (among seed lots of a variety) and across varieties (among sets of seed lots bearing different names). Fourteen of the 26 cultivars identified by farmers (all six local varieties and eight exotic varieties) were selected for analysis based on their origin and seed availability. The number of seed lots per cultivar (one to six) varied according to the importance of the cultivar in terms of planted area.

Morphological descriptors were measured in a controlled experiment of maize grown in pure stand in three complete blocks. Seed for each plot was taken from 100 ears (two grains per ear) selected by the owner, to obtain a sample representative of the diversity of each seed lot. Descriptors were measured using a sample of 20 plants and 15 ears per elementary plot, and refer to characteristics of the vegetative parts, tassel and ear.

Factorial Discriminant Analysis (FDA) and Hierarchical Cluster Analysis (HCA) (STATITCF program) were used to analyze diversity among the seed lots within varieties and among varieties.

Documenting the exchange of seed lots and varieties
By detailing the geographic origin of each farmer’s seed lots, for each variety, in each planting cycle, one can determine and characterize the frequency of seed exchange among farmers and the pattern of variety diffusion. Thirty-nine farmers (one-fifth of Cuzalapa farmers) were surveyed during six cropping seasons spanning three calendar years. For each farmer and cropping season, data were collected on varieties cultivated and seed source. Each variety was registered with the name given by the farmer. When the seed introduced from another region shared the same name as a local variety but was not considered, by the farmer growing it, to be the local variety, a second label was noted in brackets (e.g. Negro [Exotic]).
The seed source was classified in three ways: (1) as own seed (seed selected by the farmer from his own harvest), (2) as seed acquired in Cuzalapa (seed obtained in the valley of Cuzalapa from another farmer), and (3) as an introduction (seed acquired outside of the Cuzalapa watershed). The origin of a seed lot is defined independently of the origin of the previous generation of seed. A seed lot is considered “own seed” if the ears from which the kernels were selected were harvested by the farmer in his field in Cuzalapa, even though the seed that produced those ears (i.e. the previous generation of seed) may have originated in another region. The data, therefore, are representative of the extent of seed exchange, but they underestimate the importance of exotic genes in Cuzalapa.

Monitoring geneflow
To evaluate the level of geneflow between different varieties, the sowing pattern of seed lots in space (localization of the different seed lots) and in time (sowing date and flowering date) was studied over three seasons, on a 10-ha area. This area corresponded to seven fields separated from each other by less than 200 m. Since this is the minimum distance for reproductive isolation in maize breeding, geneflow can take place between all seed lots planted on this area.

Determining the quantity of seed used per seed lot each cycle
Replanting each variety from small samples of seeds theoretically leads to a loss of alleles (Maruyama and Fuerst 1985; Ollitrault 1987). For an open-pollinated plant, the theoretical work of Crossa (1989) and Crossa and Vencovsky (1994) has shown that a seed lot formed from less than 40 ears (1) does not permit the conservation of alleles whose frequency in the population is less than 3% (rare alleles), and (2) is conducive to the loss of heterozygosis superior to 1% when there are less than three alleles per locus. Thus, the use of reduced and variable quantity of seeds leads to the fluctuation of diversity with loss of alleles (Maruyama and Fuerst 1985; Ollitrault 1987).

To determine the effective population size of the seed lots planted in Cuzalapa, the volume of seed of each seed lot was obtained for the 39 farmers participating in the survey during six cultivation seasons. This was converted to the number of shelled ears for each seed lot, based on the weight of 1 L of grains and of 100 grains, for each variety, and considering an average of 250 grains used for seed per ear.

Results
Phenotypic diversity of varieties
During the 6 seasons included in the survey, survey farmers grew a total of 26 varieties (Table 1). Each farmer grew, on average, more than two varieties per season (1–7). Most of these cultivars are white-grained dents and are primarily used for making tortillas, the starchy staple of the Mexican diet. Three flinty popcorn varieties (Guino Rosquero, Negro [Guino] and Guino Gordo) were also identified, as well as three purple-grained varieties (Negro, Negro [Exotic], Negro [Guino]) and three yellow-grained varieties (Amarillo Ancho, Amarillo, Amarillo [Tequesquitlán]). The purple varieties are generally consumed roasted at the milky stage, while yellow varieties are used essentially as feed for poultry and horses.

From the 26 varieties identified, only the cultivars Blanco, Amarillo Ancho, Negro, Tabloncillo, Perla and Chianquiahuitl are local and all related to the Tabloncillo race. Four of the six local varieties are cultivated by a large percentage of farmers. Since two of these varieties have white grains (Blanco and Chianquiahuitl), one has yellow grains (Amarillo Ancho), and the fourth has purple grains (Negro), all four varieties provide for the different household uses of maize in Cuzalapa. Although reduced in number, the local varieties cover more than 80% of the area.

The remaining 20 of the 26 varieties that Cuzalapa farmers grew during the survey period are classified as exotic. Each exotic variety covered less than 5% of the maize area planted in each season, and most were cultivated by only a few farmers at a time. The composition of this group of varieties changed from season to season. Only three of these varieties (Argentino, Enano and Amarillo) had
been regularly cultivated over the preceding 4 or 5 years by a significant percentage of farmers (10–12%). The group of exotic varieties is morphologically diverse, including white-, yellow- and purple-grained materials, and representatives of different races.

Table 1. Cultivated maize varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>% of area sown with maize</th>
<th>% farmers</th>
<th>Kernel colour</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local varieties</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blanco</td>
<td>51</td>
<td>59</td>
<td>White</td>
</tr>
<tr>
<td>Chianquiahuitl</td>
<td>12</td>
<td>23</td>
<td>White</td>
</tr>
<tr>
<td>Tabloncillo</td>
<td>5</td>
<td>6</td>
<td>White</td>
</tr>
<tr>
<td>Perta</td>
<td>0.4</td>
<td>0.02</td>
<td>White</td>
</tr>
<tr>
<td>Amarillo Ancho</td>
<td>8</td>
<td>23</td>
<td>Yellow</td>
</tr>
<tr>
<td>Negro</td>
<td>3</td>
<td>34</td>
<td>Black</td>
</tr>
<tr>
<td><strong>Exogenous varieties</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argentino</td>
<td>5</td>
<td>10</td>
<td>White</td>
</tr>
<tr>
<td>Enano</td>
<td>3</td>
<td>12</td>
<td>White</td>
</tr>
<tr>
<td>Amarillo</td>
<td>3</td>
<td>11</td>
<td>Yellow</td>
</tr>
<tr>
<td><strong>Minor varieties</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Phenotypic characteristics and varietal identification**

With the exception of the Bl lot of the Blanco variety, the HCA analysis of seed lots for five of the more widely grown varieties (four locals and one exotic) demonstrates that seed lots bearing the same name cluster together based on their morphological characteristics. The use of colour would have perfectly differentiated AA (yellow) and N (purple). The results support the hypothesis that a farmer’s concept of a variety corresponds closely to that of a phenotype. A farmer variety is a set of seed lots having the same name; these seed lots produce maize with similar plant, tassel and ear characteristics.

The implication of these findings is that a seed lot that resembles seed of a “local” landrace can be classified as such by the farmer, even though its origin may be exotic or unknown. As a consequence, some seed lots of “local” landraces are in fact introduced from other regions.

**Phenotypic variation between varieties**

The phenotypic characteristics of the six local varieties and eight exotic cultivars (including the three most widely cultivated) were studied. The first axis is essentially defined by row number (–ROW), grain width (+WGR), ear height (–HEA) and plant height (–HPL). It is related to length of growing cycle: a long-duration variety is characteristically a taller plant that has more leaves and smaller grains arranged in more rows. The second axis is determined by ear development, including the weight and diameter of the cob (+WCO, +DCO) and weight and diameter of the ear (+WEA, +DEA).

Local and exotic varieties appear different by length of growing cycle (1st axis) and by origin or race. Local varieties and Amarillo [Tequesquitlán] are related to the Tabloncillo race, which originated on the Pacific Coast of México (Wellhausen et al. 1952) while exotic varieties included in the trial (except Amarillo [Tequesquitlán]) are from other races.
In Cuzalapa, therefore, local and exotic varieties appear to be complementary from a morphophenological point of view. Introductions of new material add diversity. The longer growing cycles of exotic varieties may reflect the fact that maize cultivation during the rainy season began on a large scale only recently or that few early maturing improved varieties have been developed for the lowland tropical zones (CIMMYT 1993). It may also reflect the fact that no introduced seed lot that is morphologically similar to a local variety would be distinguished, so no exotic variety with characteristics similar to those of local varieties would be recognized as a distinct cultivar.

Seed lot exchange
During the study period, the survey farmers sowed 484 seed lots for the total 26 varieties they cultivated, on 442 ha. Many of these seed lots came from other farmers or regions (Table 2). On average, for all cropping seasons, survey farmers selected slightly over half (53%) of their seed lots from their own harvest. About 36% of the seed lots were obtained from another farmer in Cuzalapa, and 11% were introduced from other regions. Calculated in terms of area planted, seed from farmers’ own harvests represented 45% of the maize area in the study zone, whereas 40% was planted to seed from other Cuzalapa farmers and 15% was planted to exotic introductions. Seed exchange—whether between farmers inside the valley or with farmers outside the valley—is clearly very important, contrary to the general perception of traditional rural societies in relation to cultivated varieties. The data indicate that maize cultivation in Cuzalapa depends notably on local materials but also on a changing and diverse group of exotic varieties introduced through farmer-to-farmer exchanges.

Table 2. Origin of seed lot planted in Cuzalapa (39 farmers, 6 growing seasons)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Own seed†</th>
<th>Seed acquired in Cuzalapa‡</th>
<th>Introduced seed§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local varieties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exogenous varieties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most important</td>
<td>42.1</td>
<td>52.6</td>
<td>5.3</td>
</tr>
<tr>
<td>Minor</td>
<td>39.4</td>
<td>24.2</td>
<td>36.4</td>
</tr>
</tbody>
</table>

† 52.9% lots, 45% area  
‡ 35.7% lots, 39.9% area.  
§ 11.4% lots, 15.1% area.

The pattern of varietal diffusion
Both local and exotic varieties were planted from farmers’ own seed lots, from seed lots acquired in Cuzalapa, and from introduced seed lots, but in different proportions (Table 2). Seed of the most widely grown varieties, noted in the text as “major varieties”—including the local varieties and the three most important exotic varieties—is less likely to have been obtained from farmers outside of Cuzalapa than seed of the more minor exotic cultivars (7.9% of local varieties and 5.3% of important exotic varieties seed lots were introduced, compared with 36% of minor exotic varieties seed lots).

Important and minor exotic varieties can be distinguished by their pattern of diffusion. Farmers in the valley exchange seed of the important exotic varieties (52.6%) much more frequently than seed of the minor exotic varieties (24.2%). This is explained by the fact that important exotic varieties were introduced some 10 years ago, and, since they have demonstrated characteristics of value, their seed is redistributed to other farmers in Cuzalapa.

Flow of genetic material is probably constant between communities over large geographic areas. Farmers appeared to be very curious and open-minded about testing new cultivars. The composition of the group of varieties sown, as well as the composition of the group of seed lots that comprise a variety, is variable in time. What is important to note is that seed lots introduced from outside the
valley can be considered as part of the local varieties. A “local” variety is therefore not constituted by seed lots of local origin only.

**Geneflow between seed lots**
The survey and the observation of the sowing pattern on an area of 10 ha during three cultivation seasons indicate that traditional management of seed lots does not aim to prevent the sowing in contiguous areas of different varieties (Figure 2). A farmer sows an average 2.5 varieties per cycle in the same field, independently of those sown on the contiguous fields. There is no physical isolation between local and exotic varieties and between locally reproduced seed lots and seed lots planted in other areas.

![Figure 2. Varieties cultivated over a 10-ha area of the Cuzalapa valley, during three growing seasons.](image)

![Figure 3. Probable geneflow between maize varieties sown on a 10-ha area in the Cuzalapa valley.](image)
The planting date does not, however, lead to a sufficient difference of flowering date to permit reproductive isolation, in default of spacing isolation. The work of Basseti and Westgate (1993) has shown that geneflow is more probable between two maize varieties when the difference between the male flowering date of a variety and the female flowering date of the other variety is less than 5 days. Over the three seasons observed in Cuzalapa, the differences of flowering dates between seed lots averaged less than five days in 38% of the cases (Figure 3).

Farmers are not concerned by reproductive isolation in space and time between different varieties, between local and foreign varieties or between lots reproduced locally or outside the valley. Thus, the genetic structure of local varieties is linked to the diversity of the varieties sown in the area and can be particularly influenced by exotic varieties.

**Genetic drift**

The study of the quantity of seed from which seed lots are reproduced provides evidence that confirms the genetic instability of local and exotic varieties and shows why geneflow between seed lots is so important in this system.

In Cuzalapa, as the field area is limited and various varieties are sown in the same field, the size of the seed lots planted per variety is small. More than 30% of seed lots sown during the six cultivation seasons covered by the survey were constituted from less than 40 ears. This phenomenon is important above all for varieties cultivated in small areas, such as the introduced varieties (37.7% of seed lots) and the purple and yellow varieties (54.7%). For the main varieties, the phenomenon is less important, although 16.4% of the seed lots of the Blanco variety were constituted from less than 40 ears.

In conclusion, a significant proportion of seed lots is submitted to a regular reduction of their effective population size, leading to the fluctuation of their diversity with loss of rare alleles. If farmers managed seed lots in isolation from each other from a reproductive point of view, the diversity of some seed lots would probably decrease and consanguinity would probably increase, leading to a loss of production potential. In Cuzalapa, however, this is not the case. Consider, for example, that the genetic diversity of the Negro variety, reproduced from seed lots of which 70% originate from less than 40 ears, is extremely similar to the diversity of varieties like Blanco, reproduced from significantly larger seed lots (Table 3). Geneflow could be both responsible and necessary for the restoration of the genetic diversity of seed lots submitted to genetic drift.

<table>
<thead>
<tr>
<th>Table 3. Isoenzymatic polymorphism of four principal varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
</tr>
<tr>
<td>Blanco</td>
</tr>
<tr>
<td>Amarillo Ancho</td>
</tr>
<tr>
<td>Negro</td>
</tr>
<tr>
<td>Chianquiahuitl</td>
</tr>
</tbody>
</table>

**Discussion/Conclusions**

A farmer variety is, therefore, mutable in terms of the number, origin and genetic composition of the seed lots of which it is composed. Contrary to the modern concept of variety, local varieties constitute systems that are genetically open. A landrace is far from a stable, distinct and uniform unit.

Seed exchange and the morphological structure of diversity contradict the assumption that traditional systems are closed and isolated with respect to the flow of genetic material. It is questionable whether any particular geographic scale can include all of the factors affecting "local" varieties. It is not only the set of cultivars but also the set of seed lots that constitute the cultivars...
which vary in time. Finally, the magnitude of seed exchange among farmers and the fluctuation of
the diversity of seed lots, caused by the amount of seed used and by the regular geneflow between
seed lots, raise questions about the concept of a variety.

The structure and processes described for maize cultivation in Cuzalapa can be compared to
a metapopulation structure, defined as a group of subpopulations (seed lots) interconnected by
geneflow and submitted to local colonization and extinction (Olivieri and Gouyon 1992; Slatkin and
Wade 1978). Varieties evolve within the entire set of genetic material planted, including introduced
material.

Conservation strategies and methods will depend on conservation objectives. To preserve the
genetic diversity actually present in the watershed or to conserve specific alleles, ex situ conservation
would be a more appropriate option, provided that appropriate methods are used to collect
samples.

If the objective is the conservation of the phenotypic characteristics, it would be sufficient to sow
the varieties on areas of adequate size to reduce genetic drift and to ask farmers to select the seed.
This material can alternately be sown in farmers’ fields and conserved in an official or community
genebank.

If the objective is to conserve the characteristics related to environmental adaptation of this
material, diverse varieties could succeed one another if cultivated long enough in the zone to be
locally adapted, acquiring these characteristics by geneflow or environmental selection.

Perhaps what is more important than the preservation of the varieties is the maintenance of a
high level of phenotypic and genetic diversity. In this way, we turn the discussion from on-farm
conservation of varieties to on-farm conservation of diversity.

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Community systems of seed supply and storage in the Central Amazon of Peru

Luis Collado-Panduro¹, José Luis Chavez-Servia², Alfredo Riesco¹ and Rafael Soto³
¹Consorcio para el Desarrollo Sostenible de Ucayali, Pucallpa, Peru
²Instituto Internacional de Recursos Fitogenéticos (IPGRI-Américas), Cali, Colombia
³Instituto Nacional de Investigación Agraria, Estación Experimental Pucallpa, Peru

Introduction
The Central Amazon of Peru is part of an important centre of diversity and domestication of peanuts, hot pepper, cassava and other crops (Salick 1989). Both native Indian and mestizo inhabitants preserve such crop diversity in fields and home gardens through a dynamic flow of genetic material and traditional seed management. Community seed supply is complex depending on social relations within and among communities. The most common forms of seed supply are: (1) self-supply, where a farmer multiplies his or her own seed; (2) purchase, or an exchange system based on cash; (3) loan, which usually entails returning an amount of seed 25-100% greater than was originally borrowed, and (4) gift, a system of community support based on kinship relations. This paper attempts to describe the seed supply systems and postharvest management of cassava, maize, bean, peanuts, chillies pepper and cotton used by the Shipibo-Conibo, Ashaninkas and Mestizo ethnic groups of the Peruvian Central Amazon.

Material and methods
This study covered the Central Amazon region of the Departments of Ucayali, Huanuco and Pasco, Peru. The target region was subdivided into three subregions: (1) the Aguaytia Valley, an agroecosystem composed by terra firma and the Aguaytia and San Alejandro rivers inhabited by Shipibos-Conibo and mestizo ethnic groups (as they describe themselves); (2) the Alto Ucayali Valley, an area inhabited by Shipibo-Conibo rivereños (i.e. river people) along the Ucayali River, whose fields are covered by water for 3 to 4 months (floodplain) and who therefore take advantage of river beaches and the fertile soils left by floods; (3) the Pichis-Pachitea Valley, terra firma agroecosystems and crop fields near the Pichis river dominated by the Ashaninkas. Precipitation varies yearly from 1000 to 3000 mm.

In order to study seed supply and postharvest management of cassava, maize, bean, peanuts, chillies pepper and cotton, 37 communities were visited from October 2002 to March 2003: 19 Shipibo-Conibo, 13 Ashaninkas and 5 mestizo, with an average of 48 households per community and a range of 8 (one Ashaninka community) to 300 households (one Shipibo-Conibo community). Sample size per community consisted of at least 25% of households. The data collection instrument consisted of a structured questionnaire with open-ended and closed questions, which was applied to both men and women heads of households. Descriptive analyses were performed using SPSS.

Results and discussion
Seed movement among and within communities
Seed exchange was estimated to be higher within a community (>80% of farmers) than among communities (Figure 1). The major form of seed exchange for indigenous farmers is based on social ties (neighbours, relatives or friends). Seed exchange to other communities is less common owing to the long distance and difficult access (only by river or several hours of walking). However, some farmers stated that they may seek seed outside the village in the case of natural disasters such as floods, damage caused by change in the river courses or heavy losses due to predation (by birds and monkeys).

Transaction mechanisms in seed supply
Amazonian farmers generally do not use cash to obtain seed. When a farmer needs seeds or cassava stakes, he or she usually can obtain them through a loan (promising to return a greater amount by the next harvest time) and by gift mechanisms. In the Shipibo-Conibo and mestizos communities, >50% of
surveyed families said that their principal way to obtain seed is by loan or gift, while for the Ashaninkas self-supply predominated. This seems to be related to the vulnerability of crop fields to floods, a consequence of the topographic location (flat lands and lower) of the Shipibo and mestizo communities visited, suggesting that such constraints favour or strengthen intracommunity exchange. In contrast, for Ashaninkas, among whom self-supply was found to be most common, seed production is more predictable, as they inhabit the terra firma regions where floods are not a constant menace (Table 1).

Table 1. Percentages of families using different forms of seed interchange by socio-cultural group and crop, 152 households

<table>
<thead>
<tr>
<th>Transaction forms</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maize</td>
</tr>
<tr>
<td>SHIPIBO–CONIBO</td>
<td></td>
</tr>
<tr>
<td>Self-supply</td>
<td>15.2</td>
</tr>
<tr>
<td>Purchase</td>
<td>15.2</td>
</tr>
<tr>
<td>Loan</td>
<td>64.1</td>
</tr>
<tr>
<td>Gift</td>
<td>5.5</td>
</tr>
<tr>
<td>ASHANINKA</td>
<td></td>
</tr>
<tr>
<td>Self-supply</td>
<td>50.0</td>
</tr>
<tr>
<td>Purchase</td>
<td>3.0</td>
</tr>
<tr>
<td>Loan</td>
<td>47.0</td>
</tr>
<tr>
<td>Gift</td>
<td>–</td>
</tr>
<tr>
<td>MESTIZOS</td>
<td></td>
</tr>
<tr>
<td>Self-supply</td>
<td>17.6</td>
</tr>
<tr>
<td>Purchase</td>
<td>17.7</td>
</tr>
<tr>
<td>Loan</td>
<td>58.8</td>
</tr>
<tr>
<td>Gift</td>
<td>–</td>
</tr>
<tr>
<td>Purchase/loan</td>
<td>5.9</td>
</tr>
</tbody>
</table>
Forms of transaction vary among crops and ethnic groups. In chillies pepper and cotton, self-supply prevailed; in cassava, the gift; and in beans, maize and peanuts, the loan (only Ashaninka households). Other differences among ethnic groups were that Shipibo families use all of the transaction mechanisms while Ashaninkas presented less variation and the mestizo even less. Mestizo families use purchase and loan in maize and peanuts, and they do not use loans for maize, bean, peanuts and cotton (Table 1). This may be related to the fact that mestizos have migrated from diverse regions of Peru (data not presented), suggesting the possibility of relatively low intracommunity integration.

**Seed storage**

The families interviewed usually store their seed in traditional ways and containers made of different materials (Table 2). Some of the traditional systems of seed storage include: tama-chinchan (container made of leaves of *Generium sagittatum* woven with flexible stems of different plants); mishe (a bag made of leaves of *Calathea lutea*); tázá (a basket made of fibers of *Carludovica* spp. and big oval leaves of any plants); pachaka (wild fruits of bottle shape); shequi-toshcan (a system of hanging cobs in the kitchen over the fire so they can receive smoke); and chomu (a pottery container) (Figure 2). Each system maintains seed at different qualities and for different periods of time, according to farmers. However, storage time is never more than 2–3 years.

The most frequently used form of storage consists of any container for liquids made of plastic, glass, brass or clay, including the bottles of carbonated beverages or water, with the requirement that it can be closed hermetically. What farmers aim for is to avoid any attack by pests. The system may vary between crops, with maize, beans and peanuts commonly stored in plastic bottles or containers while peanut pods and maize cobs are stored in polyethylene bags.

The vegetative propagation of cassava by stakes means that quite different storage patterns are followed in comparison with seed crops. Cassava stakes are usually 1 to 1.5 m long, and farmers store them by placing groups of them perpendicular to the soil and just touching the surface (to avoid drying), in the shade of trees or near the house, covering the basal part with soil. This allows storage of the stakes from one crop cycle to the next. There may be some loss in such a system due to rainfall, especially when the stakes remain in the soil for more than 3 months.

The situation for chillies pepper and cotton is quite different from that of maize, peanuts and cassava, as these are often cultivated in low numbers and continuous regeneration is not carried out, the crops being treated as perennials. In the survey, few people mentioned specific storage systems for these species.

<table>
<thead>
<tr>
<th>Container and system</th>
<th>Socio-cultural group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shipibo-Conibo</td>
</tr>
<tr>
<td></td>
<td>M† B P</td>
</tr>
<tr>
<td>Any plastic container for liquids (not bottles)</td>
<td>64.8 78.7 14.7</td>
</tr>
<tr>
<td>Bottles of plastic or glass</td>
<td>9.7 21.3 14.7</td>
</tr>
<tr>
<td>Brass container</td>
<td>– – –</td>
</tr>
<tr>
<td>Clay pan</td>
<td>1.4 – 3.0</td>
</tr>
<tr>
<td>Polyethylene bags (grains)</td>
<td>8.3 – 47.0</td>
</tr>
<tr>
<td>Maze: cobs hung in the kitchen</td>
<td>5.5 – –</td>
</tr>
<tr>
<td>No storage</td>
<td>1.4 – –</td>
</tr>
</tbody>
</table>

† M = maize, B = bean; P = peanut.
Seed storage problems

Farmers frequently mentioned being worried about finding a safe and suitable place or container suitable for seed storage because they find severe damages in their grains during postharvest management. People surveyed were asked to estimate the percentage of seed loss during storage for the last five years. The highest loss percentage was recorded in maize, with 29.2, 38 and 17.6%, of the total of Shipibo, Ashaninka and mestizo households, respectively, reporting a loss of from 75 to 100% of their seed (the highest percentage in at least 1 of the recent 5 years). Causes included weevils (*Sitophilus* spp.) and moths (*Sitotroga cerealella*), which mainly affected maize landraces with semi-hard grain (some hybrids between Cuban Yellow and Piricinco races), and some with soft-floury grains (such as Piricinco race). Less damaged were landraces with hard grains. Beans also presented significant loss. For example, 41.2, 19.9 and 16% of the total of Ashaninka, Shipibo and mestizo households, respectively, estimated a loss of more than 75% of the stored seed (the highest percentage in at least 1 of the recent 5 years). The same pests slightly affected peanut seed (3% of households). Every community faced significant losses during seed storage. Therefore, seed storage is a fragile point in the community seed supply system and postharvest management. *Sitophilus* sp. and *Sitotroga cerealella* damage varied across communities and villages. In the Shipibo communities, located close to the rivers, major damage was identified (60% of households) in maize seed, while for the Ashaninka *terra firma* area, damage was less (42%). In bean and peanuts, the pattern of damage was the other way around, higher in the Ashaninkas than in the Shipibo communities; 41.9 and 9%, and 31.9 and 3%, respectively. Farmers often seek alternatives to diminish this type of damage in order to increase their seed quality. Some of these will be explained below.

**Seed management**

*Seed selection.* 39.5, 58.5 and 54.5% of surveyed household heads in the Shipibo, Ashaninkas and mestizos communities, respectively, indicated that they select their maize seed after harvest, using for next year’s sowing only healthy ears and seed from the central part of the cob. Another selection criterion was uniform ears with heavy or bigger grains; between 18.4 and 33.3% of households (variation among socio-cultural groups) use this practice, less with the Shipibo group than with mestizos. Most Shipibo households make seed selections of maize in the field (21.1%), choosing tall plants and bigger cobs and also only using as seed the central part of the ear. For bean, seed selection by Shipibo and mestizo families is done at cleaning time, using bigger, well-developed and healthy seeds. However, for Ashaninka families, it seems that there is not a particular preference for a seed selection practice as they can do it directly at harvest time, during seed cleaning and in the fields. The seed selection practice apparently depends on time available and opportunity. In peanuts, more than 80% of surveyed households remarked that they do the seed selection during the harvest by choosing big pods, with well-developed, healthy seed. For cassava, all households choose their stakes during harvesting, selecting stems of not too great a thickness but healthy, and from the central part of the plant.
Seed treatment for storage

The communities surveyed usually use traditional treatments, though recently they have incorporated pesticides (mainly communities closer to markets). Because of the problems previously mentioned, maize, bean and peanuts receive special attention. A common practice over all of the communities in the study area is exposing seed to the sun for drying (to achieve seed moisture content of 10 to 20%), then setting them aside in the shade to cool down, followed by storage in some sort of container. This can be repeated every month, which implies a continuous monitoring of the seed. Survey information indicated that between 10.5 and 26.5% of households of different ethnic group use pesticides for seed treatment, 1.4 to 2.3% use ash, and a few use the smoke treatment in the kitchen.

Years of continuous use of seed

The families surveyed mentioned that they frequently use their own landraces from 1 to 9 years continuously (76-90% of households over all socio-cultural groups and crops), which shows that despite low exchange among communities, exchange within family, and among friends and neighbours is much more dynamic. Ashankinka families indicated that they keep in continuous use their cassava and maize landraces between 20 and 25 years (Table 3). Time of continuous use can be influenced by the agroecosystem (risk of floods), storage problems, food security (eating the whole seed lot is necessary in some years), and the availability of new landraces or improved varieties (for example from government programmes) for substitution. The more dynamic crops in terms of seed renovation were maize, bean and peanuts, while cassava landraces are the most stable.

Conclusions

In the central Amazon of Peru, seed exchange among communities was less than within communities, which is, in part, influenced by the difficulties of access and communication. Most of the informants do not use money in seed exchange, rather relying on loans or gifts. The community seed system presents a certain fragility during seed storage because all informants noted significant losses to pests. Seed management varied from crop to crop and among ethnic groups in the time when seed selection is done (before harvest, at harvest or at seed cleaning) and selection criteria. Pesticide use is a recent practice for seed treatment, most households using traditional practices such as ash, smoke or exposure to the sun. Low periods of continuous use, from 1 to 9 years, of the maize, bean and peanut landraces confirm that there exists a high seed flow into communities, with the exception of cassava among the Ashankinkas.

Table 3. Continuous use of maize (M), bean (B), peanut (P) and cassava (C) landraces by socio-cultural group

<table>
<thead>
<tr>
<th>Number of years of continuous use</th>
<th>Socio-cultural group</th>
<th>Shipibo-Conibo</th>
<th>Ashankinka</th>
<th>Mestizos</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>B</td>
<td>P</td>
</tr>
<tr>
<td>1 to 4</td>
<td></td>
<td>83.0</td>
<td>70.2</td>
<td>70.6</td>
</tr>
<tr>
<td>5 to 9</td>
<td></td>
<td>12.9</td>
<td>23.4</td>
<td>26.5</td>
</tr>
<tr>
<td>10 to 14</td>
<td></td>
<td>0.7</td>
<td>4.3</td>
<td>2.9</td>
</tr>
<tr>
<td>15 to 19</td>
<td></td>
<td>1.4</td>
<td>2.1</td>
<td>–</td>
</tr>
<tr>
<td>&gt;20</td>
<td></td>
<td>2.0</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Reference

Session IV. Interventions and Scaling Up

Informal seed systems and on-farm conservation of genetic diversity: scaling up and interventions

Mohammed Sadiki¹ and Devra Jarvis²
¹Institut Agronomique et Vétérinaire Hassan II (IAV), Rabat, Morocco
²International Plant Genetic Resources Institute (IPGRI), Rome, Italy

Introduction
In many developing economies, particularly in marginal environments, local management of seed is vital for small-scale farmers. For centuries, farmers in these agroecosystems have developed and maintained their own crop varieties that fit their needs and requirements through local seed production, selection and exchange. A local seed supply system is a major dynamic factor that plays a crucial role in promoting crop evolution. It influences the structure and distribution of the on-farm crop genetic diversity at different scales. It has, therefore, a potential for dynamic maintenance of genetic diversity. Seed production and supply systems vary due to diversity of climate, crops, farming systems, cultures and economics. Commonly two types of seed systems or sectors are distinguished: ‘formal’ and ‘informal’. Both systems usually occur in a country or a region.

The formal seed system is carried out by different professional groups from public and private sectors under regulations and conditions including variety release procedures, intellectual property rights, certification, seed standards and contract laws. It complies with international conventions and agreements.

Informal local seed systems are large networks of local networks operating at different geographic scales (villages, communities, provinces, etc.), which are interconnected and allow circulation of plant material in different geographic units. They prevail in agroecosystems with subsistence economics where they provide most of the seed used for crop production. Seed systems in the informal sector are mainly in the hands of farmers and rural communities. Strong reasons for promoting informal seed system include (1) the high costs of seed sources in the formal sector do limit the use of such seed in rural communities, which are largely based on subsistence farming and exchange, (2) in some cases non-availability of seed from the formal systems, due to lack of sufficient quantities or to distribution problems, (3) security of seed supply (independence of external sources), (4) varieties or landraces maintained in local seed systems are often best fitted to the local specific agroecological conditions (drought, access of water, tolerance to pests and diseases, etc.).

Scaling up
Development actions and interventions require scaling up and mainstreaming of the scientific findings and technical data and information. This calls for taking the acquired knowledge beyond experimental and testing scales to scales that allow development actions at different geographic units. This implies translation of scientific knowledge into development interventions and actions that support the seed systems as a means of maintaining and using genetic diversity. Efficient mainstreaming and transfer of the generated technical packages into development will facilitate the adoption by target communities. In general the following areas of work are needed to provide bases to enhance options to farmers through strengthened seed systems to contribute to sustainable livelihoods:
• Assessing the seed and geneflow systems and how they are maintained by different stakeholders;
• Understanding the factors that affect farmer decision-making to maintain different seeds or new genotypes in their systems (variety spectrum);
• Increasing the scientific capacities, representative partnerships and institutions at community and national levels to support local seed and geneflow systems;
• Understanding how the systems can be better supported through national, regional and international programmes.

Interventions
Interventions depend on the components of the networks of the seed system. In general seed production in the informal sector is part of the common cultivation of the crops. Informal local seed systems consist of common interlinked components including farmer selection, on-farm seed production, seed storage, and local seed diffusion and supply (local market, seed dealers, etc.). Potential interventions may be classified as seed system component (sequence of the chain), targeted stakeholders involved, or who should be responsible for intervention.

Support on-farm seed production
At the technical level, improvement of seed production for ensuring better quality should be targeted through use of adapted and economically viable approaches and packages for strengthening the competence of farmers in selecting and producing quality seeds of their preferred adapted varieties.

Support on-farm seed storage
The degradation of seed quality during storage may be reduced through supporting extension of locally adequate storage means and through seed protection during storage where chemical protection might be necessary.

Promote practices of seed treatment prior to planting
Seed treatments with fungicides and insecticides may protect seed during germination from soil-borne diseases and pests and prevent transmission of pathogens and insects to the field by seeds. Seed-treatment equipment and chemicals specifically adapted to crops and local conditions should be advertised and promoted.

Promote practices of seed cleaning after harvesting, before storing and/or at planting
As soon as the seed is produced cleaning operations may significantly improve seed quality and germination by eliminating immature seeds, infected seeds, broken seeds, other crop and weed seeds.

Organization at the village and community levels
Actions should be designed that encourage seed cooperatives and associations through empowerment of farmers and their direct involvement in such groupings. At the market level, training and demonstrations should be extended to seed traders particularly for practices ensuring seed quality. In many countries, complementarity between regions and agroecosystems may be a viable strategy for ensuring seed supply. Nevertheless it is important to keep in mind that these actions do not mean ‘formalizing the local seed system’.

Genebank seed back to farmers
In numerous situations genebanks may play an important role in reintroducing plant material to its original habitats from which it has disappeared and where desired by farmers. Existing community seedbank experiences may be exploited to this end. Diversity demonstration fields to expose the stored plant material to farmers are an important way to bridge the genebanks and the farming communities.

Extend training actions
Through participatory approaches, actions should be undertaken to move beyond capacity-building to capacity mobilization through training (at different levels) and by providing follow-up support and monitoring of trainees. Several actions may be considered:
• Mobilize trained people with the capacity to act as trainers in the area of seed systems/genetic conservation, biodiversity management and sustainable agriculture;
• Promote and consolidate local initiatives related to seed systems;
• Establish/initiate or support community or local-level seed systems development, genetic conservation (seedbanking) or farm conversion towards biodiversity;
• Document seed-related practices, community or local/informal seedbanking approaches and availability of local seeds/varieties in database and sourcebook formats;
• Contribute to the systematization of available information on seedbanking/storage at community, village or higher levels;
• Provide linking mechanisms for various seed-related and conservation-related initiatives;
• Collectively initiate and commit to a nationwide but non-formal system of seedbanking for diverse crop species.

Promote policy and legislation
Legislations and policies should be promoted in such a way that they support, strengthen and do not constrain informal seed systems. Supporting local seed systems requires ensuring farmers’ and local communities’ rights.

Information diffusion and communication
Actions supporting publications and information diffusion through, local, national and international media and means should be strengthened.
Exploring means of policy development to support the on-farm management of agrobiodiversity

Susan Bragdon
IPGRI, Portland, Oregon 97202, USA

The policy development process
In order to be effective, laws and regulations need to be closely matched to the physical and socioeconomic and cultural conditions of a particular site. The knowledge needed to establish such laws and regulations is that which is most in touch with this environment, i.e. local knowledge. In addition, commitment to the law is related to its perceived legitimacy and this corresponds to its relevance to the local situation where it applies. A policy approach based on field data that considers the community’s socioeconomic, cultural, scientific, technical and institutional situations and is based on the involvement of all stakeholders at the grassroots level has been coined a “ground-up” approach. A truly ground-up approach presupposes an understanding of the local management and decision-making processes and the factors affecting those processes. This information is often lacking or, if it exists, there is no precedent for its integration into policy-making at the national level. The difficulty of integrating this information into policy formulation is exacerbated because the conservation or erosion of genetic diversity in farmers’ fields is shaped by a complex range of factors over time. The multifaceted nature of the conservation and sustainable use of agrobiodiversity presents challenges to policy analysis and formulation in support of on-farm maintenance of diversity.

Policy development is a multi-step process with inter-relationships among the steps and the need for feedback on impact and effectiveness (Figure 1). The first step in policy development is to identify the goal the policy is designed to achieve or the problem it is intended to address. Next, the scientific, technical, socioeconomic, policy, legal and institutional situation needs to be explored in order to provide a meaningful foundation to formulate policy recommendations. The next step is to assess the current and potential impact of the identified scientific, technical, socioeconomic, policy, legal and institutional factors on the ultimate objective of the policy. To develop policy recommendations, opportunities and constraints in the categories explored in the situation analysis must be explored. Possible future needs in terms of supporting the policy’s goal should be anticipated. Gaps in information should be identified and means to obtain it (or to compensate as far as possible for its lack) put in place. Criteria by which policy options will be assessed should be established. Monitoring and evaluation of policies and laws developed requires establishing indicators to assess actual impact at the formulation phase. Developing legal and institutional mechanisms follows the same steps. In the cases where there is current policy relevant to the identified objectives, the development and reform of policy, laws and institutions can happen in quick succession as part of one process.

Policy and legal analysis
Perhaps the best place to start in undertaking the national component is to look to those written sources that exist—legislative enactments, executive directives, judicial decisions, published regulations and the like. Administrative agencies and institutions are a fertile source of law and policy and an analysis must make use where possible of understandings about administrative practice. Legislatures will often give broad guidance, whereas administrative agencies and institutions implement the policies outlined, sometimes in quite a different form or with quite different effects from those intended. This step is related to but distinct from the institutional situation analysis which identifies the institutions and agencies that implement the relevant laws and policies. Clearly, it can be helpful to have identified these actors before looking to them for the scope of their responsibilities, but in many cases their
roles will become apparent only after exploring legislative enactments to determine the range and subject matter of the power granted to them. Consequently, any matrix developed for the policy, legal or institutional analysis will need to provide flexibility for different national situations. Tables or matrixes should be seen as providing a framework for analysis that allows comparison across countries and a minimum common foundation and not as an exclusive list that may inadvertently miss a policy, law or institution of relevance. In addition, there should be a feedback mechanism between the policy/legal and institutional analysis so, for example, policies or laws uncovered in the institutional analysis but perhaps missed in the legal/policy analysis can be included.

Another source of information on policies and laws is the farmers themselves. The farmers are in the best position to know which laws or regulations are having an impact on their management of agrobiodiversity on-farm.
Institutional analysis

Like the policy and legal analysis, the institutional analysis will need to evaluate institutional actors at the international, national and local levels. Table 1 outlines some of the categories of institutions at each level.

As noted in Table 1, part of the analysis will need to include how institutions charged with implementation interact with one another. Does the statute or regulation enable them to work harmoniously or set them up to work at cross-purposes? Does one institution take precedence over another, either in its funding or its organizational position? Are there coordination mechanisms?

Identifying the agencies and institutions charged with implementing a law or policy, however, is not enough. Many institutions exercise broad discretion under a grant of power from an executive authority. Others carry out quite specific functions in carefully prescribed ways. Even where an agency has no formal law-making functions of its own, such as issuing regulations or adjudicating disputes, its implementation of a given law or policy could deviate from what a cursory reading of its guiding statute might lead one to suppose. Consequently, simply compiling the laws and policies that describe what an agency or institution should be doing does not necessarily paint an accurate picture of what it is actually doing. To get a more complete picture, it is necessary to ask the agencies themselves what they do and to ask the farmers and others who feel the effects of the policies and laws as applied for their assessment of the institutional presence and impact.

One means to gather this information is to conduct in-person surveys or interviews with responsible institutions and officials based on agreed questions. Generally speaking, this stage should occur after analysts believe they have a workable compilation of policies and laws and a good grasp of what the governing authority intends to accomplish with those policies. Without such a compilation, the surveys and interviews will have no particular object and will result in less useful data. The surveys should examine not just what agencies prohibit or require by way of regulation or policy-making, but also what taxes they impose, what subsidies they provide, what educative or extension functions they undertake, what goods or services they provide by way of infrastructure, capital or other resources and which agricultural products they purchase directly for their own use or for distribution elsewhere.

Table 1. Situation analysis – institutional

<table>
<thead>
<tr>
<th>International</th>
<th>National</th>
<th>Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intergovernmental for a:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- CBD</td>
<td>Sectoral mandates and authority</td>
<td>Local community institutions: mandates and authorities (roles over access, use)</td>
</tr>
<tr>
<td>- IT</td>
<td>Coordination mechanisms</td>
<td></td>
</tr>
<tr>
<td>- WTO Agreement on Agriculture</td>
<td>Judicial enforcement institutions</td>
<td>Local genebanks</td>
</tr>
<tr>
<td>- TRIPS, etc</td>
<td>Courts</td>
<td>Farmers’ unions</td>
</tr>
<tr>
<td>- WIPO Patent Treaty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intergovernmental bodies:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- UNEP</td>
<td>Provision for extension</td>
<td>Cooperatives</td>
</tr>
<tr>
<td>- FAO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- WIPO (e.g. Intergovern-mental Committee on Genetic Resources, Traditional Knowledge and Folklore)</td>
<td>NGOs</td>
<td>Tribal systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NGOs</td>
</tr>
</tbody>
</table>

Networks (regional and /or NGOs crop specific)
Policy recommendations

Effective policy and legal development is based on sound field data and consideration of the needs and capabilities of relevant stakeholders. Its relevance is further ensured when policy and laws are developed in a participatory way. Furthermore, sound policy and legal development requires an understanding of (1) the current policy and legal environment and (2) the role of relevant institutions. The challenge of step four of Figure 1 is to establish a process by which these components are assessed and integrated into policy and legal recommendations.

The on-farm project has already identified some policy and legal factors that have an impact on on-farm maintenance of diversity. For example, information gathered in the project thus far illustrates how the seed supply system can be affected by policy and law. This example also illustrates why the integration of the many facets of the situational analysis is necessary for policy development to be meaningful and why building monitoring and evaluation into the process is also critical. Each year farmers decide how much seed to plant and where that seed comes from. In addition to the seed selected and stored from their own crop, farmers may obtain new seed from markets or other farmers. Many factors influence the seed supply system, such as the relative importance of the informal and formal seed supply systems, access to each, wealth, environmental factors, etc. Simply advocating for improvement of the seed supply system without greater understanding of these factors and also a means by which the impact of the policies promoting this strengthening over time is not useful. Improvement of the seed supply system, for example, could increase farmers’ access to genetically diverse crop varieties at the same time that it decreases genetic diversity by decreasing differentiation among populations. Similarly, the structure, organization and performance of formal seed systems is controlled by various rules and regulations (e.g. seed certification, seed distribution regulations) that influence the type and quantity of seed that is supplied through formal channels. The impact of these rules and regulations, the relation to the informal seed system in place, on in situ conservation on-farm needs to be understood with the effect of possible reforms monitored for impact.

Policy options must also be assessed in accordance with agreed criteria. For example, because poverty alleviation is a primary concern of most developing countries there are often calls for legal and policy mechanisms aimed at adding economic value to on-farm conservation as a means to improve the livelihoods of resource-poor farmers. The impact of such measures may be positive in some aspects and negative in others. For instance, the measures might have a negative effect on diversity over time by valuing some local varieties over others. If the maintenance of diversity over time is a national (or international) objective, means to bear the cost of such a choice will need also to be considered. If an option to add value to an on-farm crop population is proposed, it will be important to design a mechanism for monitoring its progress and impact.

Illustrative criteria for analyzing policy options are contained in Table 2.

Table 2. Develop common criteria/technique by which policy options are assessed

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Policy option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding required</td>
<td>1</td>
</tr>
<tr>
<td>Direct effect on diversity over time</td>
<td>2</td>
</tr>
<tr>
<td>Indirect effect on diversity over time</td>
<td>3</td>
</tr>
<tr>
<td>Acceptability: nationally, institutionally, locally</td>
<td>4</td>
</tr>
<tr>
<td>Agency capability</td>
<td></td>
</tr>
<tr>
<td>Capability of other necessary actors</td>
<td></td>
</tr>
<tr>
<td>Capable of satisfactory performance</td>
<td></td>
</tr>
</tbody>
</table>
Monitoring for impact is also important as impact may be different from what a desk-top analysis might predict. For example, at first glance, a national policy subsidizing the use of modern varieties and related fertilizers might be seen to reduce the planting of landraces. It could, however, be the case in some instances that the increased income from marketing of the improved varieties actually facilitated those farmers in continuing to maintain preferred varieties on a smaller land area. Policy and legal responses must be monitored over time for their genetic, ecological and economic impacts on farming systems to see if they do indeed fulfil the goal of maintaining high levels of diversity on-farm, as well as achieving the benefits of supporting agroecosystem health and improving farmers’ livelihoods in different contexts.
Seed systems and crop genetic diversity on-farm: community gene banking in Zimbabwe

C. Mujaju
Genebank of Zimbabwe, Harare, Zimbabwe

Introduction
The process of agricultural modernization in Zimbabwe has marginalized the majority of farmers, increasing social and economic inequalities. The dissemination of the green revolution technologies has brought about genetic erosion and disappearance of ecogeographically adapted crop cultivars, which provided a basket of choices for farmers. Farmers, in the process of adopting improved crop cultivars, lost some of their inheritable and accumulated knowledge, innovations and technologies of seed selection, treatment and storage.

Given the high cost of hybrid seed and the associated inputs, recurrent droughts experienced at least once in every 5 years punctuated with a pronounced one every 10 years, and the general harsh climatic and economic environment associated with the semi-arid areas, the majority of the farmers have been left wanting. This scenario immensely contributed to the farmers’ desire for their reputable traditional varieties. However, the limited supply of good-quality seed for local varieties can be an obstacle to farmers’ continued maintenance of genetic diversity. In Zimbabwe, one potential intervention for overcoming this limitation was the establishment of community genebanks or community seed banks. In the Zimbabwean situation currently, the terms Community genebanks and Community seed banks (CSBs) are often used interchangeably and this is because the two are usually found in the same structure. The same room used to store germplasm *ex situ* is also used to retrieve the required seeds for multiplication and distribution to the needy farmers. These two terms are, however, used separately in other parts of the world, particularly West Africa. CSBs are small-scale institutions, serving individual communities or several communities in a locality, which store local seed on a short-term basis. These genebanks are inexpensive, usually employing simple storage technologies. In Africa, Zimbabwe has spearheaded the community genebank concept, and has had success stories in its implementation by communities (Zinhanga, pers. comm.).

Problem identification prior to the intervention
Seed insecurity, or the lack of availability, of affordable and suitable planting material in a timely manner, is caused by a poor previous harvest because of climate-related problems or socioeconomic factors, or by poor seed selection or storage. It results in reduced production due to the absence of preferred varieties, as well as a lower area cropped due to absolute seed shortages, leading in turn to hunger and malnutrition, genetic erosion and dependence on external sources. Seed security can be expressed within individual households, or across an entire community.

Methodology
The methodology in using Community Seed Banks (CSBs) is a step-wise approach involving the following process.

Community diagnostics and needs analysis
A community diagnostic or needs analysis is first implemented to ascertain the need for a CSB, and for proper management procedures, including inventory, monitoring, regeneration strategy, and multiplication protocols. Participatory diagnostics of plant genetic resources-based livelihood strategies are preferred in order to determine appropriate interventions. A CSB was therefore an appropriate intervention, through which an understanding could be achieved of how management of plant genetic resources could be improved for better overall crop yields and stability of production. The most favourable factor for a CSB construction is chronic seed insecurity.
Community Seed Bank construction
According to farmers, a CSB is treated as a facility to store seed, at the community level, for a period of one season or more in order to avoid problems of seed insecurity. It can include the conservation of small quantities of a diverse range of varieties (as in a genebank) as well as larger quantities, sufficient for distribution, of a smaller number of preferred varieties. Construction of such a facility follows a design suggested by farmers but then forwarded to the Department of Agricultural Engineering for reworking into a proper design. Farmers’ suggestions are very crucial for sustaining the structure, as most of the materials to be used will be locally based.

Structures can be of various forms: with separate large and small rooms, or large and small and large pots within a single room, or racks to store panicles.

Management of a Community Seed Bank
Community farmers inaugurate a meeting at which they elect their leadership, which is mostly five people to oversee the running of the CSB. The process of elections involves casting of votes for particular contested positions, which include: Chairperson, Vice-Chairperson, Secretary, Vice-Secretary and Treasurer. In some cases committee members are elected. These farmers then highlight the roles and responsibilities to be vested upon this management committee.

Implementation
Do a diagnostic; don’t build a CSB unless there is a clear demand for it and a capacity to manage it.

Management plans are needed for:
• Determining the crops and crop cultivars to be multiplied;
• Identifying farmers who should multiply the seed;
• Estimating the seed demand by crop and variety;
• Coordinating seed distribution and supply to farmers;
• Training of farmers in seed selection, drying and storage techniques;
• Training of farmers in seed multiplication procedures.

Linkage networks
A multi-stakeholder linkage approach is needed that involves public institutions, in particular genebank staff and extensionists for technical backstopping, NGOs for financial support and some technical backstopping and the farmers themselves who should form the engine to drive the effective implementation of this intervention. The Zimbabwean scenario saw the effective synergy of this linkage network with the result that positive impacts and benefits have accrued to the communal farmers. To avoid networking problems, clear roles should be identified for each stakeholder involved.

Results
Impacts and benefits
• Availability of good-quality seed, higher seed security and increased production;
• Improved knowledge and capacity for seed storage;
• Reduced genetic erosion;
• Stimulated community cooperation and networking with national genebank and other institutions;
• Option to market seed of traditional varieties;
• Self-sufficiency in seed supply.

Strengths of Community Seed Banks
Drought mitigation and management strategy at community level—safety of germplasm against human consumption. Agrobiodiversity conservation by communities, unlike by individuals, is associated with some rules and regulations governing the use of germplasm. The rules and
regulations are spelled out in the form of a constitution and are said to deter people when enforced by a Management Committee, whereas individuals are easily tempted to consume the germplasm in times of drought.

- Economic benefits to communities. Communal people no longer have to spend a lot of money travelling to distant places in search of desired germplasm;
- A centre for exchange of valuable information on agrobiodiversity conservation. The genebank has increasingly become a meeting place and subsequently a centre of excellence for sharing of local knowledge and adoption of additional knowledge through farmer/extension worker/researcher interactions;
- Accessibility to farmers as storage units and sources of new and local seed. These genebanks give farmers the ability to store small amounts of seed in a secure environment over the short term, in order to test new varieties or to help negotiate environmental risks. In addition, farmers can access the genebank to identify new seed stocks to incorporate into their fields. Some community genebanks invite local farmers to evaluate landraces when germplasm is grown out;
- A way for farmers to store valuable landrace germplasm in a community-based *ex situ* setting. Part of the Community Seed Bank becomes a reservoir of germplasm for future use. This approach may further enhance benefits when integrated with a seed-exchange network, helping to improve farmers’ control over their genetic material;
- Contributes germplasm nationally. The community genebank can also be linked to the national genebank, where duplicates can be deposited and serve as back-up systems from which lost and endangered materials can be recuperated.

**Upscaling of community genebanks**

The way to upscale this plant genetic resources (PGR) initiative is to integrate it into a permanent system.

The following points that link farmers with the formal institutional systems, as factored in SEARICE 2003, need to be considered before upscaling of PGR initiatives, and these include:

- Genebank staff looking for possible collaborating organizations;
- Breeders need to consider the involvement of grassroot organizations or extensionists to facilitate participatory breeding activities;
- Collaboration with organizations that can take charge of the seed distribution and diffusion;
- Space for diversity in development (i.e. space for genetic diversity, cultural diversity and diversity in approaches).

When this approach is institutionalized, the picture of the PGR system should be dynamic, requiring flexibility to respond to changing situations and needs. In this system the farmer and the formal systems integrated with multiple linkages between them (Figure 1) need to evolve with the changing environment, contributing professionals who are well trained and open-minded. In such a system farmers play a role in conservation, breeding and seed supply. Technical backstopping will then be provided to the local farmers to improve the germplasm management, seed storage and processing.

For upscaling to realize success, players in this system should take cognizance of the existing constraints and some verifiable indicators (Table 1) and follow ways that seek to address them.

**Conclusion**

An integrated way of institutionalizing community genebanks, though complex in nature, seems the only better way to safeguard sustainability and upscaling. A national competent authority or a public institute dealing with genetic resources activities and farmers should be the key elements to this integration, through which all other relevant linkage networks are identified and subsequently incorporated and the network.
Table 1. Community genebank intervention: comparative analysis

<table>
<thead>
<tr>
<th>Verifiable indicators for upscaling</th>
<th>Old system approach</th>
<th>Farmer system approach</th>
<th>Integrated system approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation</td>
<td>NGOs</td>
<td>Farmers</td>
<td>Farmers and Govt. agents</td>
</tr>
<tr>
<td>Source of finances</td>
<td>NGOs</td>
<td>Farmers plus well wishers</td>
<td>Govt. plus well wishers</td>
</tr>
<tr>
<td>Functional control</td>
<td>NGOs with some farmer consultations</td>
<td>Farmers</td>
<td>Farmers in consultation with Govt. agents and NGOs</td>
</tr>
<tr>
<td>Management of genebanks</td>
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<td>Financial sustainability</td>
<td>Sustainable for as long as sponsorship is available.</td>
<td>Short-lived</td>
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<td>Political perceptions in developing country</td>
<td>Generally viewed as being against the ruling party</td>
<td>For the ruling party, and if not are normally viewed neutral</td>
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<td>Seed source</td>
<td>Mostly from collections</td>
<td>Mostly farmer contributions</td>
<td>Collections, seed fairs and farmer contributions</td>
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<td>Management of germplasm</td>
<td>NGOs</td>
<td>Farmers</td>
<td>Farmers with inputs from Govt. agents</td>
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<td>Farmer to farmer interaction</td>
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<td>Farmer to researcher interaction</td>
<td>Feasible where linkages exist</td>
<td>Feasible where linkages exist</td>
<td>Very feasible</td>
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<td>Availability of manpower for upscaling</td>
<td>Limited and also limited by the area of operation</td>
<td>Unlimited, but limited by their traditions, cultures and territories</td>
<td>Unlimited and can spread easily as Govt. agents are countrywide</td>
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<td>Linkage systems for upscaling</td>
<td>NGOs to NGOs</td>
<td>Farmers to farmers</td>
<td>Researcher/Extensionist/Farmer</td>
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<td>Area covered in upscaling</td>
<td>Areas under control of NGOs</td>
<td>Minimal</td>
<td>Countrywide</td>
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NGOs = Non-Governmental Organizations; Govt. = Government.
References
Seed transmission of *Fusarium oxysporum* f. sp. *quitoense* appears an important cause of naranjilla collapse in Ecuador

Jose Ochoa¹ and Mike Ellis²

¹Departamento de Protección Vegetal, Estación Experimental Santa Catalina, INIAP, Quito, Ecuador
²Department of Plant Pathology, OARDC, Ohio State University, Wooster, Ohio, USA

Introduction

Naranjilla (*Solanum quitoense* Lamarck) is a Solanaceous fruit popular in Ecuador and Colombia (NRC 1989). The fruit is ideal for markets of exotic products (Heiser 1985; NRC 1989). Naranjilla is also grown less extensively in Venezuela and Peru and has recently been introduced in Panama, Costa Rica and Guatemala (NRC 1989; Heiser and Anderson 1999). Domestication of naranjilla appears have taken place in Ecuador and Colombian after the arrival of the Spanish. There is no evidence of naranjilla cultivation in pre-Columbian times. Although little variation is reported in naranjilla (Heiser and Anderson 1999), two horticultural varieties (*S. quitoense* var. *quitoense* and *S. quitoense* var. *septentrionale*) have been identified (NRC 1989).

In Ecuador, naranjilla is cultivated in plots of up to 2 ha erratically distributed along both the eastern and western sides of the Andean mountains (Ochoa et al. 2001a). Naranjilla area reaches 9460 ha and is cultivated by 7125 families (MAG 2002). Owing to a high internal demand, naranjilla is a high-input crop grown mainly in monoculture in primary and secondary forests. Intercropping of naranjilla with cassava and plantain is less frequent (Ochoa et al. 2001a).

During the 1970s, naranjilla became very scarce in Ecuador (Heiser 1985; NRC 1989). In the early 1980s a small and seedless type of naranjilla appeared in the market. This sterile hybrid derives from an interspecific cross between naranjilla and a wild cocona (*Solanum sessiliflorum* Dunal) (Heiser 1993). The cross was apparently made by the farmer Raul Viteri (Torres and Camacho 1981). This hybrid is now called *hibrido Puyo*. Fruit size of hybrid Puyo is regularly increased in commercial production with low doses of the herbicide 2–4–D. This effect with 2–4–D was also accidentally discovered by another farmer (Heiser 1993). A new hybrid made from a cross between naranjilla and a cultivated cocona was obtained in Indiana by C. Heiser (1993) and released by the National Institute of Agricultural Research (INIAP) in 1994 (Fiallos 2000). Hybrids Puyo and Palora are grown in 95% of the naranjilla area while the domesticated naranjilla—presently called “common naranjilla”—is grown in the remaining 5% of the naranjilla area.

Farmers have generally abandoned production of “common naranjilla” in many areas mainly because of uncontrollable epidemics of a vascular wilt disease, which was first noted in the early 1970s. The disease is referred to as naranjilla vascular wilt (NVW) (Ochoa et al. 2001b), and is currently the major constraint to the production of “common naranjilla” in Ecuador (Ochoa et al. 2001a). The disease is consistently observed in the few “common naranjilla” commercial plantings and in the few “common naranjilla” plants growing nearby or within the Puyo and Palora hybrids. Hybrids Puyo and Palora are resistant to the pathogen. The disease reaches up to 30% of incidence in the hybrid Puyo while in the hybrid Palora the disease is very sporadic.

Diseased plants are readily distinguished by their flaccid and chlorotic appearance. Flaccidity and chlorosis start in the lower part of the plant and progressively move upwards, causing wilt of the entire plant. Discolouration of the vascular system is also a characteristic symptom (Ochoa et al. 2001b). NVW is caused by *Fusarium oxysporum* f sp. *quitoense* (Ochoa et al. 2001b), which is very specific to naranjilla (Ochoa et al. 2004).

The rapid spread of NVW within established production areas and into new production areas suggest that *F. o. f. quitoense* could be transmitted by seed. Details of seed transmission and its consequences are discussed in this article.
**Methods**

Seed transmission of *F. o. f. sp. quitoense* was studied in seeds sampled in the Pastasa Valley, traditionally one of the most important naranjilla production areas. The Pastaza Valley is located along both sides and lower valleys of the Pastaza River near the Amazon basin. Seed transmission experiments were conducted at the Santa Catalina Experimental Station of the National Institute of Agricultural Research (INIAP), Ecuador.

Branches with attached fruits from plants with typical symptoms of NVW and from asymptomatic plants were collected in a commercial “common naranjilla” planting with a severe epidemic of NVW. Branches with attached fruits of hybrids Puyo and Palora with symptoms of NVW were also collected from a location where the disease is endemic. Symptomatic plants of Puyo hybrid are characterized by a slow development of foliar wilt with vascular discolouration. On the other hand symptomatic plants of hybrid Palora show only slight vascular discolouration. Fruits of “common naranjilla” as well as of Puyo and Palora hybrids from apparently healthy commercial plantings were included as controls. Ten branches bearing fruits were selected in each case. In order to verify vascular colonization by *F. o. f. sp quitoense*, isolations were made from symptomatic (discoloured) as well as asymptomatic vascular tissue. Tissue sections (0.125 cm³) from each branch were surface-disinfected by soaking for 3 minutes in a 1% solution of sodium hypochlorite, then rinsed three times in sterile water. These tissue sections were then placed on Petri dishes containing potato dextrose agar (PDA) and incubated at 20°C for 5 days.

Seeds were removed from mature fruits collected from the same branches used for pathogen isolation. Seeds were dried on a greenhouse bench and then stored in the laboratory at room temperature prior to use. Part of the seeds was subject to germination for 6 days in a petri dish containing humidified sterile paper. Pegerminated and dry seeds were surface-disinfected as described above and then placed on PDA. Petri dishes were incubated at 26°C for 2 weeks. Each treatment consisted of 10 Petri dishes containing 10 seeds each.

In a second experiment, “common naranjilla” seeds from symptomatic and asymptomatic plants were germinated in Petri dishes containing sterilized sand. Seeds from asymptomatic plants came from the apparently healthy commercial planting. Petri dishes were incubated at 26°C for up to 3 weeks. Seed germination and symptoms on seedlings were monitored in detail. The apparently healthy seedlings were transplanted to pots containing 300 g of sterilized soil composed of 2 parts of organic soil, 2 parts of compost and 1 part of vermiculite. Symptoms of NVW were also carefully monitored on the transplanted plants. Time in days to the wilting stage was evaluated in transplanted plants. The *wilting stage* was considered flaccidity and/or chlorosis reaching the upper part of the plant. Pathogen isolation as previously described was conducted on non-germinated seeds, on seedlings with root and hypocotile necrosis and on plants showing vascular discolouration.

**Results**

*Fusarium oxysporum* f sp. *quitoense* was isolated from all tissue sections from branches coming only from symptomatic plants. Taxonomical identification of the fungus was based on morphology of conidiophores, macroconidia and microconidia as well as on colony appearance on PDA (Nelson et al. 1983). Koch’s postulates were completed with an isolate recovered from these branches as previously described by Ochoa et al. (2001b).

*Fusarium oxysporum* f sp. *quitoense* was recovered only from pregerminated seeds in “common naranjilla” as well as hybrids Puyo and Palora as soon as 4 days after isolation. In “common naranjilla”, the pathogen was recovered in 90% of seeds from symptomatic plants and in 60% of seeds of asymptomatic plants from the commercial planting severely affected by NVW. The pathogen was also isolated from seeds of symptomatic plants of hybrids Puyo and Palora in 70% and 80% of the seeds respectively. *Fusarium oxysporum* f sp. *quitoense* was not recovered from asymptomatic plants coming from apparently healthy plantings of “common naranjilla” as well as of hybrids Puyo and Palora. Koch’s postulates were also completed with an isolate recovered from seed.
Germination and plant development were significantly affected by pathogen colonization in common naranjilla. Thirty-eight percent of seeds did not germinate; 11% of seeds developed seedlings with root and hypocotyle necrosis and did not progress further and 20% of seeds developed plants showing the wilting stage within 94 days after transplanting. The remaining non-symptomatic plants may have been colonized by the fungus; however, symptoms were not apparent. Germination in control plants coming from a commercial planting with healthy appearance reached 95% and signs of fungus colonization were not observed either in seedlings or during plant development.

**Discussion**

Seed colonization of *F. o. f. sp. quitoense* appears as a common and efficient mean of pathogen transmission in naranjilla. Pathogen isolation only on pre-germinated seeds suggests the pathogen is located inside the seed and is activated during seed germination. In “common naranjilla” presence of the pathogen in fruits coming from asymptomatic plants suggests that seed colonization takes place during the early pathogen colonization stage, when the plant does not show symptoms yet. Although most of the seeds are unviable in hybrids Puyo and Palora, the pathogen efficiently colonizes them. Resistance operating in both Puyo and Palora appears to be associated with restriction of pathogen colonization in the vascular system; however, seeds are readily colonized. Rapid colonization of seeds is most likely due to an efficient movement of microconidia into the seeds even before symptoms are evident.

In these experiments seed transmission in “common naranjilla” caused loss of seed viability, root and hypocotyl necrosis on seedlings and vascular colonization during plant development. These epidemiological consequences are also observed regularly in the field. Farmers frequently complain about seed germination which appears associated with loss of viability and seedling colonization by the pathogen. In the field, vascular wilt symptoms regularly appear during the early fructification stage which seems to be associated with vascular colonization. Vascular colonization then allows the pathogen to abundantly sporulate in the entire plant. From this sporulation, secondary infections successively takes place, building up a rapid epidemic. Diseased plants then sporulate abundantly. Sporulation consist primarily of macroconidia that become chlamydospores (resting spores) when incorporated into the soil. Chlamydospores can survive in the soil for a fairly long time and in this way the pathogen also becomes soil-borne.

Seed- and soil-borne epidemics of NVW were experimentally observed in “common naranjilla” in the field (Shiki et al. 2003). In these experiments NVW symptoms appeared 266 days after transplanting when the pathogen was seed-borne while disease symptoms appeared 114 days after transplanting when the pathogen was soil-borne. The seed-borne epidemic allowed only one harvest of around 2000 kg/ha while the soil-borne epidemic did not even allow the plant to reach the flowering stage. Both seed-borne and soil-borne epidemics appear to have been experienced successively by farmers in the past. Farmers at present are looking for primary or secondary forest where soil-borne inoculum is less likely to occur owing to the high specialization of the pathogen (Ochoa et al. 2004). At present, epidemics of *F. o. f. sp. quitoense* in “common naranjilla” appear primarily to be seed-borne in nature.

Naranjilla appears as a highly susceptible species to *F. o. f. sp. quitoense*. On the other hand, close relatives of naranjilla within the Lasiocarpa section are fairly resistant (Baez 2003). Resistance of hybrids Puyo and Palora comes from *S. sessiliflorum* (Heiser 1993). Stability of Puyo and Palora hybrids in traditional naranjilla areas appears to be mainly associated with their resistance to *F. o. f. sp. quitoense*.

Rapid distribution of *F. o. f. sp. quitoense* in naranjilla in Ecuador is mainly explained by seed transmission. Simultaneously, a high degree of susceptibility of most “common naranjilla” varieties should have forced farmers to abandon “common naranjilla” cultivation during the 1970s. Decrease of “common naranjilla” cultivation and introduction to cultivation of Puyo and Palora hybrids might also explain the low variability reported in naranjilla (NRC 1989; Heiser 1993).
In Ecuador, naranjilla seed is informally produced. Farmers regularly select ripe fruits and obtain seeds from them. Plants are produced in improvised seed beds near the naranjilla plots. This informal seed system appears to have contributed to the fast establishment of NVW. At present there is no programme for production of disease-free naranjilla seed in Ecuador. The production and use of disease-free seed should aid in preventing the introduction of the pathogen in new production areas. Seed disinfection is necessary as a complementary approach to manage NVW.

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In situ conservation and potato seed systems in the Andes

Stef de Haan and Graham Thiele
International Potato Center (CIP), Lima, Peru

Seed systems and conservation

Potatoes grown by Andean farmers can be divided into three groups: commercial improved varieties, commercial native varieties and non-commercial native varieties. The first two groups consist of a few well-known varieties typically grown in monoculture in larger areas. The third is much more diverse and therefore of primary interest for in situ conservation. The multiple landraces that constitute this group are maintained and exchanged through informal seed systems that are decentralized, dynamic and changeable over time. Informal potato seed systems connect diversity patterning in time and consist of various subsystems. A biophysical system of production, storage, replacement and exchange of seed is supported by a knowledge system of rationales and practices and a cultural system of preferences and meaning; these in turn are embedded within a socioeconomic system of entitlements and obligations. In this article we are particularly concerned with landrace seed systems which can be conceived as an overlay of agrobiodiversity that connects one point in time with the next point in time.

Diverse potato landraces are multiplied through vegetative propagation. Sexual crosses and the use of botanical seed, though apparently practised in the past (Quiros et al. 1992), are not common practice. Introggression from wild species into cultivated stocks is possible, but cultural practices tend to restrict introgression (Brush 1995). Positive and negative selection prior to harvest for such characteristics as phenotype and vigour are rarely practised. Selection for seed normally takes place shortly after harvest, when healthy medium-size tubers for next season’s plantings are stored separately. Sometimes this is done in two phases, a first and rapid discrimination during harvest and a second, more careful, selection shortly after harvest. At this stage farmers tend to carefully monitor which landraces in their stock are abundant, which are scarce and decide which to replace. Seed lots with mixed landraces are commonly stored separate from stocks for home consumption or trade. A final selection just before sowing is common, by discarding tubers damaged by pests, disease or rot. Women play an especially important role in the identification and selection of seed.

Indigenous storage systems for landraces include straw cylinders (taqe), straw-bed piles, elevated bins (troje) and net bags. Often seed is kept in the house itself or in a separate facility close to the house. Historically some farmers allowed light to reach stored tubers; this produces shorter, more vigorous sprouts. Development projects have incorporated this principle in rustic diffused-light seed stores (Rhoades et al. 1991). Fieldside storage pits for potatoes, once common in southern Peru and Bolivia, are nowadays rarely used.

A common mechanism for maintaining diversity from one season to the next is through seed exchange. Seed is acquired through trade, barter or trueque, gifts, wages in kind and ritualized “stealing”. Zimmerer (1991a) found that farmers in Paucartambo (Cusco, Peru) sought new, disease-free seed from potato specialists in nearby uplands. Planters in Paucartambo typically acquire seed from contacts among upland cultivators at intervals of 5 to 10 years (Zimmerer 1996). In areas below 3000 m where seed degenerates faster, farmers replace seed more frequently (Scheidegger et al. 1989). Complex seed flows commonly start at high altitude and are important for the replacement of so-called “tired seeds” with healthy seeds. Most of these seed flows are over distances of 5–15 km (Thiele 1999). Extended family ties, social networks and rural markets facilitate these seed flows.

Management at all stages, from cultivation to storage and exchange, is crucial for seed quality and consequently for the maintenance of diverse landraces. Some landraces, like the early ripening chaucha or chawcha varieties (Solanum phureja), are particularly management- and labour-demanding because of short maturation and lack of seed dormancy. Varieties of this species have to be cropped two to three times annually and their yearly scheduling and subsequent labour demands are compressed
(Zimmerer 1991b). *Chaucha* landraces have been particularly prone to landrace loss. Landraces of bitter potatoes (*Solanum juzepczukii, S. curtilobum*) generally tend to be less management-demanding because of significant pest resistance, tuber dormancy and cultivation in rain-fed cropping systems. Andean farmers apply many management practices in order to obtain clean and healthy seed, including crop rotations, the use of ash or chalk for the control of Andean weevil (*Premnotrypes* spp.), “cold-therapy” at high altitude in order to improve seed quality, protecting seed against potato tuber moth (*Phthorimaea operculella, Symmetrischema tangolias*) with aromatic sprigs of pest-repelling species such as *muña* (*Minthostachys tomentosa*) and *eucalyptus* (*Eucalyptus globulus*). Farmers rarely manage separate fields exclusively for seed production. However, farmers who manage 5 to 20 plots do differentiate those that are likely to produce high-quality seed. Potato landrace diversity, informal seed systems and conservation are highly interlinked and integrated.

**Bottlenecks and problems of the potato landrace seed systems**

One view is that informal potato seed systems lead to yield losses through the use of poor-quality seed. An opposed view maintains that resource management of indigenous peasants is intrinsically sound. Thiele (1999) unravels both views for the informal potato seed systems in the Andes and highlights the middle ground. The informal system has many qualities and some major deficiencies. The informal seed systems of potato landraces are part of higher-scale systems. They have emergent properties and consequently change at any level affects the whole; these processes of change and adaptation vary in different regions. Informal seed systems are dynamic and not necessarily sustainable in every context.

One example is offered by the influence of demographic pressure on informal seeds systems. In the Yauyos province, department of Lima, permanent migration has substantially reduced the population size and increased the mean age of inhabitants. Local rural markets have largely disappeared and reciprocity relationships of labour exchange for potato landraces are in decline. As social networks of landrace exchange disintegrate, so does the informal quality certification that normally accompanies these mechanisms. Another result of migration is an increase in irrigated land per family. The production of healthy seed of floury potato landraces in the rain-dependent sectorial fallowing system, at the upper altitudinal levels, has declined, as farmers prefer to prioritize their labour inputs for cropping in the less risky irrigated production zones. As a consequence of these changes the availability of healthy potato seed of diverse landraces has diminished. Typical landraces from Yauyos, such as bauchi, collota and several chaucha varieties, are less commonly grown as regional seed availability and exchange has decreased. Farmers now travel more frequently to cities such as Huancayo and Cañete to purchase seed of commercial native varieties such as huayro and peruana. These seeds are of doubtful quality, especially those purchased in coastal Cañete where virus infection is much more important.

Quite a different scenario can be found in the central Huancavelica department, where Quechua communities are confronted with population growth and hence with a shortage of land. Several communities decided to give up part or all of the communal sectorial fallowing system and allot areas to young families. As a consequence of shortening rotations and increased monocropping of potatoes, farmers are now confronted with decreased seed quality. Plant nutrition factors, increased incidence of pests such as the Andean weevil (*Premnotrypes* spp.) and soil-borne diseases such as Rhizoctonia (*Rhizoctonia solani*) have become threats for landrace seed quality.

Some of the problems faced by informal seed systems are extrinsic, a result of the external socioeconomic context which they face; others are more intrinsic, although even these cannot be addressed in isolation from the context in which they occur. Both types of problems are dynamic and variable according to the specific regional socioeconomic context. Specific bottlenecks and problems that affect informal seed systems of diverse landraces in the Andes include:

- Limited seed availability as exchange mechanisms and social networks lose viability. This is especially notable where migration has affected population density;
• Increased incidence of certain field pests, especially Andean weevil in areas where rotation design has changed and potato cropping intensified;
• Increased incidence of certain field diseases, especially late blight (Phytophthora infestans);
• Increased incidences at higher altitudes are possibly the result of climate change, evolution of specific late blight strains and reduced barriers to pathogen movement due to monocropping;
• Seed degeneration as a consequence of viruses and other pathogens, especially where “cold-therapy” of potato seed is not practised;
• Incidence of storage pests, especially tuber moths in storage facilities below 3600 m.

**Strengthening potato seed systems for conservation**

Relatively little is known about the relationships between informal seed systems and farmer-driven *in situ* conservation of many potato landraces. Detailed characterization of such links and the identification of bottlenecks should be a first step, including seed-selection procedures, storage systems and mechanisms of seed exchange. Local realities in the Peruvian Andes are diverse; hence efforts should preferably be regional and initially concentrated in those areas where high levels of intraspecific diversity exist.

A next step might concentrate on resolving bottlenecks through participatory and development-oriented capacity development. Specific intervention might focus on reintroduction of lost landraces, selection procedures, appropriate storage systems, seed exchange, and disease and pest control, yet it is important that farmers perceive these interventions as a priority. Landrace conservation by itself is not an objective for Andean farmers; it is a means to assure their livelihoods.

Sustainability is an important factor to take into account for seed systems interventions. There needs to be a socioeconomic as well as an ecological demand for diversity (Prain and Hagmann 2000). Agricultural biodiversity in the Andes is strongly embedded in a variety of culturally determined food systems. Local food systems demand diverse landraces and their enhancement is important for sustainable conservation. On the other hand, special market niches for exotic, high-quality and ecological produce can possibly offer a new demand for landraces. Landraces can be promoted for use in restaurants, processing of naturally pigmented chips or as ecological fresh produce. Linking landrace diversity to new markets is a challenge, yet does not necessarily guarantee conservation. Markets generally demand uniformity in variety, size, quality, etc. Consequently market demand for a few landraces might actually trigger landrace loss and reduce the total diversity within landrace pools. Nevertheless, the enhancement of local food systems and the incorporation of landraces in urban food systems are challenges that need consideration.

Increased integration between formal and informal seed systems might also be considered. However, decisions within formal systems about what varieties to promote will have substantial implications for diversity. In Peru the formal seed system is centralized and concentrates on few varieties; diverse landraces are not part of the formal system. In Ecuador the formal seed system purposively disregards landraces. In Bolivia, cleaning and reintroduction of lost landraces, participatory breeding and selection, transfer of appropriate technology and capacity-strengthening have provided building blocks for linkage but interventions have been difficult to sustain outside of specific and limited project funding.

Critical policy areas where change could help potato seed systems include seed legislation, coordination of seed policies, adapting public plant breeding programmes, seed technology research for the informal sector and attention to improved institutional linkages. Landraces are typically produced by lower-income farmers in higher areas with limited access to certified seed. Much current seed legislation works against these farmers and landraces because it fails to recognize the possibility of producing quality seed within the informal seed system. Seed legislation and certification could be adapted in favour of landraces through increased flexibility of rules and standards. Policy formulation will be aided by opportunities for dialogue with diverse and representative stakeholders; this will make policies more relevant and sustainable.
Learning from some interventions in potato seed systems
Since 1998 CIP’s ex situ genebank has provided clean seed of diverse potato landraces to farmer communities. Village authorities or local institutions request seed to replace “lost” local landraces. This so-called repatriation of landraces to communities is a pilot example of complementarity between different conservation approaches and linkage of formal and informal systems. CIP stimulates the installation of Community Seed Banks (CSB) so that seed is available for the whole community after local multiplication. Andean farmers are able to multiply small amounts of seed relatively quickly (Scheidegger and Prain 2000) and after a few years the CSB can evolve into family-managed landrace stocks. Although implemented on a modest scale, the repatriation of landraces proves successful in most cases. CSBs work well if there is a local committee that is directly responsible; this committee should preferably consist of farmers interested in conservation and be supervised by village authorities. CSBs have failed to dynamize local seed systems where local organizations are weak.

Cleaning and return of landraces to farmer communities is also practised by Programa de Investigacion en Papa (PROINPA) in Bolivia. Conserved diversity, superior yields and increased awareness of the importance of good-quality seed are reported as positive results (Iriarte et al. 2000). Looking for ways to supply seeds from formal seed systems to highland potato production systems, PROINPA began research to adapt rustic nurseries for potato seed production. The rustic seedbed is a small hothouse (big box) made of local materials. Both native and commercial varieties were multiplied in these seedbeds. Its theoretical advantages are: protection against frost and hail, better control of pests and diseases, low construction and production costs, optimization of local resources (water, soil, labour) and high multiplication rates. Aguirre et al. (1999) found high production and multiplication rates compared with seed production in open fields. Average multiplication rates reported were 1:15 in seedbeds compared with 1:7 in the field. Considering the construction costs and the potato production costs, the cost of the seed obtained in the seedbeds was found to be similar to seed from the formal system. Constraints identified by PROINPA included fertility of the substrate, control of soil pests and diseases, access to healthy seed to plant seedbeds, and marketing of seed originated from the seedbeds after field multiplication.

The amount of Biodiversity Seed Fairs (BSF) in Peru has grown exponentially since they were first organized in the late 1980s as a strategy for in situ conservation, cultural reaffirmation, knowledge and seed exchange. Nowadays, from May until August, multiple actors organize an estimated 300 yearly BSF. Competitions are very much part of Andean culture and the organization of BSF, where farmers display their varieties and those with the most landraces and knowledge win prizes, have special appeal (Scurrah et al. 1999). Most fairs stimulate seed exchange between farmers from different communities and regions (Tapia and Rosas 1993). Generally it is considered that the fairs complement local seed systems if culturally appropriate incentives are provided. Farmers and local authorities should have a role in the organization of the fairs in order to make them sustainable. BSF can stimulate local seed systems, but can also work adversely, especially if incentives are too large and the element of competition impedes exchange of seed.

Applying the principle that light inhibits sprout elongation, diffused light storage (DLS) systems have been improved, promoted and implemented by CIP, FAO, Instituto Nacional de Investigaciones Agrarias (INIA) and a large number of development organizations in Peru. Compared with traditional dark storage, sprout length was reduced from 20 cm to 2 cm, and yield increased about 15% in multi-locational on-station trials. On-farm trials led to similar results: significant shorter, more vigorous sprouts and a yield advantage of about 10% (Fuglie and Walker 2002). Storage designs that are appropriate for Andean conditions have been developed; these designs use local materials and are cheap to implement. However, blueprint designs that cannot be adopted to specific and diverse farmer’s requirements can impede adoption. DLS systems have been adopted by thousands of farmers in the Peruvian Andes, yet non-adoptions by farmers in remote areas has been grouped in three categories: lack of knowledge, economics and socio-cultural factors (Rhoades et al. 1991). The first is a consequence of distance, inaccessibility and lack of development resources in certain parts.
of the Andes. The second is a direct consequence of the very limited monetary income of small-scale farmers dedicated to potato cropping. The last has to do with farmer’s caution against possibly maladapted technologies.

Integrated Pest Management (IPM) of field and storage pests can have a positive impact on the overall quality of potato seed produced by Andean farmers. The control of Andean weevil (*Premnotrypes* spp.) and potato tuber moth (*Phthorimaea operculella, Symmetrischema tangolias*) is especially important for the seed quality of diverse landraces. Alcázar et al. (1992) found a damage reduction of 17% one year after IPM of Andean weevil was initiated in an Andean community in Cusco. Cisneros (2003) found considerable reductions in both damage and pesticide use three years after IPM of Andean weevil was implemented in two communities in central Peru. Not all individual IPM strategies are socioeconomically or culturally viable for resource-poor farmers in the Andes. Methodologies and materials of adult education such as used in Farmer Field Schools (FFS) help to generate increased local knowledge about pests and viable control strategies, but may not reach farmers in remote and biodiversity rich areas of the Andes. The FFS are relatively expensive and require special skills from the facilitators.

**Upscaling experiences**

Emphasis on the existing successes of farmers and institutions and how to enhance and widen impact is important (Zimmerer 1996). Yet, few attempts have been made to increase the impact of local activities to benefit a greater number of communities. Upscaling support for on-farm conservation through seed system interventions is only in its infancy.

Since the Convention on Biological Diversity (1992) the number of actors involved in externally driven *in situ* conservation in the Peruvian Andes has steadily increased. They include international and national agricultural research institutions, donor organizations, universities, farmer movements, municipalities, a large number of NGOs and even private enterprises. The actors involved in *in situ* conservation of potato landraces are not only remarkably diverse (research to development orientated), they also have widely different ideological backgrounds that are directly reflected in the strategies proposed. Often planning of *in situ* conservation processes occurs behind closed doors. Debates about intellectual property rights and indigenous knowledge have added to limited information sharing.

A precondition for upscaling is documentation, monitoring, systematization and social learning; this is not necessarily common practice in most institutions. For future efforts it is extremely important that experiences are systematized, lessons are drawn and information made available. This should preferably occur in a participatory manner with active farmer involvement. Impact and sustainability are key considerations and upscaling can only take place if lessons are drawn first. The fact that *in situ* conservation is still an evolving area of rural R&D makes the need for social learning especially important.

Upscaling can be facilitated by enhanced networking, collaboration and information exchange between farmers’ organizations, research institutes, NGOs, formal and informal seed systems. Farmer-to-farmer training and visits, exchanges of experiences between different actors, development of tools and methods for adult education, and the use of media such as popular radio can all have a valuable role. However, upscaling will be effective only if these activities are set up and undertaken from a perspective that attempts to offer options (a basket of opportunities) rather than to impose solutions (Visser and Jarvis 2000).

**Conclusions**

A large group of non-commercial potato landraces are maintained and exchanged through informal seed systems managed by small-scale farmers. These seed systems are decentralized and dynamic and consist of biophysical, knowledge, cultural and socioeconomic subsystems. Potato landrace diversity, informal seed systems and conservation are highly interlinked and integrated. Landrace
seed systems can be conceived as an overlay of agrobiodiversity, which determines temporal
patterning.

The informal seed system of potato landraces has many qualities and some major deficiencies. Many of these deficiencies are the result of changes in farmers’ livelihood systems. Even problems, which appear as strictly seed related, cannot be treated in isolation from the livelihood context in which they occur. The kinds of changes which have occurred in livelihood systems and hence the problems which have emerged in the embedded seed systems vary considerably with the regional or local socioeconomic context. Hence understanding the changing context of farmer livelihoods is a precondition for appropriate interventions in seed systems.

Links between informal seed systems and the conservation of diverse potato landraces have been scarcely studied and little is known about intrinsic relationships. The detailed characterization and documentation of these relationships and the identification of bottlenecks is a priority. Participatory and development-oriented research could help resolve the major bottlenecks. Local capacity-building as a solution for problems identified and prioritized by farmers will add to the sustainability of interventions. There are options for increased linkage between formal and informal seed systems, but changes in seed legislation and certification are needed for this to be effective.

There are valuable lessons to be learned from previous interventions in potato seed systems. A precondition for upscaling is documentation, monitoring, systematization and social learning. A major limitation is the closed institutional environment that is characteristic of national in situ conservation projects and programmes in the Andean region. Whereas mechanisms for scaling up are well known they have not been critically evaluated, and lessons from previous interventions should be drawn and made available. The increased collaboration, networking and information exchange required to put into practice the suggestions made here pose a challenge.

References
Iriarte V, Gino Aguirre FT and Thiele G. 2000. Local seed systems and PROINPA’s genebank: working to improve seed quality of traditional Andean potatoes in Bolivia and Peru. In: Participatory approaches to the conservation and use of plant genetic resources (E. Friis Hansen and B. Sthapit, eds.). IPGRI, Rome, Italy. pp. 154–161
Seed systems in Morocco

Amar Tahiri
Seed and Plant Control and Certification Service, Rabat, Morocco

Introduction
The seed system is an important factor in plant genetic diversity distribution in a country. Seed is the basic vector of the diversity. In Morocco two types of seed systems coexist: the formal seed sector and the informal seed sector. Each system is a chain of components, with interactions between the two systems at different levels. The importance of each system depends on crop species and type of agroecosystem.

Source of seed supply
In the informal sector, the main seed supply resources are: the farm (farmers using their own seeds), the exchange between farmers (of the same village or of neighbouring villages) and the traditional markets (souks). In certain cases, the seed supply can be cooperatives, markets in cities or seed companies. In the formal sector, the seed supply is authorized seed companies for certified seeds, produced locally or imported. Table 1 shows the use rate of certified seeds for the main crops in Morocco.

<table>
<thead>
<tr>
<th>Species</th>
<th>Area ('000 ha)</th>
<th>Seed needs ('000 quintals)</th>
<th>Quantity of certified seeds ('000 quintals)</th>
<th>Use rate of certified seeds (%)</th>
<th>Source of supply of certified seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durum wheat</td>
<td>1125</td>
<td>1687</td>
<td>214</td>
<td>13</td>
<td>Local production</td>
</tr>
<tr>
<td>Soft wheat</td>
<td>1428</td>
<td>2142</td>
<td>421</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>2195</td>
<td>2195</td>
<td>24</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4748</td>
<td>6024</td>
<td>660</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>400</td>
<td>80</td>
<td>8</td>
<td>10</td>
<td>Importation</td>
</tr>
<tr>
<td>Rice</td>
<td>7</td>
<td>14</td>
<td>0.28</td>
<td>2</td>
<td>Importation</td>
</tr>
<tr>
<td>Food legumes</td>
<td>420</td>
<td>340</td>
<td>7</td>
<td>2</td>
<td>50% importation; 50% local production</td>
</tr>
<tr>
<td>Forage crops</td>
<td>360</td>
<td>280</td>
<td>28</td>
<td>10</td>
<td>40% importation; 60% local production</td>
</tr>
<tr>
<td>Pastures</td>
<td>–</td>
<td>–</td>
<td>0.3</td>
<td>–</td>
<td>Local production</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>65</td>
<td>9.4 polygermes (+ 4000 units of monogermes)</td>
<td>9.4 polygermes (+ 4000 units of monogermes)</td>
<td>100</td>
<td>Importation</td>
</tr>
<tr>
<td>Sunflower</td>
<td>120</td>
<td>12</td>
<td>1.2</td>
<td>10</td>
<td>50% local production; 50% importation</td>
</tr>
<tr>
<td>Potato</td>
<td>56</td>
<td>1360</td>
<td>365</td>
<td>27</td>
<td>96% importation; 4% local production</td>
</tr>
<tr>
<td>Vegetables</td>
<td>174</td>
<td>3.7</td>
<td>2.4</td>
<td>65 (standards)</td>
<td>70% importation; 30% local production</td>
</tr>
</tbody>
</table>

Formal seed system in Morocco
Because of the co-existence of the two seed systems, a clear knowledge of the formal seed system in a country is very important when establishing a strategy for the conservation of the agrobiodiversity. In Morocco, a country known for high local diversity for many species, the main factors that can have potential impact on the conservation of the genetic diversity are:
• Morocco is an open market for seeds, with a high rate of regional and international exchanges (mainly with Europe, USA, Australia and North Africa);
• The formal system is relatively old, having been established in the early 1920s. The certified seed flow in the cropping system is very important
• The national strategy targets increasing the use of certified seeds (i.e. to reach 30% for cereals in 2008);
• A large number of varieties of different origins are already registered in the Moroccan catalogue;
• These varieties can be freely introduced in the country;
• The law on plant breeder’s rights was implemented on 28 October 2002; this will encourage breeders to create new varieties locally and introduce varieties from abroad;
• Transgenic varieties are becoming a reality in the international exchanges. The area cultivated internationally using these varieties reached 60 million ha in 2003. Even though the production of these varieties is not allowed in Morocco, the country is still exposed to international exchanges and negotiations on this issue;
• Agreements for free zone exchange with the European Union and the USA will make the borders open to more and freer exchanges.

For all these reasons, this paper will focus on the formal seed sector in Morocco.

History of formal seed system
In Morocco, formal seed activities began in the 1920s, but the first legislation was not promulgated until the 1940s. However, the actual legislation related to the production and trade of seeds and propagated material is based on legislative texts promulgated in 1969. During the 1970s, the seed sector in Morocco made several important advances:
• Breeding, through national programmes, of adapted and high-yielding varieties
• Promulgation of texts adapted to the international legislation
• Creation, in 1975, of the national company for seed trade [Société Nationale de Commercialisation des Semences (SONACOS)] to promote the production and use of certified seeds.

Thus, before 1980, variety release, control and certification were under the responsibility of agronomic research services.

Since 1980, these activities have been the responsibility of the Direction de la protection des végétaux, des contrôles techniques et de la reression des fraudes (DPVCTR).

Organization of the seed sector
Breeding and introduction of new varieties
Breeding activities are mainly conducted by the National Agronomic Research Institute (INRA). The private companies introduce varieties to do adaptation trials and present varieties to the national catalogue.

Multiplication and production of seeds and propagating material
Prebasic material is produced by INRA and certain private companies. Basic, certified and standard materials are produced by a limited number of companies under contract with seed-growers (farmers). The majority of these seed growers are affiliated with the Association Marocaine des Multiplicateurs des Semences (AMMS).

Processing
Processing is done in industrial units belonging to both private and public companies. However, the regional distribution of the processing capacities is inadequate. In general there is no equilibrium between production potential and processing, treatment and storage capacities. The majority of the units are located in three areas.
Seed and plant trade
The trade of certified seeds and plants is done by authorized companies (more than 100). The majority of these companies are members of Association Marocaine des Semences et Plantes (AMSP).

Control and certification
The control and certification of seeds and plants produced locally and the control of importation is under the responsibility of DPVCTRF. The control is done according to international rules and methods [i.e. those of International Seed Test Association (ISTA), Organization for Economic Cooperation and Development (OECD), the European Union (EU)].

Coordinating organizations
Three organizations are responsible for coordination of management of new varieties, each with separate responsibilities, as follows:

- Comité National de la Selection des Semences et des plantes: makes proposals to the Minister of Agriculture related to variety release, testing procedures and regulations related to the registration of new varieties in the national catalogue.
- Commission Nationale des Semences: establishes annual programmes of seed production; proposes legislative and regulatory changes.
- Comité Provisoire des Semences et Plants: created in 1998 following the National Seed Plan recommendations; comprised of representatives of both administrative and private sectors. Its main mission is to set up the administrative and regulatory basis of the Groupement Interprofessionnel des Semences et Plantes.

Legislative and regulatory basis
Law no. 1-76-472 of 19 September 1977 related to the production and trade of seeds and plants (mother law). Implementing texts related to the official catalogue, control and certification of seeds and plants, and importation and trade.

Law no. 9-94 related to plant breeder’s rights. This law was promulgated in 1997 and implemented in 2002.

Variety registration in the catalogue
The objective of variety registration in the national catalogue (Table 2) is to protect the farmer (user) by allowing only varieties with high potential and adapted to Moroccan conditions. The catalogue contains two official lists (A and B) of about 50 species of major economic importance, and provisional lists.

List A contains varieties whose seeds and/or plants can be certified and traded in Morocco or exported. List B contains varieties whose seeds and/or plants can be produced in Morocco for export of the product. The provisional lists contain varieties belonging to species not on the official lists (A or B).

All varieties coming from national breeding programmes or imported have to go through trials before registration in the catalogue. Trials are conducted prior to registration for varieties of list A [Distinctness, Uniformity & Stability (DUS) tests, and Value of Cultivation & Use (VCU) tests] and varieties of list B (only the DUS test is conducted). The trials are conducted over 2 years, in one to two locations for DUS tests and 6 to 12 locations, depending on the species, for VCU tests. Annually, 45–50 DUS trials and 180–200 VCU trials, for more than 200 new varieties are conducted. For varieties of the provisional list, trials are conducted in Morocco under the responsibility of the breeder or his representative. Registration is made on the basis of the results of these trials and the morphological description of the variety. More than 800 varieties belonging to 85 species are registered on this list.

The results of DUS and VCU tests are examined by Technical committees and approved by a National committee. If the variety is accepted, it is approved by ministerial decree and is registered for 10 years renewable for periods of 5 years each.
Since 1977, the date of creation of the official catalogue, more than 3200 varieties belonging to 50 main cultivated species have been tested. Of these, 1713 varieties were registered and only 12% of these varieties have come from the national breeding programmes. The remainder have been introduced mainly from Europe, USA and Australia (see Table 1).

<table>
<thead>
<tr>
<th>Table 2. Current status of registered varieties in Morocco</th>
<th>Breeder</th>
<th>Total of registered varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Public</td>
<td>Private</td>
</tr>
<tr>
<td>Cereals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durum wheat</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Soft wheat</td>
<td>24</td>
<td>39</td>
</tr>
<tr>
<td>Barley</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>Triticale</td>
<td>06</td>
<td>03</td>
</tr>
<tr>
<td>Rye</td>
<td>03</td>
<td>00</td>
</tr>
<tr>
<td>Spring Cereals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Maize</td>
<td>21</td>
<td>283</td>
</tr>
<tr>
<td>Forage Crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Faba bean minor</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Lucerne</td>
<td>3</td>
<td>53</td>
</tr>
<tr>
<td>Medic</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Vetch</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Fodder peas</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fodder beet</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Food Legumes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faba bean Major (List A)</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Faba bean Major (List B)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lentil</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Chickpea</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Pea</td>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td>Field pea</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Industrial Crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>0</td>
<td>126</td>
</tr>
<tr>
<td>Oil Crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soyabeans</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>Rape</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Sunflower</td>
<td>4</td>
<td>108</td>
</tr>
<tr>
<td>Safflower</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Legumes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato (List A)</td>
<td>0</td>
<td>165</td>
</tr>
<tr>
<td>Potato (List B)</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Melon</td>
<td>0</td>
<td>137</td>
</tr>
<tr>
<td>Lettuce</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Feggous</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Red beet</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Tomato</td>
<td>0</td>
<td>276</td>
</tr>
<tr>
<td>Tomato—rootstock</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>209</td>
<td>1504</td>
</tr>
<tr>
<td>Percentage</td>
<td>12.20</td>
<td>87.80</td>
</tr>
</tbody>
</table>
Importation and trade
The importation and trade of seeds and plants are submitted to the following conditions:
• The company should be authorized by the Ministry of Agriculture;
• The variety should be registered in the catalogue;
• The seeds should be certified according to OECD schemes or standard type for vegetables. The seeds should also be tested according to ISTA.

For varieties not listed in the catalogue, small quantities can be authorized to be introduced for experimental purposes only. In general, the quantities allowed are sufficient for 1-ha trials.

Plant variety protection
In order to enhance plant breeding research and to encourage foreign breeders to introduce well-adapted and performing varieties, Law 9/94 on plant variety protection was promulgated in 1997. The law conforms to the 1991 UPOV (Union pour la protection des obtentions végétales) convention, thus permitting Morocco to be member of UPOV and fulfilling the TRIPS agreement requirements.

For implementation of the law, two decrees were published in the official journal in March 2002, and seven ministerial decrees (arrêtés) were published in the official journal on 28 October 2002.

Definitions
Variety: a plant grouping within a single botanical taxon of the lowest known rank, which grouping, irrespective of whether the conditions for the grant of a breeder’s right are fully met, can be:
• Defined by the expression of the characteristics resulting from a given genotype or combination of genotypes;
• Distinguished from any other plant grouping by the expression of at least one of the said characteristics;
• Considered as a unit with regard to its suitability for being propagated unchanged.

Propagating material for plant production includes:
• Reproduction material: seeds and fruits;
• Vegetative multiplication material: plants or parts of plants, cuttings, tubercles, bulbs, rhizomes.

Breeder:
• The person who bred, or discovered and developed a variety;
• The person who is the employer of the aforementioned person or who has commissioned the latter’s work;
• The successor in title of the first or second aforementioned person, as the case may be.

Conditions of protection
In order to be protected, the variety should fulfil the following conditions:
• Novelty: at the date of filing of the application for the breeder’s right, propagating material or harvested material or products thereof of the variety have not been sold or otherwise disposed of to others, by or with the consent of the breeder, for the purpose of exploitation of the variety, for more than one year in Morocco or for 4 years abroad or 6 years for trees and grapevines.
• Distinctness: the variety should be distinguishable from any other variety whose existence is a matter of common knowledge at the time of filing of the application, for one or more characters (morphological, physiological, etc.).
• Uniformity: the variety is sufficiently uniform for its relevant characteristics, subject to its propagating system (sexual or asexual).
• Stability: the relevant characteristics of the variety remain unchanged after repeated propagation.
• Denomination: the variety should have an acceptable denomination which is not against the law and morals.
Scope, exceptions and duration of plant breeder’s rights
The scope of the breeder’s rights is that protection concerns the propagating material of:
- The protected variety;
- Any variety not clearly distinguishable from the protected variety;
- Any variety essentially derived from the protected variety;
- Any variety for which production requires the repeat use of the protected variety (e.g. hybrids).

The acts for which the authorization of the breeder are required are:
- Production or reproduction (multiplication);
- Conditioning;
- Offering for sale (selling or other marketing);
- Exporting or importing;
- Stockpiling for any of the objectives mentioned above.

If the breeder was not able to exercise his rights on the propagating material, he can exercise this right on the harvested material or on the derived product.

There are exceptions to the breeder’s rights, e.g. the breeder’s rights are not extended to the acts done privately for non-commercial purposes or for experimental purposes, nor for breeding other varieties, with the conditions that the new variety is not essentially derived from the protected variety, and does not require repeated use of the protected variety. Nor to the acts accomplished by farmers for reproduction or multiplication purposes, on their own holdings, of the product of harvest which they have obtained by planting, on their own holdings, the protected variety except for trees, floral and ornamental species. This is deemed to be a farmer’s privilege.

And finally, the duration of protection for Breeder’s Rights is deemed to be 20 years for annual species, 25 years for trees and grapevines, and 30 years for date palms.

Seed production and use
The seed supply is characterized by the coexistence of two sectors:
- Informal sector: where the farmers are using their own seeds, or obtain them through exchange between farmers, purchases from traditional markets (souks), or purchases from seed sellers and cooperatives. The seeds are either of improved registered varieties or of traditional varieties, but with no guaranty of the quality of the seeds.
- Formal sector: source of certified seeds commercialized by authorized companies. These seeds belong to varieties registered in the catalogue, and are controlled and tested by official services.

The use rate of certified seeds is very variable depending on the species (Table 1). It varies from less than 1% (barley) to 100% (sugar beet). However, for the majority of species the use rate is very low. In general, the farmers are satisfying their needs through the informal sector. However for some other species, 100% of their needs are imported (sugar beet, hybrid varieties of vegetables, corn and sunflower).

The production of certified seeds concerns mainly cereals (95% of total certified seeds production). For these species, the actual demand (75 to 8000 t annually) is satisfied with certified seeds produced locally. Seed production is by farmers fulfilling requirements depending on technical capacities and know-how. The fields designated to seed production are controlled by official services in charge of certification, according to technical regulations. These regulations conform to the OECD seed certification schemes. Morocco has been a member of the OECD seed certification system since 1989. Morocco also has had the European Union (EU) seed certification scheme equivalence since 1991.

After harvesting and processing, the seed lots are sampled and analyzed in the National Laboratory of Seed Analysis, according to ISTA methods and rules. Morocco has been a member of this association since 1964.
Transgenic varieties
The introduction and production of transgenic varieties are not allowed. A law on the use, dissemination and trade of GMO has been drafted and submitted for approval. In 1998, a National Committee for Biosafety was created, chaired by the Prime Minister. Its main duty is to advise the Government on issues related to GMOs. Moreover, a training and capacity-building programme was started mainly in the field GMO control and identification.

In May 2000, Morocco signed the Carthagena protocol on biosafety. The procedure is on the way to being ratified. The Carthagena protocol on biosafety is part of the Convention on Biodiversity signed and ratified by Morocco.

Plant genetic resources
Morocco, because of his climatic and geomorphologic diversity, is host to a large and rich biologi diversity adapted to different zones (humid, semi dry, dry, pre-Saharan and Saharan).

Concerning the conservation of the agricultural biodiversity, several actions have been taken on landscape and ecosystems management, particularly those containing the major part of the plant genetic resources and mainly wild species that are parents of cultivated species. Moreover, important progress has been made in inventorying and characterizing genetic resources, species and ecosystems dynamics. The local populations of major cultivated species (cereals, food legumes, forage crops and fruit trees) have been collected, characterized and preserved in order to be used in breeding programmes.

At the international level, Morocco has signed the International Treaty on Genetic Resources for Food and Agriculture. For the ratification of the Treaty, a draft law has been submitted to Parliament. Morocco is also a member of the Commission on Genetic Resources for Food and Agriculture, and signed the agreement that created the International Plant Genetic Resources Institute (IPGRI) in 1994.

Morocco and international and regional organizations
Morocco has been a member of ISTA since 1964. Therefore, the National Laboratory for Seed Analysis is allowed to deliver the international certificates necessary for international trade of seeds.

Morocco has had the equivalence to seed scheme certification of OECD since 1989 and the EU since 1991. This equivalence allows Morocco to control and certify seeds traded within EU countries or at an international level.

Morocco has participated in the UPOV activities, as an observing member, since 1978. All the DUS tests are conducted according to UPOV methods. The actual law on plant variety protection was examined by the UPOV council in 1997, and it was declared as conforming to the 1991 UPOV convention. This allows Morocco to become a member of UPOV.

Morocco is also a member of the International Seed Federation (ISF).

At the regional level, Morocco is a member of the West Asia and North Africa (WANA) seed network, created in 1992, and the African Seed Trade Association (AFSTA).

Conclusion
Morocco is an important source of genetic diversity for many species. The conservation of this diversity is very important for the development of agriculture in the present but also for the coming generations. It has to be a national priority. However, the strategy for the conservation of this genetic diversity has to take into consideration many aspects, mainly the status and future development of the formal seed sector in harmony with the general strategy of Moroccan agriculture, the requirements of international treaties and the need for international trade.
The dynamics of local seed systems in Mozambique, and the roles played by women and men

Carlos E. Dominguez O. and Richard B. Jones
ICRISAT, Maputo, Mozambique

Introduction
Mozambique is a climatically diverse country in southern Africa bordered by the Indian Ocean on its eastern side. The long coastline stretching from just 12° south of the equator all the way south to 28° has exposed the country to Muslim and European traders for more than 1000 years. This border represents a big potential for the country’s development.

Over 70% of the 15 million people depend on agriculture for their livelihood, but crop production is especially precarious in the southern third of the country which is semi-arid with an average annual rainfall of less than 600 mm, the majority of which falls from October to April. The northern third of the country has a more tropical environment with an average rainfall ranging from 800 to 1500 mm distributed over a somewhat longer period but still with a very distinct dry season. Several large rivers bisect the country from west to east and the floodplains with their rich alluvial soil are agriculturally productive. However flooding is an ever-present risk as occurred in February 2000 when world attention was focused on the country. Torrential rains caused by cyclones Eline and Gloria, and the opening of dam floodgates upstream, resulted in several hundred deaths from drowning and the submerging of more than 100,000 ha that had been planted by smallholder farmers.

In A History of Mozambique, Newitt (1995) chronicles how social development and political control have often been associated with drought and ecological disasters. To live in such an environment the population had and still has many ways of coping with drought. One response has been to plant both lowland and upland plots with assorted crops planted after each small rain. This type of production has been facilitated by the traditional land tenure system that facilitates access to land and is accepted in the current law (Land law: Art.12 line A 1996). Other economic alternatives largely practised by men have included intensified hunting and increased labour migration to the cities and neighbouring countries, especially Republic of South Africa. More recently women have started to be involved in trading, especially of crop surpluses to obtain cash. These diverse livelihood strategies are still very much in evidence today, with large numbers of men migrating to work and sending back remittances to help support household members in the rural areas.

A more recent threat to livelihoods is the effect of HIV/AIDS. The full impact of HIV/AIDS is still to be felt as prevalence rates continue to rise dramatically but already 12.2% of the national population was infected by 2000 (Della-Vedova 2003). Prevalence is considerably higher in areas where there are high levels of migration to and from neighbouring countries, particularly in the central and southern regions of the country where from 16 to 20% of the population may be infected. HIV/AIDS itself has a strong gender dimension and indeed gender inequality. For socioeconomic, cultural and political as well as physiological reasons, women in southern Africa are more vulnerable than men to HIV/AIDS infection and its impact. In Mozambique this is partially reflected in the fact that 57% of people living with HIV/AIDS are women. In the 20-24 age group women outnumber men by 4:1, while the infection rate among girls in the 15-19 years age group is 16% compared with 9% for boys (UNFPA 2002). There are already clear indications that this epidemic will have a severe negative impact on household food security.

In much of southern Africa agriculture is divided into two distinct sectors—the smallholder sector and the large-scale sector—although the balance between the two varies significantly from country to country. In Mozambique the smallholder sector predominates, accounting for around 90% of the country’s planted area. Food security is underpinned by the ability of women and men farmers to make decisions about what crops to grow and which inputs to use. By tradition, women
are responsible for the family’s food security and therefore the primary production is to meet the household’s subsistence needs. A key factor in food security at household and community levels has been local knowledge on seeds and seed management that resides mainly with women. Their knowledge of how to multiply, conserve and utilize different crops and varieties of seeds is a crucial component of food security. Equally important are the dynamics utilized by farmers to obtain seeds in both normal times and during crises such as the frequent droughts and floods that are endemic. These dynamics are just as diverse as the different environments in which these farmers live and work. Apart from land and labour, farm-saved seed supplemented by grain from markets and small amounts of commercial seed is the main input used for food production (Dominguez 2001).

Although smallholder agriculture predominates in Mozambique, there is a small but growing commercial sector that is heavily influenced by neighbouring Republic of South Africa and Zimbabwe, where commercial farming is well developed. In recent years the government has even welcomed commercial farmers from both countries, but especially Zimbabwe where the government is pursuing a policy of land re-distribution. Commercial farmers tend to rely more on certified seed procured from commercial seed companies. There are presently two commercial seed companies operating in the country, and much of the seed marketed is actually imported from neighbouring countries.

Frequent droughts and floods have affected agricultural production in many parts of the country. One response by government and humanitarian agencies has been to provide affected households with free seeds, and from 1992 until 2001 hardly a season passed without free seeds being distributed somewhere in the country (Rohrbach et al. 2001). In the early 1990s most of the seed supplied was sourced from outside the country as SEMOC, the only seed company operating in the country at that time, did not have the capacity to meet the massive demand for seed from relief and development agencies. This demand was to supply the hundreds of thousands of returning refugees who had fled the country during the 15 years of civil war that ended in 1992. By the mid-1990s, SEMOC was able to meet some of the local demand from relief and development agencies, but the company made only limited investments to develop a distribution and retail network for commercial seed sales. In 1996, the Mozambique Government sold its controlling interest in SEMOC to the Seed Company of Zimbabwe (Seed Co), and since then the company has focused largely on the sale of hybrid maize seed supplied by Seed Co from outside Mozambique. In mid-2000, the South African Seed Company PANNAR started operating in Mozambique.

By the mid-1990s, there was increasing concern from government and other agencies that such initiatives were creating a dependency syndrome among farmers, and undermining any incentive for the private sector to invest in the development of a commercial seed sector. Throughout Mozambique the informal seed sector (farmer-managed seed) plays an important role in meeting the seed needs of farmers. An analysis of local seed systems in Mozambique found that village seed systems are active and reasonably efficient in meeting the annual seed requirements for most small-scale farmers, and that seed losses associated with war, drought and floods have probably been overestimated (Rohrbach and Kiala 2000). However, the same study pointed out that there is substantial scope for improving the capacity of village seed systems to meet both annual needs for quality seed, and periodic emergency seed requirements. An important recommendation from the study was the need to link local seed systems with the larger national seed market, to ensure the delivery of new higher-yielding varieties.

In 2002 the Mozambique Government adopted the Input Trade Fairs (ITF) methodology as the preferred way of addressing seed insecurity in times of crises. Rather than providing free seed directly, farmers are supplied with seed vouchers that can be exchanged for seed. To facilitate the process and ensure that vouchers are used for the purpose intended, an ITF is organized at a designated location on a set day to which seed (and other inputs such as tools and fertilizers) vendors are invited. The recipients of vouchers can then purchase seed of the crops and varieties they need and from whom they choose. Seed vendors can be local farmers with surplus seed to sell, commercial seed companies.
or any combination of the above as determined by the organizers. More than 100 ITFs have been organized, and many of the seed sellers at these events have been women traders marketing locally procured seed.

**The prevailing seed system**

Most of the seed presently used by Mozambican farmers today is sourced through informal channels, often referred to as the local seed system. This system encompasses all activities from production through to utilization including seed exchange that is not controlled by formal institutions, either public or private. Its main characteristic is that production, selection and storage are carried out by local farmers primarily for their own use but also for exchange amongst neighbours through well-defined local dynamics. Another important characteristic is that, with few exceptions, seed production is an integral part of crop production whether for food or other uses. This is one of the reasons for the higher adaptability of local varieties to specific growing conditions compared with introduced varieties, and the resilience of the system.

As women have the primary responsibility for ensuring the household’s food security, they have the main responsibility for selecting and saving seeds from the crop harvest. Men provide containers or construct storage facilities for both grain and seed, and sometimes bring seed of new varieties from elsewhere for testing in the farms.

The following is a diagnosis and description of methods used by farmers for seed production in Mozambique.

**Selecting area and planting time**

Cropping, and hence seed production, is carried out on relatively small pieces of land known as *machamba*. In very dry areas women plant small pieces of land after each rain to spread out the risk of crop failure, and to better ensure household food and seed security. In some circumstances “small gardens” situated in lowland areas with a high water table throughout the year are planted to ensure a continuous supply of food and to regenerate seed stocks that can be used in the following season (Dominguez and Chidiamassamba 1997). With vegetatively propagated crops such as cassava and sweet potato, the custom is to leave some plants unharvested or to bury planting sticks/cuttings in freshly cultivated places to carry these over until the appropriate planting time. Planting the same crops and varieties in both upland (vulnerable to drought but relatively safe from flooding) and lowland areas (susceptible to floods) is also used as a food and seed security strategy (ICRISAT 2002b).

**Production practices during the vegetative period**

Women, who are primarily responsible for crop production activities, do not normally differentiate between plants that will be harvested for seeds and those for grain in the period between planting and harvesting. This agrees with the findings of Tripp et al. (1998) who reported that only 3% of farmers in Ghana select maize plants and 4% select bean plants for seed production. Rohrbach and Kiala (2000) found that selection of plants during the vegetative period reached 20% in Tete province and 30% in Zambezia province but recognized that this practice is rare in Sofala and Nampula provinces, in the centre and north of Mozambique, respectively. In cases where plant selection is carried out before harvesting, normally the men carry out this selection. However, women are in charge of collecting the plants and selecting the seeds from the harvested plants (Dominguez and Chidiamassamba 1997). This selection is based on physical attributes such as size of the plant itself, size of the fruit structure, physiological characteristics such as pod maturity (beans), panicle maturity (rice), or total plant maturity (peanuts). Choosing an area at harvest that has developed better than the rest of the plot, from which plants can be selected for seed, is done in some places.

Smallholder farmers value diversity both in terms of the number of crops grown and the range of maturity periods within crops. One of the main difficulties faced by the formal system in providing
seeds is to meet these requirements as formal systems are more geared toward providing large volumes of a few crops. Depending on the region, farmers may prefer crops with early maturity period (peanuts), crops with late maturity period (sorghum), or crops with variable harvest time (rice and maize). The choice based on the maturity period is mainly influenced by the availability of family labour and on availability of storage facilities.

At harvest time
Women separate the best fruit structures, grain or plant parts to be used as seed from the rest at harvest. If the harvest is poor the seed is mixed with sand or dung to prevent consumption during hard times and the amount of seed set aside is often less than would be set aside after a good harvest (Dominguez and Chidiambassamba 1997). In cases where plants are selected before harvest for seed, priority is given to harvesting these plants and the seeds are stored separately; otherwise the total harvest is stored together, and women select seed in the process of taking grain for family consumption. The size and physical condition of the seed are the main criteria used for selection. These criteria are applied repeatedly in future selections, especially at planting time. Finally, if seeds are not selected before the new planting season, women carry out seed selection from what remains of the stored grain, applying the same criteria. The process of repeated selection year after year favours selection of materials that will be better adapted to climatic and cultural conditions (Longley and Richards 1998).

Storage
As there is genetic diversity in crop maturity, seed selection at harvest is not done at a single time. Diversity in plant maturity is an important characteristic for smallholder farmers as it favours the distribution of family labour, especially crucial at harvest. Crops and varieties with uneven maturity periods adapt better to subsistence agriculture than very uniform materials.

The great diversity of methods for food and seed storage cannot be described adequately. Detailed observations have found that farmers use whatever is in their reach to store and protect seed until the next sowing. The most common means of storage are containers made of clay, straw, cork, wood, leather, glass or metal. Maize, rice, all type of beans, peanuts, sorghum and vegetable seeds are stored in these containers. These containers are kept in special silos and sometimes they are even buried.

Often seeds are not removed from the fruit structures but are stored on the cob (maize), in panicles (rice and sorghum) or in pods (beans and peanuts). These structures can be tied together, and hung from trees near the house (maize) or over the stove (beans, rice, maize, etc.). Straw containers used for storing peanuts or cowpea seeds are also hung from trees.

Farmers hang their seeds from trees for several reasons: to keep them cool, out of the reach of rodents, and to discourage consumption as food. Seeds are placed over stoves as the smoke discourages possible insect attack. In the drier areas of southern Mozambique, maize cobs for seed and consumption are stored in open silos with no roof. In some cases a portable roof can be put on quickly if it rains. Whatever system is used, the storage facilities aim to keep the product clean and protected from insects, rodents and theft.

Both women and men handle seeds during storage, but with different roles. Men are more involved in building storage structures and containers while women prepare the seeds to be stored and safeguard the seed as the grain is consumed, thus ensuring that seeds are available for the next season.

Seed cleaning and conditioning
The methods used to clean and condition seed are simple. They eliminate impurities and prevent pest attack. Wind is the most common element used for this purpose, as well as manual winnowing. There is not a generalized use of mechanical equipment to assist seed or grain cleaning. The amount
of seed required to supply the family needs is so small that the use of special equipment is simply not justified.

**Seed treatment**

A great diversity of local products is available that can be used by farmers to prevent insect attacks, although this is not a widespread practice. The efficiency of local products for seed treatment deserves greater research. The first and most common treatment is the sun. Seeds are dried in open areas near the home in the belief that the heat will keep insects away (FAO 1998). In thatched silos with a removable roof the roof is removed when the sun is out so that the sunshine will penetrate the grain.

When seeds are stored in containers as described above, it is common to find them treated with ash, cow dung or sand. Crushed eucalyptus or tobacco leaves or crushed hot peppers are also used in some areas. Smoke treatment in rural areas of Mozambique is a widespread practice for basically all seeds. Chemical treatment is rare, but there is strong interest from farmers who feel that insect attack is the greatest threat to the carryover of local seed (Dominguez and Chidiamassamba 1997).

**Selection at the time of planting**

This seems to be the period most frequently used by women and men to select seeds for sowing. Selection criteria are rigorously applied, especially by women, who are responsible for this activity. Women describe good seed as having a good “appearance”, free of stains and insect marks. Here again, subjective empirical criteria are used, but owing to the years of experience, appropriate selection is done. Stained and damaged seeds are discarded, eliminating possible contamination and poor health in the fields and “breeding” a diversity of varieties that are tolerant to pathogenic and insect problems by means of different components. While individual farmers tend to reduce genetic diversity, this diversity is ample within and among regions.

**Seed quantity**

Certainly the quantity of seeds needed by the subsistence family is quite small, and this is one of the reasons why many of the practices described above can be carried out. Subsistence farmers work small areas (less than 1 ha), cultivating a variety of crops (intercropping) at relatively lower density than what is recommended for monocultures.

FAO (1998) estimates that a farming family in Zambia or Burundi only needs 10 kg of maize and 15 kg of beans for each season. In Malawi, the estimated quantities are 5 kg of maize, 14 of peanuts and 6 of beans (Cromwell and Zambezi 1993). Longley and Richards (1998) estimated that only 5–7% of rice and 2–3% of sorghum stored by the family is used as seed. These amounts roughly estimate the requirements for Mozambican farmers.

**Prevailing means of seed exchange**

Very low levels of improved inputs are used for crop production in Mozambique. Seeds are the most important input and often the only input used. Women and men farmers are conscious that seed is an essential input for food security and use a wide range of local varieties or landraces that have specific names in each region. The extent of genetic diversity between these local landraces in different regions is not fully understood. According to Ferguson, varieties with the same name often have widely different morphological and genetic characteristics and little homogeneity. They might actually be different (ICRISAT 2002a).

Women and men farmers commonly exchange seed with their neighbours or with farmers from nearby villages. Seed may be provided as a gift, as a loan to be repaid at harvest, or exchanged for labour or other products. In many villages, some women and men farmers are recognized as “seed providers”. Seed donations are more common among relatives but seed exchange is always practised if seed is available.
The grain market is an important source of seed. Women and men farmers buy grain for use as seed, but are careful in selecting the right variety. Even though traders bring grain from distant areas, farmers are aware that not all varieties are suitable to the local conditions and recognize the adapted ones.

Small-scale farmers rarely use commercial seed, except for vegetable crops. There are several reasons for this, the main one being the limited number of retail outlets in villages and the high cost of seed compared with grain. Instead, farmers use a combination of seed sources to obtain planting seed. Under normal conditions, the main source is their own seed (72%) supplemented with grain purchased from the markets and/or gifts or loans from relatives and friends (16%). Few farmers (12%) rely solely on purchased seed (data from Ferguson study). Surprisingly, it is the poorest farmers who most rely on purchased seed—possibly a day-to-day survival strategy for families with very low incomes.

Impact of disasters on the seed system
During emergencies (droughts and floods) farmers travel to other villages/regions with similar environmental conditions to exchange or buy seed. The local market is an important source of seed, especially during emergencies, but often the poorest farmers cannot afford to buy seed. Not all villages have markets and farmers in remote areas that are far from markets have been found to be more vulnerable to seed insecurity (ICRISAT 2002a).

The study done by Ferguson two years after the big floods affecting the Chokwe district (ICRISAT 2002a) reports than the main seed sources following a flood emergency were a combination of seed relief and market purchases (45%), followed by a combination of seed relief and gifts/loans from other farmers (17%). Only 14% of the farmers interviewed used seed relief exclusively. Relief seed is not necessarily assimilated into the farming system. Out of 38 farmers who received cowpea seed under relief programmes, only 8 farmers were still growing the variety after two and a half years.

In contrast, most of the smallholder farmers who received the maize variety Matuba (developed by INIA) are still using it. Farmers like the variety’s characteristics, which are similar to local types, and therefore save the seed for future use. Further studies should be undertaken to examine the effect of seed relief on genetic diversity in the farming system.

Floods may be more severe than drought on genetic erosion, but in the long run, droughts also affect seed security as farmers exhaust their seed and food reserves. According to Ferguson’s study (ICRISAT 2002a), cowpea varietal diversity was higher in areas not affected by floods compared with the affected areas (0.55 versus 0.47), suggesting that some recovery had taken place but the impact on diversity was still evident.

Seed and tool distribution has been widely used to assist the poorest families to re-initiate farming after an emergency. These programmes have suffered from several problems. Because Mozambique’s seed industry is weak, emergency requirements cannot be met from existing seed stocks, and therefore non-adapted varieties have been introduced to affected areas. Farmers rarely retain these varieties in subsequent seasons, although small quantities may be found in fields, mixed with local varieties. Few if any studies have been undertaken to determine the effectiveness of the seed and tools approach in restoring crop diversity to a disaster-affected area.

Final remarks
As a result of climate and topography, parts of Mozambique are prone to floods and droughts. Most farmers use their own seeds supplemented by grain purchased from the market and gifts/loans from relatives and neighbours for food production. During emergency situations, seed has been distributed through relief programmes. Farmers may plant this seed but rarely retain seed of relief varieties in subsequent seasons, and therefore the informal or local system continues to be the main source of seed. Because of this lack of knowledge seed relief is less effective than it potentially could be and there is a need for better information on how local seed systems operate and their strengths and weaknesses. This understanding can help farmers protect their genetic diversity, and where appropriate, new varieties can be introduced in a more informed way.
The work done by generations of farmers in selecting appropriate materials is not well documented, and these materials could be used more effectively in crop improvement programmes. The use of molecular markers offers great potential to better understand the diversity that exists and which can be exploited for the benefit of farmers.

The frequency of natural disasters in Mozambique and the repeated distribution of seed justify further research on the effect of seed relief methods on genetic diversity and seed practices. These studies should determine the effectiveness of the seed and tool approach in restoring crop diversity to a disaster-affected area.

References
Foiras de semences et champs de diversite comme strategies de conservation, gestion et utilisation durable des ressources phytogenetiques

Amadou Sidibe  
Chef URG, Coordinateur National, Ministere de l’Agriculture de l’Eleveage et de la Peche, Institut d’Economie Rurale, Direction Scientifique, Republique du Mali

Résumé
Dans le cadre de la mise en œuvre du projet conservation in situ des mil, sorgho, niébé, et voandzou financé par le Fonds International pour le Développement Agricole (IFAD) ; et exécuté par l’Institut International des Resources Phytogénétiques (IPGRI) ; l’Organisation des Nations Unis pour l’Alimentation et l’Agriculture (FAO) ; le Mali (Institut d’Economie Rurale (IER); la Direction Nationale de la Conservation ; de la Nature (DNCN) ; l’Institut Polytechnique Rural de Katibougou (IPR); les Organisations Non Gouvernementales (ONG) ; Association des Conseillers Agricoles du Sahel (ACAS) ; Fondation pour le Développement au Sahel (FDS) ; l’Unité Service Coopération (USC) ; et les paysans de différents villages de Gao, Douentza et San, différentes actions en guise de stratégies ont été entreprises pour renforcer les stratégies paysannes de conservation et d’utilisation durable des ressources phytogénétiques locales. Les foiras de semences et les champs de diversité constituent ces stratégies/actions participatives initiées, et développées par les différents partenaires cités ci dessus pour la préservation de la diversité génétique des espèces en études.
Discussion and future work

The central statement of this workshop has been that seed systems are a fundamental component of on-farm diversity maintenance. The properties of seed systems that maintain or change the genetic make-up of plant populations include seed source, seed flow, seed production, farmer selection and seed storage. These properties impact the extent and distribution of genetic diversity in traditional farming systems through their effects on the evolutionary forces of population size and bottlenecks and their effect on genetic drift; migration (which includes both seed exchange and pollen flow), mutation and recombination (which create new genes or gene combinations), and selection as a result of environmental forces or human actions.

Discussions were centered on characteristics of seed systems that support or limit diversity maintenance. The size and connectiveness of seed populations can affect patterns of genetic diversity over time, with “non-connectiveness” resulting in divergence of populations. Social barriers can influence the methods and processes that move seeds from source to destination. Storage conditions and seed selection practices can affect the quality of seed and the resulting population planted. The mixing, blending and replacement of seed lots are other elements shown to affect the nature of the diversity maintained as environmental and economic conditions change.

Extensive debate occurred on selecting and upscaling interventions that have been shown to support seed system functions in ways that optimize the maintenance of diversity within the seed systems. Most highly promoted were interventions that (1) include local crop varieties in organic farming initiatives; (2) improve access to low-cost, good-quality seeds through supporting local seed networks, diversity fairs, and seed banks at local or regional institutions and communities; (3) support communities to produce low-cost quality seeds through improved seed cleaning and multiplication techniques; (4) stimulate local agro-industry and link products to markets, and (5) create awareness through media and farmer exchange visits.

Upscaling of such interventions is constrained in many of the partner countries as non-governmental organizations, who are often responsible for the intervention, are not usually integrated into the main national development programme or in state agricultural extension systems. Moreover, in many countries political priorities are often focused on short-term gains and are not suitable to marginal or fragile environments, and this is coupled by an unwillingness to share the costs of the service proved by genetic diversity.

Looked toward the future, interventions and the scaling up of interventions can be better supported by focusing new research on (1) translating seed flow measurements into genetic diversity statements; (2) identifying which of all the possible factors affecting seed systems are the critical ones; (3) understanding the affect of seed flows and seed-transmitted pests and diseases on genetic diversity; (4) assessing how drought, flooding and other environmental events affect seed flows and the genetic structure of seed populations; (5) analyzing the effect of changes in social networks on genetic diversity in seed systems; (6) quantify the economic value of genetic diversity in seed systems, and (7) developing a process for monitoring the impact of seed system interventions on the amount and structure of genetic diversity maintained on-farm.
Participants

Tony Brown
Centre for Plant Biodiversity Research (CSIRO) / IPGRI
CSIRO Plant Industry
GPO Box 1600
Canberra ACT 2601, Australia
Tel: +61-2-6246.5081
Fax: +61 262465000
Tony.Brown@csiro.au

Luis Collado-Panduro
Consorcio para el Desarrollo Sostenible de Ucayali
Pucallpa, Peru

Dominique Louette
SHS (Lago Sul)
Qi 26 Conjunto 3 Casa 1
71670-030 Brasilia DF, Brazil
Tel/Fax: +55 (61) 367 75 26
dlouette@terra.com.br

Didier Balma
Institut de l’Environnement et Recherches Agricoles (INERA)
01 BP 476 Ouagadougou, Burkina Faso
Tel: 329 308269
Fax: 329 319206
dbal@fasonet.bf

Tesema Tanto
Institute of Biodiversity Conservation and Research (IBCR)
P.O. Box 30726
Addis Ababa, Ethiopia
Tel: 251 1 612244
Fax: 251 1 613722
tesematan@hotmail.com

Istvan Mar
Institute of Agrobotany
H-2766 Tapioszele, Hungary
Tel: 36 53 380070/71
Fax: 36 53 380072
imar@agrobot.rcat.hu

Bart Barten
Plant Production and Protection Division
FAO
Via Terme di Caracalla
00100 Rome, Italy
Tel: +39 06 57053230
BART.BARTEN@FAO.ORG

Luis Arias Reyes
CINVESTAV-IPN; Unidad Merida
Carretera Antigua a Progreso km 6
A.P. 73 CORDEMEX, C.P. 97310; Merida
Yucatan, México
Tel: 52 999 981.4287
lmarias@kin.mda.cinvestav.mx

Zoila Fundora Mayor
Instituto de Investigaciones Funda-mentales en Agricultura Tropical (INIFAT)
Calle 2 esq. 1
Santiago de las Vegas
Boyeros, Cuba
Tel: 53 7683 4039/2323
Fax: 53 7 579014
zfundora@inifat.esihabana.cu

Jose Ochoa
Estacion Experimental Santa Catalina
Km 14 Panamericana Sur
Casilla 17-01-340
Quito, Ecuador
Tel: 593-2-2697496
Fax: 593-2-2690693
jbochoa@punto.net.ec

Juan Jose Jimenez Osornio
Jefe del. Departamento de Manejo y Conservacion de Recursos; Naturales Tropicales; Facultad de Medicina Veterinaria y Zootecnia; Universidad Autonoma de Yucatan
Carretera Mérida-Xmatkuil Km. 15.5
A.P. 4-116 Itzimná 97100 Mérida, Yucatán, México
Tel: (999) 9 42 32 12
Fax: (999) 9 42 32 05
juanjose@sureste.com
Roberto Valdivia
Centro de Investigación de Recursos Naturales y Medio; Ambiente (CIRNMA)
Jr. Libertad No. 345 4to. Piso
Puno, Peru
Tel. 51/54/352891
Fax: 51/54/353182
rvaldiviaf@terra.com.pe

Victor Soto Cabellos
Programa Nacional de Investigacion (INIA) en Recursos Fitogeneticos
Av. La Molina 1981
Casilla No. 2791, Lima 12, Peru
vsoto@inia.gob.pe
vsosocabello@hotmail.com

Miguel Pinedo
Center for Environmental Research and Conservation Columbia University
1200 Amsterdam Ave., MC 5557
New York, NY 10027, USA
map57@columbia.edu

Claid Mujaju
Genebank of Zimbabwe
P. O. Box CY550
Causeway
Harare, Zimbabwe
Tel: 263-4-702519 or 704531-9 ext 2188; Cell: 263-11630037
Fax: 263-4-731133
ngbz@mweb.co.zw

IPGRI
Prem Mathur
IPGRI-SAS
c/o Centres Block
Ch Devi Lal National Agriculture Research Centre
Dev Prakash Shastri Mareg
Pusa Campus
New Delhi 110 012, India
Tel: +91-11-25847337 /25847546 /25847547
Fax: +91-11-25849899
p.mathur@cgiar.org

Paola De Santis
IPGRI-HQ
Via dei tre Denari 472/a
00057 Maccarese (Fiumicino)
Rome, Italy
Tel: 39 06 6118 211
Fax: (39) 06 61979661
p.desantis@cgiar.org

Toby Hodgkin
IPGRI-HQ
Via dei tre Denari 472/a
00057 Maccarese (Fiumicino)
Rome, Italy
Tel: 39 06 6118 212
Fax: (39) 06 61979661
t.hodgkin@cgiar.org

Devra Jarvis
IPGRI-HQ
Via dei tre Denari 472/a
00057 Maccarese (Fiumicino)
Rome, Italy
Tel: 39 06 6118 414
Fax: (39) 06 61979661
d.jarvis@cgiar.org

Susan Bragdon
IPGRI
3651 SE Rex
Portland, Oregon 97202, USA
Tel: (503) 768-6714
Fax: (503) 777-4995
S.bragdon@cgiar.org

Eldad Karamura
IPGRI/INIBAP
P.O. Box 24384
Kampala, Uganda
Tel: 256 41 286213/286948
Fax: 256 41 286949
e.karamura@cgiar.org

Jose Luis Chavez
IPGRI-AME
C/o CIAT
Apdo. Aereo 6713
Cali, Colombia
Tel: 57 2 4450048
Fax: 57 2 445 006
jchavezservia@yahoo.com
Marleni Ramirez  
IPGRI-AME  
C/o CIAT  
Apdo. Aereo 6713  
Cali, Colombia  
Tel: 57 2 4450048  
Fax: 57 2 445 006  
M.ramirez@cgiar.org

Unable to attend  
Youyong Zhu  
The Key Lab. for Plant Pathology of Yunnan Province  
Yunnan Agricultural University  
Kunming  
Yunnan 650201, China  
Tel: 86-871-5227872  
Fax: 86 871 5227945  
yppl@public.km.yn.cn

Amadou Sidibe  
Unité des Resources Genetique  
BP 258  
Bamako, Mali  
Tel: 223 2225215  
Fax: 223 2223775  
urg@ier.ml

Luis Latournerie Moreno  
Inst. Tecnologico Agropecuario  
No. 2; Km. 16.3 Antigua Carretera  
Merida-Motul  
Conkal, Yucatan, México  
Tel: 52 991 24135  
Fax: 52 991 24135  
napoleon@mucuy.itaconkal.edu.mx

Le Dinh Huong  
Department of Plant Protection, Hue  
University of Agriculture and Forestry  
102 Phung Hung street  
Hue City, Vietnam  
Tel: 84-54-525544  
Fax: 84-54-524923  
huongledinh@yahoo.com

Nguyen Tat Canh  
Hanoi Agricultural University; Experiment and Practice Station  
Hanoi Agricultural University  
Giam Lam Hanoi, Vietnam

Observer  
Linda Sears  
S11 BoxE C8  
Naramata, BC V0H 1N0, Canada  
Tel: 1-250-496-5027  
Fax: 1-250-496-5028  
ljsears@telus.net