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Proceedings of a Symposium, 6–12 December 2001, Hanoi, Vietnam

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The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of genetic diversity for the well-being of present and future generations. IPGRI has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The Institute operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

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Foreword

Vietnam represents a country of ancient human culture, where agriculture has existed for millennia. It is the long history of agriculture and diverse ecological systems that grant Vietnam such an enormous diversity of plant genetic resources (PGR). Results of numerous studies show the existence of more than 13 000 plant species, belonging to 3500 genera and 500 families, 60% of which have their origin in Vietnam. This diversity has greatly contributed to the socioeconomic development and prosperity of our nation. Unfortunately, the population pressure and inappropriate utilization of natural resources are shrinking these rich and diverse PGR at an increasing rate.

Recently, the national and international concern about biodiversity conservation has risen as we become aware of its important role in the survival of humankind, particularly under conditions of climate change and environmental degradation. The 1992 World Summit in Rio de Janeiro and Agenda 21 recognize the urgent need to promote effective conservation and sustainable use of biological resources in order to meet present demands without harm for future generations.

Consequently, the Government of Vietnam has made great efforts to facilitate PGR conservation and use. The first steps have resulted in successful conservation of biodiversity *ex situ*, which is known as the safest method. At present, however, the important role of *in situ* conservation in allowing evolution and adaptation processes, which are fully stopped by *ex situ* conservation, to take place, has gained more and more recognition.

The project for *"Strengthening the Scientific Basis for In situ Conservation of agrobiodiversity on-farm"* serves as a good expression of this common trend. Nine countries, namely Burkina Faso, Hungary, Mexico, Morocco, Nepal, Peru, Turkey, Vietnam and Ethiopia participate in this project. The main purpose is to develop essential knowledge to answer the questions WHAT, WHERE, WHEN and HOW *in situ* conservation can be effective.

These proceedings contain the results achieved by Vietnamese partners in the first phase presented in the Project Annual Meeting organized by VASI and IPGRI-APO in Hanoi, Vietnam from 6 to 8 December 2001. The objectives of this meeting were to review the progress and outputs of different activities in different ecosites, to share experiences, to enhance collaboration between in-country working teams, and also with foreign partners from Nepal and IPGRI so as to develop work plans for participating institutions. It is hoped that the proceedings will share our experience with all concerned national and international partners of the project.

I am grateful to Vietnamese partners for their cooperation and contribution to the success of the meeting. My sincere thanks are expressed to Dr Devra Javis, Dr Percy Sajise, Dr Bhuwon Sthapit and other IPGRI staff as well as our colleagues from Nepal for their support and active participation in this meeting. I highly appreciate the contribution of the organizers, the *in situ* project secretariat, the staff of the Department of Research Planning and International Cooperation and Plant Genetic Resources Center of VASI to successful organization of this meeting. I hope that these proceedings will be useful to a wide range of concerned organizations and individuals and also to other programs concerning *in situ* conservation of biodiversity on-farm to serve sustainable agricultural production and food security for humankind.

Prof. Nguyen Huu Nghia
Director General, VASI

Chapter 1. Introduction

On-farm management of agricultural biodiversity in Vietnam: concept and perspective

Bhuwon Sthapit and Devra Jarvis

Introduction

Genetic resources of animals and plants are some of the few resources available to resource-poor farmers in Vietnam to ensure sustainable production and improve livelihoods. It is the foundation upon which animal and plant breeding depends for the creation of new breeds and varieties and is, therefore, a critical aspect of food security.

Genetic resources can be conserved by two approaches: *in situ*, in its place of origin, or *ex situ*, outside its place of origin, as in zoos, botanical gardens, field genebanks and genebanks. The surest and cheapest way to keep this genetic diversity alive is to keep growing it in farmers' fields or home gardens.

On-farm conservation is generally used to describe a process by which farmers maintain the traditional crop varieties that they have developed and which they continue to manage and improve. Thus, the conservation of specific genes or genotypes is secondary to the continuation of the processes that allow the material to evolve and change over time (Jarvis and Hodgkin 2000).

What factors are shaping the crop genetic diversity on-farm?

Climatic, agroecological and sociocultural ethnic divergence and the prevalence of traditional farming systems of small farms and niches have contributed to diverse crops and cultivars in Vietnam. Farmers search locally adapted cultivars for diverse target niches and maintain seed for their need. Genetic diversity gives species the ability to adapt to changing environments, including new pests and diseases and new climatic conditions. Farmer preferences for specific colour, taste and type also demand diverse crop varieties. Hence, the goal of *in situ* conservation is to encourage farmers to select and maintain local crop diversity for the benefit of humankind.

Environmental, biological, cultural and socioeconomic factors influence a farmer's decision of whether to select or maintain a particular crop cultivar at any given time (Jarvis *et al*. 1998; Jarvis and Hodgkin 2000). In the process of planting, managing, selecting, rogueing, harvesting and processing the farmers, in turn, make decisions on their crops that affect the genetic diversity of the crop populations. Over time a farmer may alter the genetic structure of a crop population by selecting for plants with preferred agromorphological or quality characteristics. Thus, the crop genetic diversity present in farming systems has been maintained through the combined action of natural and human selection.

Rationale of in situ *conservation*

From the perspective of a farming community, on-farm conservation is a source of biodiversity-based livelihoods as it meets basic food and nutritional requirements. For the last few decades, agricultural scientists have responded to the threat of genetic erosion by developing a worldwide network of genebanks and botanical gardens for conserving the available useful genetic resources *ex situ* (Bommer 1991). While this form of conservation remains no doubt a useful method, it has some drawbacks in terms of effectiveness and cost. First, an *ex situ* genebank freezes the natural evolutionary process (Altieri and Merrick 1988). Second, *ex situ* collections are more vulnerable to mismanagement and the transmission of seed-borne pathogens (Wood 1993). In addition, genebank facilities do not conserve farmers'

traditional knowledge of crop selection, management and maintenance processes in the development of local cultivars. Nor can they ensure the continued access and use of these resources by farmers. However, in a country like Vietnam, an integrated approach to conservation may be required to combine different *ex situ* and *in situ* conservation methods depending upon biology, costs, resource availability, technical capacity, user's needs and the threats to the genepool. Nevertheless, both systems have complementary roles in conservation and utilization of genetic resources.

The continuing use of landraces contributes to stable food production and income especially in marginal or upland environments where impacts of modern varieties are limited or less effective. Therefore, the Convention on Biological Diversity (CBD) has recognized the continued maintenance of traditional varieties *in situ* as an essential component of sustainable agricultural development. The concept of *in situ* conservation is partly an effort by the scientific community to honour its debt to the legacy of farming peoples who created the biological basis of crop production (Brush 2000).

In situ management of local crop diversity is important for sustainable agriculture because it:

- conserves the evolutionary processes of local adaptation of crops to their environments
- conserves diversity at all levels—the ecosystem, the species, and the genetic diversity within species
- conserves ecosystem services critical to the functioning of the Earth’s life-support system, thus improving the livelihoods for resource-poor farmers through economic and social development
- maintains or increases farmers’ control over and access to crop genetic resources
- ensures farmers’ efforts are an integral part of national PGR systems and involves farmers directly in developing options for adding benefits of local crop diversity
- links the farming community to genebanks for conservation and utilization (Jarvis *et al.* 2000a).

The importance of conservation of agrobiodiversity for future global food security lies in its potential to supply crop breeders and other users with future germplasm needs. On-farm conservation will provide public and private benefits (socioeconomic, ecological and genetic benefits). Witcombe (1999) reported that there has been a significant increase over time in the number of landraces that are used in the major CGIAR centres of CIMMYT and IRRI. In Vietnam, the proportion of parents used by the plant breeders from genebank is still limited.

What basic information is needed to understand in situ *conservation?*

It is useful to identify four aspects where information is needed to support farmers and local communities in on-farm crop diversity conservation, management and use. Following are four basic research questions, which will provide a scientific basis for designing and planning effective on-farm conservation:

1. What is the extent and distribution of the genetic diversity maintained by farmers over space and over time?
2. What are the processes used to maintain the genetic diversity on-farm?
3. Who maintains genetic diversity within farming communities (men, women, young, old, rich, poor, certain ethnic groups)?
4. What factors (market, non-market, social, environmental) influence farmer decisions on maintaining traditional varieties?

How in situ *conservation provides benefits to a community*

If crop genetic resources are going to be conserved on-farm, it must happen as a spin-off of farmers’ productive (development) activities (Berg 1997). This means conservation must be put into a context of development (farmers’ livelihood and cultural interest).

The project, therefore, is concerned with how *in situ* conservation can be linked with genetic, socioeconomic and ecological benefits for livelihoods of people (Jarvis *et al.* 2000b). Benefits accruing from such efforts could be both monetary and non-monetary. Answering the above-mentioned basic questions provides the knowledge needed to (i) support local seed systems, (ii) improve participatory plant breeding programmes, (iii) develop markets for traditional crops and cultivars, (iv) promote appropriate curriculum development, (v) create methodologies for integrating locally adapted crop cultivars and farmer preferences into development and extension projects, and (vi) advise on appropriate policies that support the management and use of crop diversity in agroecosystems (IPGRI 2001). Answers to these questions are also needed to develop methods for mainstreaming the use of local crop genetic resources into the agricultural development arena that aims for poverty alleviation and food security.

Effective management and conservation of genetic resources on-farm takes places where the resources are valued and used to meet the needs of local communities (Jarvis *et al.* 2000a). In order for local crop systems to be maintained by farmers, the genetic resources must have some value and/or be competitive with other options a farmer might have. Two options were used in adding benefits: the first, on adding benefits through participatory plant breeding, seed networks and grassroots strengthening, and the second, on adding benefits through public awareness, better processing, marketing, policy incentives, and education in the formal sector (Jarvis *et al.* 1998).

The first option is to seek improved quality, disease resistance, high yield, better taste, longer storability and other preferred traits through breeding, seed networks and modified farming systems. The second option includes adding value to crop resources so that the demand for the material or some derived product may be increased. These diverse options will emerge when community, researchers and developmental institutions are directly involved in monitoring local crop diversity using a community biodiversity register and linking with crop improvement, seed and market networks for adding benefits on local resources.

The steps of effective implementation of on-farm conservation

The following steps are identified that are essential for effective implementation of an on-farm conservation programme before "best practices" can be used for policy reforms (Sthapit *et al.* 2000):

1. Locating ecosystem diversity, crops and community
2. Creating institutional framework and participatory planning process
3. Community sensitization
4. Locating diversity and custodians
5. Monitoring diversity
6. Characterizing, measuring and assessing local crop diversity
7. Developing strategy for options of on-farm conservation of agrobiodiversity
8. Mainstreaming information for development and policy reforms.

Understanding the scientific basis of on-farm conservation of crop genetic resources will allow stakeholders to appreciate the amount of genetic diversity maintained by a farming community and their genetic, sociocultural, economic, and ecological values in order to formulate national research and development policies for poverty alleviation and food security.

Strengthening local capacity to manage on-farm conservation strategies

Figure 1 illustrates the processes that involve a community in developing their own on-farm conservation strategy that provides benefits to individuals, the community, the nation and the international community. A number of participatory tools have been developed to

implement on-farm conservation activities at local level by the farming community themselves:

1. *Improving local seed system:* Understanding the local crop diversity and social networks of germplasm and knowledge flow and storage methods; identify technical gaps and strengthen local seed system.
2. *Diversity fair:* Local community can organize this fair for locating diversity and custodians, sensitizing community and policy-makers, and promoting access to information and materials.
3. *Community biodiversity register:* Recording inventory of local crop diversity and associated local knowledge and monitoring the increase and decrease of number of landraces and modern varieties and their distribution pattern within households (by area) or between households within community.

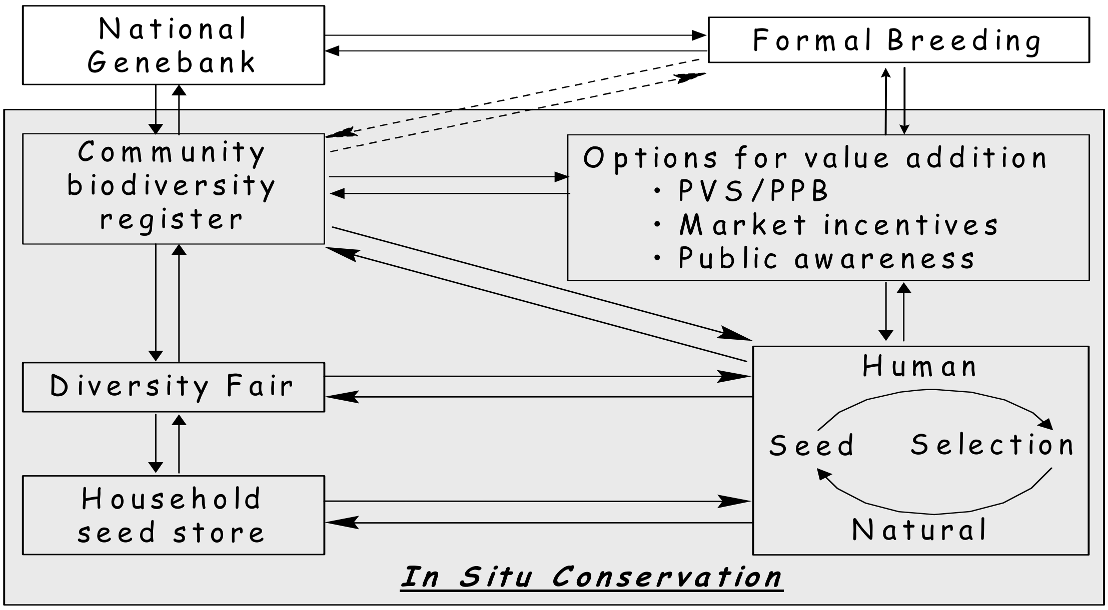

Figure 1. Strengthening grassroots institutions and informal seed networks through participatory approaches such as diversity fair and CBR and linking with value addition options and *ex situ* conservation (Sthapit and Jarvis 1999).

Such activities will raise awareness on local crop diversity and help to understand the value of local crop diversity. Diversity fair and Community Biodiversity Register are two participatory methods that can strengthen local capacity to document taxonomic data and traditional knowledge on crop genetic resources (CGR) with the following specific objectives:

- create awareness and develop a sense of community ownership on biodiversity
- locate unique, rare and culturally significant cultivars and their custodians
- enhance access to genetic materials and information on local crop diversity
- develop options of adding benefits and support biodiversity-based livelihoods
- build local capacity for monitoring diversity *in situ* and promote on-farm management of local crop diversity
- make stakeholders aware of and protect economically important biowealth against biopiracy.

A challenge of successful implementation of CBR will depend upon how the approach could provide direct benefits to a farming community. One of the direct benefits is that it may help to network key households, which maintain rare, unique and rich local crop diversity resulting in a network of seed stores to form a decentralized community seed bank.

The value of such a decentralized community biodiversity register will be clearer when activities such as diversity kits, Participatory Variety Selection and Participatory Plant Breeding (Witcombe *et al.,* 1996; Sthapit and Jarvis 1999; Sthapit *et al.* 2000) are integrated into community-based informal seed management and exchange programmes. Participatory plant breeding and deployment of diversity kits will strengthen the capacity of farmers to search, select, maintain and exchange genetic resources for obtaining both genetic and socioeconomic benefits for farmers and society. All this requires greater collaboration between formal and informal sectors with more benefit-oriented activities.

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The historical development of *in situ* conservation in Vietnam: institutional arrangements for project implementation with multipartners

Pham Van Chuong, Ha Dinh Tuan, Nguyen Thi Ngoc Hue, Luu Ngoc Trinh, Devra Jarvis and Bhuwon Sthapit

Introduction

In situ (on-farm) conservation is concerned with maintaining species' populations in the natural habitats where they occur, whether as uncultivated plant communities or in farmers' fields as part of existing agroecosystems. The CBD (Convention on Biological Diversity) assumes that the continuing use of landraces contributes to stable food production and income, especially in marginal environments where impacts of modern varieties are limited or less effective. Therefore, the CBD has recognized the continued maintenance of traditional varieties *in situ* as an essential component of sustainable agricultural development (Jarvis and Hodgkin 2000).

Historical perspectives

Since 1950 Vietnam has enjoyed some attention on PGR work; however, the economic and technical basis of plant genetic resources conservation and management in Vietnam was destroyed during a prolonged war of 30 years (1945-75) (Khoi 1995). Initial collection of germplasm started after 1975. The collaboration with the International Plant Genetic Resources Institute (IPGRI), then IBPGR, began in 1989 with the official visit of Dr Jan Engels. PGRC of Vietnam became a member of RECSEA in 1992 and became more aware about the Convention of Biological Diversity. The national activities on PGR in Vietnam are implemented by several Ministries with minimal coordination.

Vietnam's national plant genetic resources programme had been strengthened with support from IPGRI (Wood 1995). Initial efforts were made to create an organizational framework to work together in PGR management. In 1995, the first national workshop on strengthening of plant genetic resources programme in Vietnam was conducted at VASI with support from IPGRI and brought up some key issues on PGR conservation and use (Riley and Rao 1995). A total of 41 papers were presented to document the status of PGR work in Vietnam. Conservation and sustainable utilization of agricultural biodiversity is of great concern to the Vietnam government. Vietnam has been critically studying the strategy of crop genetic resources conservation and considers that *in situ* conservation can serve as a complementary approach to genebanks to preserve germplasm in a cost-effective way. In 1996, Dr Trinh took part in the fourth international Technical Conference on PGRFA held in Leipzig, Germany in which Vietnam endorsed the need for implementing on-farm conservation of agricultural biodiversity.

On-farm Conservation Project: Phase I (*1997-99*)

During a preparatory phase, an external consultant (Dr Stephen Brush) and Regional Director of IPGRI APO (Dr Ken Riley) visited Vietnam to meet national partners. In 1995, Vietnam was identified as one of the nine countries in the IPGRI's Global Project, "Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm" and Dr Trinh from VASI and Dr Vo Tuan Xuan from Cantho University were invited to participate in a proposal refinement meeting in Rome. The other eight countries in the project are Nepal, Hungary, Mexico, Peru, Burkina Faso, Ethiopia, Morocco and Turkey. These countries were selected on the basis of high degree of genetic diversity, presence of a functional PGR system, potential of *in situ* conservation in the traditional farming systems and donor interests.

The project objectives of Phase I were:

- To enhance and support a framework of knowledge on farmer decision-making processes that influence *in situ* conservation of agricultural biodiversity.
- To strengthen national institutions for the planning and implementation of conservation programmes for agricultural biodiversity.
- To broaden the use of agricultural biodiversity and the participation in its conservation by including farming communities and other groups.

The Vietnam country component was supported by SDC, Switzerland for both 3-year phases (1997-1999 and 2000-2003). IPGRI acts as a contracting party to the project donors. IPGRI has set up a transparent management system to implement the project activities through the Letter of Agreements (LoAs). Vietnam Agricultural Science Institute (VASI) has been identified as the focal institution with Cantho University as an additional partner in southern Vietnam. IPGRI played an important role within the national components to ensure that various partners are working together as a multidisciplinary team as far as implementation and sharing of results is concerned.

Site locations in Vietnam

Vietnam has seven agroecosystems. Contrasting macrosites were chosen representing six agroecosystems to provide a range of conditions that encompass high to low levels of genetic diversity, optimal to low agricultural conditions and high to low levels of market integration. Table 1 summarizes comparative features of all sites, diverse ecology and crops, coordinating institutions and site coordinators. Contrasting characteristics of all seven sites of Vietnam *in situ* project sites are described in Tables 2.1 and 2.2. The following agroecosystems were considered for selecting regions for *in situ* conservation study of agricultural biodiversity.

Table 1. Study area for *in situ* conservation project in Vietnam

Agroeco-system	Name of site, altitude and villages	Diversity of traditional crops	Lead institution and site coordinator
Northern high mountain	Sapa (500–1500 m) Ban Khoang village	cold-tolerant rice, taro, cardamom	Hanoi Agricultural University (HAU) Dr Nguyen Tat Canh/Mr Tran Van On
Mountain	Da Bac (600–700 m) Cang and Tat villages	rainfed rice, upland rice, taro	Vietnam Agricultural Science Institute (VASI) Dr Nguyen Thi Ngoc Hue/Mr Nguyen Phung Ha
Intermediate hills	Nho quan (60–90 m) Yenminh and Quangmao villages	rice, taro	VASI Dr Nguyen Thi Ngoc Hue
Lowland Red River Delta	Nghiahung (<1.5 m) Donglac and Kienthanh villages	aromatic rice	VASI Dr Nguyen Thi Ngoc Hue/Mr Pham Hung Cuong
Coastal central lowland ecosystem	Hue Thua Thien site (<10 m) PhuDa and Quang Thai villages	rice, taro	Hue University of Agriculture and Forestry (HUAF) Dr Truong Van Tuyen/Ms Hoa
Southern Central plateau ecosystem	Daklak (500–670 m) Jara, Rut zu and R'Kap villages	upland rice, mung bean, gourds	Tay Nguyen University (TNU) Dr Pham Van Hien
Mekong delta sand dunes	Tra cu (<1.2 m) Dai An village	rice, taro	Mekong Delta Farming Systems Research and Development Institute (MDFRDI), Cantho University Mr Nguyen Ngoc De/ Mr Huynh Quang Tin

Table 2.1. Contrasting site characteristics of the IPGRI's *in situ* project for Phase I: Vietnam

Macrosite	Location	Agroecology	Farming system	Local crops diversity	Socioeconomic factors	Level of technical and market interventions	Opportunity for adding benefits
Mountainous agroecosystem	Cang village Doanket commune Da Bac district Namdinh province 105°02'E 20°56'N	Subtropical monsoon 630-675 m altitude 23.5°C 1750 mm/annum Loam mixed with gravel soil	Upland agriculture. rainfed lowland	Rice (38), taro (8) Sesame (1) Blackbean (1)	Tay ethnic group =100% 378 =Total population 27.7 =Area (ha) 0.40 = Average landholding/HH 4.50 = Rice cultivars/HH	Low 18 km=Distance from nearest market 170 km from Hanoi	Low
	Tat village Tanminh commune Da Bac district Nam dinh province 105°02'E 20°56'N	Subtropical monsoon 630-675 m altitude 23.5°C 1750 mm/annum Loam mixed with gravel soil	Upland agriculture; rainfed lowland	Rice (41) Taro (8) Seasame (1) Ricebean (1)	Tay ethnic group =100% 406 =Total population 36.1 =Area (ha) 0.43 = Average landholding/HH 4.50 = Rice cultivars/HH	Low 22 km= Distance from nearest market 130 km from Hanoi	Low
Intermediate terrain	Qungmao village Thachbinh commune Nho Quan district Ninhbinh province 105°42'E 20°23'N	Subtropical monsoon 60-90 m altitude 27°C 1950 mm/annum Gravel soil	Mixed farming with unique home gardens	Rice (16), Taro (3) Sesame (2)	Kinh =30%; Muong =70% 250 =Total population 17.94 =Area (ha) 0.46 = Average landholding/HH 2.2 = Rice cultivars/HH	Intermediate 5 km= Distance from nearest market 140 km from Hanoi	Intermediate
	Yen minh village Yen quang commune Nho quan district Ninh binh province 105°42'E 20°23'N	Subtropical monsoon 60-90 m altitude 27°C 1950 mm/annum Alluvial loam soil	Mixed farming with unique home gardens	Rice (9), Taro (4) Mungbean (2)	Kinh 50%; Muong 50%; 465 =Total population 48.8 =Area (ha) 0.20 = Average landholding/HH 2.5= Rice cultivars/HH	Intermediate 5 km=Distance from nearest market 120 km from Hanoi	Intermediate
Lowland Red River Delta	Dong lac village Nghia lac commune Nghia hung district Nam dinh province 106°5'E 20°5"N	Tropical monsoon 0.4–1.4 m 28°C 1550 mm/annum Loamy alluvial soil	Irrigated rice-based farming under high yield potential areas	Rice (17) Taro (3) Mungbean (2) Blackbean (2)	Kinh 100% 6300 =Total population 315.4=Area (ha) 0.29 = Average landholding/HH 2.96= Rice cultivars/HH	High 2 km=Distance from nearest market	High
	Kien thanh village Nghia loi commune Nghia hung district Nam dinh province 106°5'E 20°5"N	Tropical monsoon 0.4–1.4 m 28°C 1550 mm/annum Loamy alluvial soil	Irrigated rice-based farming under high yield potential areas	Rice (16) Taro (2) Mungbean (2) Blackbean (2) Sesame (2)	Kinh 100% 558 =Total population 68.7 =Area (ha) 0.22 = Average landholding/HH? 2.4= Rice cultivars/HH	High 1.5 km=Distance from nearest market	High
Sand ridges Mekong Delta	Dai An village Tra cu district Tra vinh province 106°7'E 10°7'N	Tropical monsoon Sand ridges-coastal line 0.8–1.2 m 26.6°C 1450 mm/annum Saline soil /sandy soil	Rice-based farming with small home gardens	Rice (16) Taro (3)	Khmer = 80%, Chinese =10% and Kinh =10 % 8909 =Total population 1530 =Area (ha) 0.90 = Average landholding/HH	Intermediate 40 km= Distance from nearest market	Intermediate

Table 2.2. Characteristics of IPGRI's *in situ* conservation project sites in Vietnam for Phase II

Macrosite	Location	Agroecology	Farming system	Local crops diversity	Socioeconomic factors	Level of technical and market interventions	Opportunity for adding benefits
Coastal central Vietnam	Phu Da commune Phu Vang district Thua Thien Hue province 107°45'E 16°27'N	Tropical monsoon coastal-lagoon sandy soil rainfed	Intercrops and rice-based farming with home gardens	Rice (19) Taro (9) Sesame (2) Jam (1) Bean (3)	Kinh ethnic group=100% 272 =Total households	High 10 km to national road 20 km to Hue city	Intermediate
	Quang Thai commune Quang Dien district Thua Thien Hue province 107°25'E 16°40'N	Tropical monsoon coastal-lagoon, sandy soil, deep-water field	Rice-based farming with home gardens	Rice (14) Taro (3)	Kinh ethnic group=100% 143=Total households	Intermediate 20 km to national road 50 km to Hue city	Intermediate
Northern mountain site	Ban khoang commune Sapa district Lao Cai province	Sub-tropical Mountain ecosystem 500-1500m asl 15.5°C 2800-3500mm/annum rainfed	Maize-based farming system in slope land and rice in terrace fields	Rice (23) Taro (10) Cardamom (10)	Dao ethnicity=90% H'mong ethnicity=10% 1894=Total population 258=Total households 219 ha =Arable land 5663 ha = natural lands 3.2= Rice cultivars/HH	Low 60 km from Sapa 300–400 km from Hanoi	High

North-west mountain ecosystem: Sapa and Da Bac districts are located in remote mountainous areas of Vietnam. Sapa site is accessible by train and roads and has been an important tourist destination in Vietnam. In Sapa, main sources of livelihoods are off-farm employment and sale of large cardamoms for medicinal purposes. Da Bac site is an all-day drive from Hanoi and is popular for quality upland rice and taro diversity. Traditional crops and cultivars are major sources of livelihoods and poverty is widespread. Sapa site was added during the second phase of the project.

Red River Delta ecosystem: The villages around Nghiahung site are located in what is thought to be the original area for the Vietnamese civilization. These districts are located at an average elevation of 1.5 meters and are representative of the Red River Delta Ecosystem. The region is considered a centre of diversity for aromatic rice and in many villages, aromatic rice occupies nearly 80% of the total rice production.

Nho quan ecosystem is located in the foothills and Lake Watershed. Both subsistence and commercial home gardens and large agroecosystems are found. The villages are accessible to market, which is 2-3 hours distance from Hanoi. Taro diversity and home gardens are unique to the site.

Coastal central Vietnam ecosystem: Hue province is representative of the Central coastal Vietnam region. The province extends from the coast westward to the mountains from an elevation of 10 to 100 meters. The region is drier than the Red River Delta agroecosystem but the coastal side of Hue site is wet, humid and prone to floods. Diverse types of rice and taro are cultivated in the region including floating rice. This site was added during the second phase of the project.

Southern Central plateau ecosystem: Daklak province is the driest of the three provinces. The proposed study area ranges in elevation from 500 to 700 m and is representative of the Central Plateau agroecosystem. The local crop diversity is affected by transformation processes of commercialization and land-use policy interventions. The region has a large diversity of ethnic minorities, including the Bana, M'nong, Ede and Giarai. In this region, farmers grow upland rice in the wet season with irrigated legume crops in the dry season. This site was added during the second phase of the project.

Mekong Delta ecosystem: Tra cu district is the unique sand dune ecosystem of Mekong Delta. Water sources from Mekong River and saline water from the sea influence adaptation of local crop diversity. Traditional varieties are grown in large areas in areas prone to salinity whereas the modern IRRI and Chinese hybrids have replaced local cultivars in irrigated high yield potential areas. The root crops such as taro, yams and cassava play important crops for food security, as the areas are prone to frequent floods.

Target crops

Rice, finger millet, taro, mungbean, large cardamom and sesame have been tentatively selected but diversity of rice, taro and cardamom was also found. The major criteria for priority crop selection were as follows: native to East Asian Centre of Origin, rich intraspecific diversity and importance to farming community. Diversity fairs showed that rice, cardamom and taro have only some degree of genetic diversity and remaining crops cannot be considered for *in situ* conservation.

Major outcomes

Main outputs for (1) creating a national framework for project implementation, (2) agroecosystem factors, (3) sociocultural factors, (4) agromorphological characters and farmer criteria, (5) population structure and breeding systems, (6) seed supply systems, (7) and adding benefits to local crop resources through breeding and non-breeding methods for this phase of the project in Vietnam were published in the 1999 Proceedings of the Global Participants Meeting, 5–12 July 1999, Pokhara, Nepal (Jarvis *et al.* 2000). A total of nine papers were published and some of the project outputs are summarized in Table 3.

Table 3. Progress achieved during the first phase by objectives and general observations for each output

OBJECTIVE 1: To enhance and support a framework of knowledge on farmer decision-making processes that influence *in situ* conservation of agriculture.	
'lanned Outputs	**'rogress and General Observations**
1A. Measures of the extent and distribution of the genetic diversity of selected crops over time and space.	A preliminary diagnosis was made of the diversity of local rice and taro varieties. Participatory tools were used to identify farmer cultivars and farmer descriptors. Local rice and taro varieties are currently being characterized through diversity blocks on-farm and through standard field trials on-station. An inventory of crop species diversity was completed by PRA for all villages. Six different cultivars of Vietnamese aromatic rice (*Tam xoan, Tam Tieu, Tam Thom, Tam Nghen, Tam Co ngong, Tam cao cay*) from different villages of Nam Dinh province of Red River Delta assessed at DNA level. Twenty primers generated 55 polymorphic bands among 205 plants investigated, of which 45 landraces were found polymorphic among all tested aromatic rice cultivars of Red River Delta. Aromatic rice landraces showed different banding patterns compared with the control *japonica, indica* and modern cultivars. There were two distinct groups: Group A represented 23% of total aromatic landrace samples whereas Group B comprised 76% of the total samples. Two groups have similarity index of 0.900. A Vietnamese scientist from PGRC did RAPD analysis at NIAR Japan with the support of the National Institute of Agrobiological Resources (NIAR). Field samples and agromorphological studies were carried out with the support of IPGRI project in order to complement the resources. In Tra cu site, agromorphological data and seed samples of Trang Tep rice population were collected from 66 farmers' fields to assess the population structure of the farmers' variety. The team completed the work in December 1999. Characterization of taro population cv. Sap is in progress at present.
1B. A data set linking farmer decision-making on the selection and maintenance of local cultivars with measurable indices of genetic diversity.	Preference ranking of common farmer varieties was carried out to identify good and bad traits of cultivars. A survey of 39–140 farming households has been completed in Da Bac (Cang, and Tat villages), Nho quan (Quang Mao, and Yen Minh villages), Nigha hung (Dong lac and Kien Thanh villages) of three northern ecosites. Teams of interviewers worked in different villages, each interviewer visiting different households. Baseline survey of Tra cu site was also accomplished in April by Can Tho University and early May of 1999. Data analysis is currently in progress using MS-Excel. Following parameters of selected villages have been completed: computation of diversity index, distribution of target crop diversity.

Table 3. Continued

1C. Identification of key or limiting factors (environmental, biological, socioeconomic) that influence farmer decisions to maintain local cultivars.	A PRA survey was carried out in all villages and preliminary site description profiles were prepared that describe the agroecology and production constraints of the villages.
1D. Description of farmers' access and use of formal and informal seed supply systems.	Seed flow study was conducted in Tra cu site in two rice landraces (namely *Trang Tep* and *Nep Than*). The study was initiated in August and completed in December 1999. Similarly, there is plan to monitor geneflow of two taro landraces (*Cao* and *Sap*) during dry season. Similar studies on seed flow system have been reported from the northern ecosites.
1E. Key indicators and measurements of the effect of increasing population pressures, land degradation and environmental change on the maintenance of on-farm diversity.	Bibliographic revision and fieldwork is planned for documenting demographic growth, and changes in rainfall patterns (meteorological stations), land use and tenure in the study areas.
1F. Information on the effect of market development (access to market, off-farm income, availability of credit to male and female farmers) on the maintenance of on-farm diversity.	Changes in local and regional economy, market access, off-farm labour and credit availability are planned for a later time.
1G. Recommendations for national economic and agricultural policy to aid the maintenance of on-farm diversity.	The National Multidisciplinary Group (NMDG) contains members from the Ministry of Agriculture who are linked to policy-makers. Information from the project is made available to Members of the Ministry of Agriculture and other institutions interested in conserving genetic diversity on-farm.

OBJECTIVE 2: To strengthen national institutions for the planning and implementation of conservation programmes for agricultural biodiversity.

'lanned Outputs:	'rogress and General Observations:
2A. Trained male and female personnel in plant population genetics and ecology, biogeography, conservation biology, economics and anthropology.	Ms Nguyen Thi Thanh Tuyet has recently finished her MSc on an investigation of inter- and intravarietal diversity of rice from Da Bac *in situ* site, assessing genetic variation using agromorphological characters, biochemical and quality characteristics. Research work of another MSc student (Mr Nguyen Van Khoi) is still in progress. His area of research focuses on influence of traditional cultural practices on management of local genetic diversity of taro and rice. Mr Vo Minh Hai, field staff of Tra cu site was trained on PGR conservation through Development training held by BUCAP Project, SEARICE in Cantho and HMC City from 14 to 25 July 1999. Three site coordinators—Mr Ha, Mr Suu and Mr Cuong—from other ecosites have been identified for on-the-job MSc thesis research in VASI and research outputs would be knowledge products of the project. Short courses held by IPGRI/SEACA on Genetic Diversity and on Ethnobotany and Genetic Diversity in China. Group training conducted at VASI on Capacity Building on Computer and Data Management. Group training was also held on Participatory tools for PGR Management with 22 participants. In addition, a three day training course was held with 15 participants on Agrobiodiversity Assessment and Household Economy.

2B. Criteria for the identification of priority crops and regions for *in situ* conservation.	Based on the sociocultural, economic, dietary, and genetic criteria, priority crops of the study region have been identified. Factors conducive to their *in situ* conservation are being identified through analyses of the socioeconomic survey and the characterization of the genetic diversity encountered.
2C. Linked biological and social science programmes in institutes and universities.	Activities have been initiated to exchange research methods, information and to conduct joint analyses.
2D. Guidelines for research and practice in *in situ* conservation.	Participation of Vietnamese partners in global meetings and input into training guide and into concept and method fliers. Translation of In Site/On farm conservation presentations and Agadir ZOPP meeting completed in Vietnamese.
2E. Standardized terms/definitions and research protocols for *in situ* conservation for the nine participating countries.	Electronic discussion groups and information exchange with projects in other regions, as well as working group outputs during the global meeting.
2G. Gender awareness incorporated in national *in situ* conservation programmes.	National Multidisciplinary team includes members of both genders. Women motivators have been identified at the village level and participate in local and national meetings. Gender study undertaken in northern sites.
2H. Increased number of women in management and decision-making roles and in training courses.	Site coordinator for one site is female. Women motivators participate in project implementation. One female MSc has completed her degree. Short course in China attended by 1 male and 1 female project staff.
2I. Participation in email discussion group with other countries of the global project.	National partners from VASI and Cantho University participate in global discussion groups, directly, and through the local coordinator.
Establishment of National and Local Multidisciplinary Groups (NMDG/LMDG)	Formal meeting of National Multidisciplinary Group (NMDG) is the main institutional framework to facilitate participatory planning and implementation of the *in situ* project. The NMDG meeting was held in September to plan the visit programme of SDC review team in Vietnam and assigned the responsibilities.

Table 3. Continued

OBJECTIVE 3: To broaden the use of agricultural biodiversity and participation in its conservation by including farming communities and other groups.

'lanned Outputs:	'rogress and General Observations:
3A. Decentralized breeding and selection techniques that enhance or maintain on-farm genetic diversity.	Farmer criteria for desired traits have been collected in preparation for decentralized breeding. Adding benefits through integrated pest management, PPB and deployment of diversity initiated in the Mekong Delta Phenotype analysis of two populations was carried out in Tra cu site: one for Trang Tep population of rice and another for Sap population of taro. Data collection has been done in Dec 1999 and data analysis has been planned in April-May 2000. Farmers' field day was organized in Tra cu site in September 1999 to evaluate participatory variety selection plots of five rice cultivars. Similar farmers' field days were also organized at harvest time of diversity block in three northern ecosites.
3B. Improved local cultivars combining substantial genetic diversity with enhanced performance.	Participatory variety selection and PPB work initiated in Tra Cu site, Mekong Delta – 25 participants. The purpose of the activity is to foster conservation through developmental activities. New crop diversity of sweet potato, potato, okra and tomato were distributed in northern ecosites through female motivators in order to raise the value of genetic resource. In Tra cu site as well 6 cultivars of taro landraces and 3 cultivars of cassava were deployed at the hands of farmers. In Can Tho seed multiplication of farmer-preferred crops and varieties was also carried out to transfer skill of seed selection to farmers and also to link conservation with informal seed markets and promotion network.
3C. Male and female farmers and project personnel trained in decentralized breeding.	A training course was also held in Tra Cu with participating farmers on strengthening the Farmer Role in PGR Development and Conservation. A separate LoA was signed between IPGRI and Rice Breeding Department of VASI on PPB in collaboration with the NMDG of the project to link PPB as a process to enhance on-farm conservation of local crop diversity. The purpose of the exercise was to promote interinstitutional collaboration and partnership, which is difficult to achieve in Vietnam. Initial need assessment of rice and taro cultivars has been carried out using preferred trait analysis. Further training on participatory approaches to crop improvement may be needed to strengthen the capacity of VASI breeder.
3D. Strengthened community institutions for biodiversity management.	Through the direct involvement of farmers in Diversity fairs and Diversity blocks of rice and taro in the villages from local and also genebank collections, agrobiodiversity is made more directly available for farmers.

3E. Improved links between formal and informal institutions and farmers.	Through the sociocultural survey, the collecting of seed samples and diversity fair activities, both formal and informal relations are being established between the farmers and the different project institutions. IPM approach has been used as a participatory method to add value of local rice cultivar of *Nep Do* combined with the use of leaf colour chart for nitrogen requirement. Training on IPM and EPM was regularly organized on a weekly basis to establish rapport between farmers and project staff and also to understand the value of local diversity in maintaining health of ecosystem. The project staff and local plant protection officers from the district were the main resource persons for such training activities and about 30 farmers are regularly taking part in the training. In addition, there has been a sharing of information and skill transfer between CBDC and IPGRI *in situ* projects.
3E.1 Improved links through Diversity Blocks.	Diversity blocks of taro and lowland rice were maintained in all ecosites and data were recorded for 1999 seasons. The materials collected in diversity fair were planted in rented land of the site in order to multiply materials and facilitate local distribution. Diversity block has two main objectives: research and development. Research objective is to measure diversity of landrace population by agromorphological charcterizations and also to acquire local knowledge associated with local diversity. Development objective is to sensitize community about the value of local germplasm and provides opportunity to farmers to identify local landraces and enhance exchange of the materials and knowledge. Vietnamese scientists have taken up the methodology enthusiastically after a field visit in Nepal.
3F. Measure gender variables in the conservation of genetic diversity on-farm.	A gender study was undertaken – see Nepal 1999 Proceedings
3G. Information bases, for farmer-use, on the characteristics and value of local varieties.	Two Vasi scientists participated in a visit to Bangladesh NGO to learn about community mobilization, community seed banking and information bases for community use.

SDC External Review

The SDC review team, consisting of Dr Gordon Prain, Dr Jurg Benz and Dr S. Appa Rao, visited Vietnam from 13 to 20 September. Dr Luu Ngoc Trinh, National Project Coordinator of Vietnam, Dr Devra Jarvis and Dr Bhuwon Sthapit, also accompanied the review team. Dr Ramanatha Rao, Interim Activity Manager also met the team in HMC. The purpose of the SDC review was to compare the achievements with the results as planned, including a look at benefits for farming communities. The review aimed to assess if the project was implemented as planned, and if not, what were the reasons. Main recommendations of the review team and action to be taken are listed in Table 4.

In September 1999, an external evaluation of the SDC-funded components of the project was completed. The evaluation team recommended the continued financing of the global and Vietnam component of the project for a next 3-year phase.

***Phase II* (*2000-2003*)**

A planning process for on-farm conservation workshop in Hanoi from 21 to 23 March 2000 was also initiated during the period. During the April 2000 Hoa Binh Goal Oriented participatory planning meeting, the participants verified that all the recommendations of the SDC Evaluation, which had not yet been fulfilled, were taken care of through planned activities in the project planning matrix. Three new partners—Hanoi Agricultural University, Hue University and Tay Nguyen University—along with Vietnam Agricultural Science Institute (VASI) and Cantho University joined the second phase of the project.

The main purpose of Phase II (2000 to date) is to strengthen the scientific basis, institutional linkages and policies that support the role of farmers in conservation and use of crop genetic diversity. The project has developed good practices and classified potential interventions to increase crop genetic diversity competitiveness to other options farmers might have under five broad headings:

1. Improving the landraces
2. Increasing consumer demand
3. Improving access
4. Integrating crop diversity management with ecosystem health initiatives
5. Influencing policy.

Table 4. SDC External Review: main recommendations and actions taken

Recommendation	Action
A monitoring and evaluation structure should be developed in a planning workshop which would include redefining the role and responsibilities of the NMDG, introducing responsibilities for reviewing and synthesizing data and acting as a conduit for communications and information exchange with the global component.	In June 2000 IPGRI staff visited the Vietnam partners which resulted in a change in the management structure of the project. In addition, a national planning meeting is scheduled for August 2000 (see below).
There is a need for an extensive review of the objectives and methodology of diversity blocks, especially as a means for understanding current preferences in comparison with existing local diversity.	This activity is now currently being done not only in Vietnam but also in other countries where diversity blocks have been carried out (e.g. Nepal and Morocco).
Actions should clearly be identified as being carried out in the *ex situ* genebank if this is the case.	The August 2000 National planning workshop will clearly identify which activities are related to the project implementation.
Greater priority should be given to exploring the opportunities for characterizations and evaluations in the *in situ* sites.	More emphasis is now being placed on field and site activities. The August 2000 workshop will clearly identify these tasks and responsible persons.

This programme of work has been accomplished through strengthening local, national and global frameworks and building representative partnerships. These partnerships include formal and informal institutes and organizations, researcher and farmer partnerships, gender equity in management and decision-making positions. Communes, extension workers and farmers' associations (including women) who work closely with farmers have an important role to play in identifying and adding value to farmer-managed genetic resources.

Partner Organizations in Vietnam

The project focuses on strengthening the relations of formal institutions with farmers and local-level people's community. **Vietnam Agricultural Science Institute (VASI)** is the focal coordinating institution of the project. Cantho University, Hanoi Agricultural University, Hue University of Agriculture and Forestry (HUAF) and Tay Nguyen University are collaborating partners. The Hanoi Agricultural University, Hue University of Agriculture and Forestry (HUAF) and Tay Nguyen University joined only in the second phase of the project. Besides overall coordination between partners and IPGRI, the National Project Coordinator (NPC) is responsible for organizing an annual planning meeting where the multi-institutions (identified partners) participate and all partners agree on a common workplan, activities and outputs (Table 5). IPGRI develops a separate Letter of Agreement (LoA) for each partner based upon the agreed workplan at the ZOPP planning meeting.

Table 5. Institutional setting up and manpower for the *in situ* project in Vietnam

Role	Duty station	Name and affiliated institutions
NPCC member for sharing information and linking to policy-makers	National Project Coordination Committee (NPCC) meeting	Prof. Nguyen Huu Nghia, Director General, Vietnam Agricultural Science Institute (VASI) Dr Phan Van Chuong, DDG, VASI Mr Nguyen Ngoc De, Mekong Delta Farming Systems Institute, Cantho University, Dr Pham Van Hien, Tay Nguyen University Dr Truong Van Tuyen, Hue University of Agriculture and Forestry (HUAF) Dr Nguyen Tat Canh, Hanoi Agricultural University, Hanoi, Dr Nguyen Thi Ngoc Hue, Deputy Director, Plant Genetic Resource Centre, Vietnam Agricultural Science Institute (VASI) Dr Luu Ngoc Trinh, Director, PGRC, VASI Mr Ha Dinh Tuan, Deptuy Head of Department of Planning and International Cooperation, VASI
National Project Coordinator	DG, Vietnam Agricultural Science Institute (VASI),	Prof. Nguyen Huu Nghia, Director General, Vietnam Agricultural Science Institute (VASI), Vandien, Hanoi. email: vasi@hn.vnn.vn
Site coordinators	Cantho Site Coordinator	Mr Nguyen Ngoc De, Mekong Delta Farming Systems Institute, Cantho University, Southern Vietnam
	Daklak highland site coordinator	Dr Pham Van Hien, lecture of Tay Nguyen University, Daklak, Central Vietnam
	Hue coastal ecosite coordinator	Dr Truong Van Tuyen, Hue University of Agriculture and Forestry (HUAF), Thua Thien coastal ecosite, Central Vietnam
	Sapa mountain site coordinator	Dr Nguyen Tat Canh, Hanoi Agricultural University, Hanoi, Northern Vietnam
	VASI sites, Da Bac/Nhoquan/Nighhung	Dr Nguyen Thi Ngoc Hue, Deputy Director, Plant Genetic Resource Centre, Vietnam Agricultural Science Institute (VASI), Vandien, Hanoi. email: *insitu@netnam.vn*

National Project Management Frameworks

The implementation of an on-farm conservation programme presupposes that an integrated framework at central and local levels already exists within the country's national programme. In Vietnam, a strong national genebank exists with 30 staff at the Plant Genetic Resources Centre (PGRC). During first phase of the project Dr Luu Ngoc Trinh was responsible for overall coordination and linking with partners, IPGRI, communes and policy-makers. At the local level, commune leader, village leader, site staff and members of men and women associations are key members of the site team. The meetings were carried out at site level, district level and national levels. There were no formal mechanisms to share the project outputs between sites during the first phase.

In second phase of the project (2000-2003), the National Project Coordination Committee (NPCC) was created during the Hoa Binh planning meeting (Table 5). Figure 1 illustrates the overall management structure of the second phase. The NPCC is responsible for calling an annual review and planning meeting. In this meeting partners share the findings of the project activities from their institutes with each other and with IPGRI, who participates in these meetings. The NPC is responsible for synthesizing and consolidating the outputs of the project together with the representative from each of the involved institutes. NPC is also responsible for reporting technical findings to IPGRI and to Vietnamese policy-makers and will play a linking role, which is lacking at present, with various related projects in Vietnam, including:

- IRRI on-farm conservation of biodiversity in Central Vietnam funded by SDC
- Community Biodiversity Conservation (CBDC) project in the Mekong Delta funded by SIDA, IDRC and DGIS
- BUCAP Biodiversity, implemented through the MARD Plant Protection Department in Hoa Binh, Bac Kan, Hue, Hanoi, and Quang Nam provinces, funded by NORAD
- *In situ* conservation of landraces and their wild relatives in Northern Vietnam implemented through the Institute of Agricultural Genetics (IAG) funded by UNDP/GEF
- IUCN compilation of agrobiodiversity projects in Vietnam
- NIAR Genetic diversity of rice in Vietnam, funded by Japan (JICA)
- CROCEVIA agrobiodiversity project

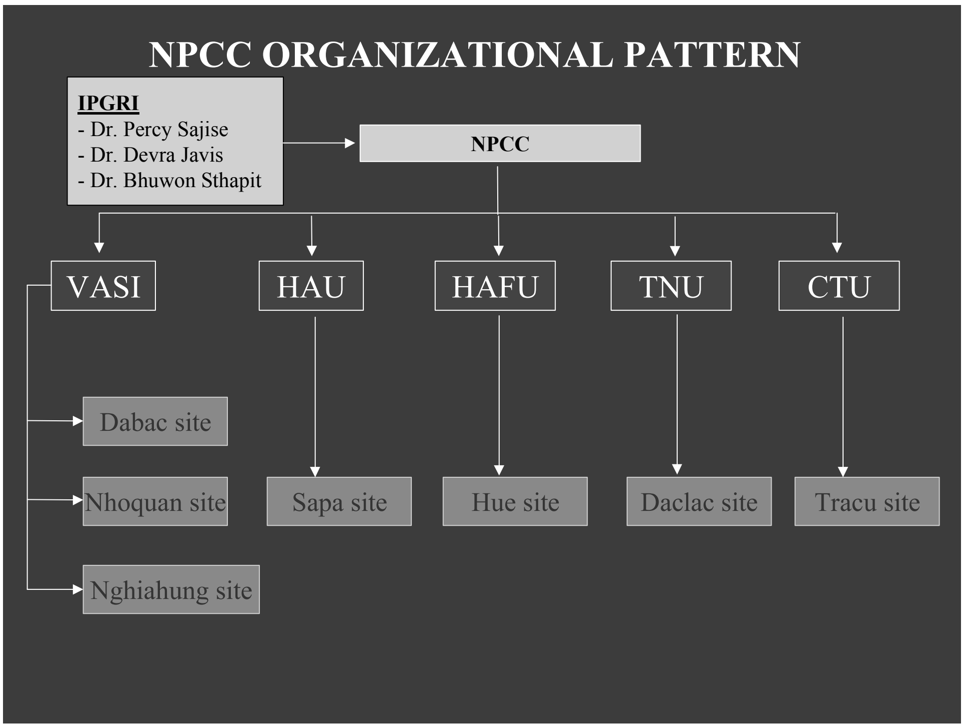

Figure 1. Institutional framework of National Project Coordination Committee in Vietnam for Phase II.

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Chapter 2. Assessment of genetic diversity for rice and taro

Genetic diversity within farmers' rice varieties in three ecoregions of North Vietnam over time

Luu Ngoc Trinh, Pham Hung Cuong, Nguyen Ngoc Hue, Nguyen Phung Ha and Dang Van Nien

Introduction

Rice diversity and associated food culture have been traditionally rich in Vietnam (Bui Huy Dap 1980). This has been possible because farmers know how to choose preferred seeds and maintain them under their conditions and thereby farmers continue to maintain the process of on-farm conservation of rice diversity (Brush 2000). Climatic, physiogeographic and edaphic divergence, as well as the prevalence of traditional farming systems pursued by diverse ethnic nationalities, have contributed to Vietnam's wealth of rice diversity. Genetic diversity studies using isozyme analysis of a large number of rice varieties from South East Asia showed a larger diversity for mountain areas of Laos, North Vietnam, North Thailand and the high plateaus of South Vietnam compared with that of Yunan Province of China (Trinh *et al.* 1995; Tuan *et al.* 1997). Trinh *et al.* (1995) classified about 643 traditional local rice varieties using isozyme patterns and reported five distinct groups: *indica* of South Vietnam, *indica* of North Vietnam, *japonica* (glutinous rainfed cultivars), mountain *indica*, linked to early varieties, to winter rice (*Chiem*), and to aromatic rice of North Vietnam. Trinh *et al.* (1999) reported that the most interesting germplasm was located in the lowland and deepwater ecosystems, which are a rich source for adaptive traits for acid sulphate and saline soil conditions. Fukuoka *et al.* (1999) also studied the genetic structure of aromatic rice landraces from Nam Dinh Province in the Red River Delta. Significant differences in the degree of dissimilarity within landraces or samples collected within a 30-km radius were found and such differences can be largely attributed to genetic drift or farmers' selection rather than natural selection because the agroclimatic conditions in the sampled locations were similar. However, there is little information available on diversity of use value of local rice cultivars and its impact on the extent and distribution of lowland and upland rice diversity on-farm. This study aimed to understand why Vietnamese farmers grow diverse types of rice cultivars with distinct farmer units of diversity, when and where they grow rice cultivars and how they maintain and use them. Information from such basic studies will assist the national plant genetic research programme to formulate options for rice on-farm as well as *ex situ* conservation strategies.

Materials and methods

PRA survey

Participatory Rural Appraisal tools were used to list the number of rice cultivars during the baseline surveys conducted by the *in situ* conservation project partners. The survey teams visited six villages in Nho Quan, Da Bac and Nghia Hung districts. Focus group discussions were held to document the list of rice cultivars and their use value. This information was used for a preliminary assessment of the amount of rice diversity, which was used to locate diversity-rich villages.

Baseline survey

In the first phase from 1999 to 2000, surveys of 39—140 households (45—95% of total households) were carried out in six villages of the three selected districts to list the farmer-named rice diversity and basic socioeconomic characteristics of rice farmers (Table 1).

In 2001 a community biodiversity register survey at village level sampled 30 farmer households (FHHs) per village for all sites.

Table 1. Sampling strategy for baseline survey conducted in 1999-2000

Site	Total HHs	Sampled HHs	% of total HHs
Cang Village – Da Bac	84	63	75.0
Tat Village – Da Bac	74	62	83.8
Yen Minh Village – Nho Quan	105	80	76.2
Quang Mao Village – Nho Quan	41	39	95.1
Kien Thanh Village – Nghia Hung	168	75	44.6
Dong Lac Village – Nghia Hung	300	140	46.7

Descriptive statistical analyses of all parameters were computed for each site and varietal diversity indices using Shannon Weaver Index and Simpson Index were calculated using the following formula, which also gives the H' values:

$$H' = -\Sigma pi\ (\log_2 pi) / \log_2 n$$

where *k* is the number of categories and *pi* is the proportion *i*=1 of the observations found in the category *i; pi* = frequency proportion of each category, and n= number of categories (Shannon and Weaver 1948).

The Simpson Index for quantifying rice diversity was calculated using the following formula:

$$H' = 1 - \Sigma(fi)^2$$

where *fi* is the frequency proportion of the farmer-named variety found in the category *i.*

Community Biodiversity Register (CBR)

CBR is a participatory approach to make an inventory of rice genetic resources and to enhance the knowledge base, empowering a farming community to manage the local biodiversity it maintains over generations.

Results and discussion

Farmer-identified variety descriptors for each conserved crop

In order to implement the project activities, the project teams carried out the agrobiodiversity register at farmer household level during May–June 2001. The new survey results are presented in Table 2.

The data from Table 1 show that farmers used local rice varieties as a sustainable resource base to assure appropriate farm management decisions. They use their descriptors, which involve morphological, environmental and use factors, for distinguishing rice varieties in their communities.

Table 2. Farmers' descriptors of rice crop

Morphological	Environmental/ Ecological	Use
Seed size	Land type	Rice
Growth duration	Moisture regime	Gleam
Plant height	Adaptability	Sweetened porridge
Lemma and palea colour		Noodle
Grain awning		Rice rolling paper
Quality		Different kinds of cakes
Resistance to disease		Medicine
		Fuel

Amount of rice genetic diversity on-farm in 2000-2001

Total number of rice varieties at HH and village levels

In Vietnam, farmers use local names to differentiate rice cultivars for their day-to-day management ease. Farmer-named cultivars used by farming communities are the first indicator of the amount of diversity at a given location. Over time, various methods were used to document the list of rice cultivars in all studied sites and some differences were found in the amount of diversity, depending on the methods used and time of information collection (Table 3).

At Tat Village, farmers could provide the names of 27 farmer-named varieties of rice including both landraces and modern varieties currently being grown by them. Among 27 varieties, 22 were categorized as landraces and the rest were modern varieties (MVs). The farmers described their varieties in different ways, but characters they used were distinct from each other.

At Cang Village, farmers could provide the names of 25 farmer-named varieties of rice including both landraces and modern varieties currently being grown by them. Among 25 varieties, 17 were categorized as landraces and the rest were MVs.

At Nho Quan ecosites: Yen Minh Village, 11 farmer-named rice varieties include 5 landraces. In Quang Mao Village, farmers could provide 14 farmer-named rice varieties. Although 14 rice varieties were described in 2001, only 12 varieties were cultivated in that year. The local glutinous variety *Nep cai hoa vang* was not grown.

In Nghia Hung District in the Red River Delta, out of 10 farmer-named varieties, only 4 were rice landraces.

The results indicate that the farmers could identify the landraces by their ways (farmer's descriptors) with different names. They gave discrete names to different landraces for local-level management decisions.

In 2001, in each village 30 FHHs were interviewed for the CBR survey. Total number of rice varieties at village level are presented in Table 4.

The data in Table 4 show that the farmers in all study sites still grow many local varieties of rice, especially in the mountainous sites. Under marginal environments the landraces become more competitive than the MVs. The landraces are specific to certain agroecological niches. They have been tailored to be grown by farmers in different domains over time with continuous selection for adaptive traits. There were no modern varieties in marginal agroecological conditions and farmers had limited choice of landraces within their community. An understanding of the factors behind why these farmers have continued to maintain local varieties provides insights into formulating activities that can help increase the competitiveness of other local crop varieties in the farmer communities where they are under threat of genetic erosion.

Number of HHs and areas of the cultivated local target crops

The number of HHs and areas cultivated under each rice landrace is different (Tables 5–10). Several varieties may be cultivated by a single household, but a single variety may be cultivated by several households.

Table 3. Varietal diversity and area coverage of different rice varieties in different ecosites of Vietnam in 2000

Geographic region	Macrosite name	Village	No. of cultivars	Total rice area (m^2)	Total no. rice growers at village
Mountain	Da Bac	Cang	25	77 895	136
		Tat	27	105 050	113
Midland	Nho Quan	Yen Minh	11	169 668	73
		Quang Mao	14	138 060	120
Lowland	Nghia Hung	Dong Lac	10	164 852	84
		Kien Thanh	18	168 246	102

Table 4. Landrace and improved rice varieties at village level in 2001 at the study sites

Study site	Total	No. of varieties	%
Tat Village	22	17	77.3
Cang Village	25	15	60.0
Yen Minh Village	10	4	40.0
Quang Mao Village	11	4	36.4
Dong Lac Village	12	3	25.0
Kien Thanh Village	12	3	25.0
Total	92	46	

Table 5. CBR data of survey on rice in Tat Village, Tan Minh Commune, Da Bac District as a mountainous ecosite (total of surveyed HHs = 30)

Variety name	No. of cultivating HHs		Area covered by each variety (m^2)	
	2000	2001	2000	2001
Q5†	16	2	17481	2200
Khang dan†	27	25	51019	36915
CR203†	4	1	5510	2360
San hoa†	3	1	4700	1000
Tap giao 1†	1	29	1200	32475
C70†	1	3	800	2300
Khau pha ho	1	0	1100	0
Tham qu	0	1	0	1000
Khau lao	6	11	3800	7300
Khau cham luong	5	5	3300	2650
Khau lon	1	1	250	150
Khau ca de cham	7	5	2650	2000
Khau khinh	17	9	9100	3900
Khau ca lan	5	3	3200	1400
Khau cham hom	6	2	2400	700
Khau cao su	4	1	820	200
Khau tang san nieu	2	6	2000	4100
Khau cam pi	2	1	1000	400
Khau cham nanh	2	2	700	1400
Khau cham khao	1	1	600	400
Khau ca de nieu	5	2	3300	1100
Khau cham pom	2	1	1500	600
Khau cham sai	0	1	0	500
Khau ca lan khao	1	0	500	0
Khau ca lan danh	1	0	500	0
Khau cong ton	2	0	100	0
Khau hang doan	2	0	350	0
Total			119880	107051

† Modern variety.

Some rice landraces such as *Khau Lao, Khau Khinh, Khau Cham Luong* and *Tang San Lieu* are grown in large areas and by many households in Tat Village. In Cang Village the varieties *Khau Do, Khau Hop, Khau Mac Mau* and *Khau Mon* were grown by many households in a large area.

In Nho Quan District, the local rice varieties were grown in small areas by few farmers. There, the rice genetic erosion occurs rapidly.

In Nghia Hung, the modern varieties have been grown at an increasing rate but in summer season the *Tam Xoan* variety is still grown by many farmers with large areas.

Table 6. CBR data of survey on rice in Cang Village, Doan Ket Commune, Da Bac District, Hoa Binh Province as a mountainous ecosite (total of surveyed HHs = 30)

Variety name	No. of cultivating HHs		Area covered by each variety (m^2)	
	2000	2001	2000	2001
Ai mai huong†	24	22	13060	11645
Bao thai trang	1	2	120	620
C70†		1	400	600
CR203†	1	2	1395	1790
Khang dan†	5	10	3715	8750
Khau do	11	9	4810	3700
Khau buom	1	1	200	200
Khau hop	10	10	8950	8550
Khau hang	1	1	210	210
Khauhang do	2	2	300	400
Khauhang mu	4	4	2085	3485
Khau khinh	4	5	2400	4200
Khau Lao	4	3	3800	2800
Khau lech luong	2	2	650	850
Khau mac cai	1		130	0
Khau mac mau	27	26	14925	5920
Khau mon	20	20	22865	14265
Khau toi	2	2	3500	3500
Khau tram khao	3	4	1700	2900
Nep Hai Phong	1	2	700	910
Nep luong	1		600	0
Tap giao 1†	1	1	500	300
Tap giao 4†	1	2	1000	1700
Tap giao 5†	3	3	370	300
Tram con dau	2	2	310	300
Total			90695	79896

† Modern variety.

Table 7. CBR data of survey on rice in Yen Minh Village, Yen Quang Commune, Nho Quan District as a midland ecosite (total of surveyed HHs = 30)

Variety name	No. of cultivating HHs		Area covered by each variety (m^2)	
	2000	2001	2000	2001
Ai hoa thanh†	29	28	96012	114408
Khang dan†	20	20	28548	41544
Tap giao 1†	1	1	0	360
Tap giao 4†	1	2	1800	3420
B4†	0	1	0	360
Q5†	0	1	0	360
Nep dum	1	–	540	0
Nep ga gay	1	1	360	468
Nep ha noi	4	7	1908	2988
Nep se	4	11	7632	5580
Nep thai binh	1	1	252	180
Total			139052	171669

† Modern variety.

Table 8. CBR data of survey on rice in Quang Mao Village, Nho Quan District as a midland ecosite (total of surveyed HHs = 30)

Variety name	No. of cultivating HHs		Area covered by each variety (m^2)	
	2000	2001	2000	2001
Khang dan †	20	21	29916	28404
Lai 2 dong †	10	10	10980	10800
Nep cau	3	0	1080	0
Nep dien bien	3	6	1800	1872
Nep may co truyen	1	1	360	360
Nep hoa vang	1	0	360	0
NN1 †	2	0	1800	0
Nep nang huong	1	1	360	360
Nep thai binh	3	6	900	1980
Q5 †	8	6	8460	3852
Tam bac †	3	4	1512	2160
Tap giao 1†	25	27	33948	35820
Tap giao 4†	30	30	45072	49824
Total			138548	137433

† Modern variety.

Table 9. CBR data of survey on rice in Dong Lac Village, Nghia Hung District as a lowland ecosite in the Red River Delta (total of surveyed HHs = 30)

Variety names	No. of cultivating HHs		Area covered by each variety (m^2)	
	2000	2001	2000	2001
Tap giao 1†	30	29	80336	64908
Luong quang†	4	4	5004	4104
X21†		1	0	2160
Bac thom†	2	6	540	7128
Nep 352†	4	5	2736	3456
Tam xoan	30	29	79776	72296
Tam thom	2		2520	0
Nep cai HV	4	4	3780	3780
Nep TB	6	4	6480	3960
Khang dan†	1		1260	0
Total			184432	163793

† Modern variety.

Table 10. CBR data of survey on rice in Kien Thanh Village, Nghiahung District as a lowland ecosite in the Red River Delta (total of surveyed HHs = 30)

Variety name	No. of cultivating HHs		Area covered by each variety (m^2)	
	2000	2001	2000	2001
Nep ba lao		1	0	1080
Nep cai HV	4	8	2340	4320
Nep TB	8	3	3420	1980
Bac thom†	8	22	10836	22104
IR352†	1		252	0
Khang dan†	11	9	8496	5760
Luong qung†	17	17	18432	18840
Q5†	6	5	5580	3240
Quy thai†	2	5	1980	4644
Tam xoan	13	11	16740	11268
Tap giao†	30	49	38646	87990
X21†	2	5	2844	7020
Total			111566	170247

† Modern variety.

From the results of our study, we can classify the local varieties into two groups: the common and the rare.

The common cultivars have high demand for livelihood (in mountainous areas) and high demand in market for quality traits (*Tam Xoan* in Nghia Hung). The rare cultivars are grown by few households in small plots for their specific use value. Generally, there are few locally common rice cultivars (1-4 types across a village).

In all three ecosites, the modern rice varieties of *Khang Dan, Q5* and *Tap Giao* have been and continue to be grown at an increasing rate. For these cultivars, there was clear market preference thanks to higher grain fertility and ready market acceptance. This indicates that the dynamics of area under different cultivars were governed mainly by the economic competence of cultivars within the studied communities. For the landraces the picture is not clear. The cultivated area is not stable. The change of cultivated area under a variety might be influenced by government policies, farmers' socioeconomic status, land holding, soil types, culture, religion and farmer decision related to landrace conservation. It is necessary to consider the collected data in detail.

Thus, the distribution of rice diversity in the mountainous sites is influenced by local adaptive traits of upland rice and their specific use value. The extent and distribution of upland rice diversity can be related to multiple use values and preferences for local consumption. For the lowland ecosites, the extent and distribution of specific rice (aromatic and glutinous rice) can be related to high demand in market for grain quality.

Genotypic diversity index

Diversity indices across the sites were computed for Shannon Weaver Index and Simpson Index to compare varietal richness of rice, the number of cultivars at village level, evenness, and the frequency of farmers growing each cultivar at village level (Table 11). A comparison of the SWI between 2000 and 2001 shows that in 2000 Tat Village of Da Bac site was richest in rice cultivar diversity followed by Kien Thanh Village of Nghia Hung site, and the third was Cang Village of Da Bac site. In 2001, the richest in rice varieties was also the Da Bac site. The ranking of richness is as follows: the first is Cang Village, followed by Tat and Kien Thanh Villages, and the third is Quang Mao Village. Comparing the calculated SI index between 2000 and 2001, the evenness of genotypic diversity was as follows: the two first villages were Tat and Kien Thanh, the second was Cang Village and the third was Quang Mao. The evenness ranked in the following order: Kien Thanh, Cang, Tat and Yen Minh Village.

In all study sites, the farmers still grow many rice landraces but not all HHs are equally involved in cultivation and maintenance of landrace diversity within a village. In Tat, Cang, Yen Minh, Quang Mao, Kien Thanh and Dong Lac Villages, the number of local rice varieties grown in 2001 were 17, 15, 4, 4, 3 and 3, respectively. The choice of rice cultivars by farmers and their extent and distribution were often guided by multiple uses of rice cultivars and farmers' ecological circumstances.

Rice structure of landraces and modern varieties has been changed, especially with lowland rice. Comparing with the year 2000, the level of modern varieties in rice production in three sites increased significantly in the studied areas.

Table 11. Richness and evenness of rice varieties in different ecosites

			2000				2001			
Geographic	Macrosite				Rank†				Rank†	
Region	Name	Village	SWI	SI	R	E	SWI	SI	R	E
Mountain	Da Bac	Cang	0.52	0.88	3	2	0.53	0.89	1	2
		Tat	0.56	0.90	1	1	0.51	0.86	2	3
Midland	Nho Quan	Yenminh	0.34	0.67	6	5	0.37	0.74	5	6
		Quang Mao	0.44	0.85	4	3	0.42	0.84	3	4
Lowland	Nghia Hung	Dong Lac	0.36	0.73	5	4	0.38	0.75	4	5
		Kien Thanh	0.54	0.90	2	1	0.51	0.90	2	1

† R=richness; E=evenness.

The public awareness of the use values of rice diversity can be a strategy for *in situ* conservation beside the deployment of new diversity across sites.

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Agromorphological variation of *Mon Sap* taro populations in the Mekong Delta, Vietnam: role of *on-farm* conservation

Vo Minh Hai, Huynh Quang Tin and Nguyen Ngoc De

Introduction

Dai An Village is located in an area affected by saline water, and therefore agricultural production is dependent on the rain. The soils in the village are of three main types: sandy ridged soils, saline-alluvial soils and saline-acid sulphate soils.

Rain usually starts in May and stops in November. Rainfall distribution is highest in September-October (300-400 mm/month), and the maximum depth of water is about 40-60 cm in the rice field. In the dry season, saline water can penetrate into the rivers from December to July and salinity is highest in March (15-20‰). Salinity is the main problem for crop growth during the dry season. Almost all farmers have to dig wells to provide fresh water for irrigating vegetables, beans and root crops, of which the *Mon Sap* variety of taro has been a well-adapted and common crop for a long time in this village.

The differences among populations in morphological traits of *Mon Sap* taro are recognized by farmers who have seasonally cultivated this variety in different soil areas and with different management techniques. This diversity means the *Mon Sap* variety is conserved in a dynamic condition. A study was conducted in 1998-2000 to evaluate the genetic diversity among different populations of this local taro variety.

Materials and methods

Site selection for survey

Based on distribution of cultivated land areas of *Mon Sap* variety in the whole village, 64 farms were selected to observe and describe. Most of these areas were in the hamlets of Giong Lon A, Cay Da, Giong Dinh and Me Rach B.

Each selected farm was at least 500 m^2 in size. This was to ensure the variation within population, increase the number of random samples and limit the errors in describable data.

Criteria of data collecting

Correct type plant: for each individual, 19 characteristics were measured and described (see descriptor list, Annexe 1).

Off-type plant: symbolic different traits among individuals within their population were recorded and described.

Natural conditions and cultivation practices

Soil

As mentioned above, there are three main soil groups in the Dai An Village, but more than 57% of *Mon Sap* variety is cultivated in the sandy ridge soil area and the rest (43%) in the sandy-silt soil.

Irrigation

Agricultural production in this area is dependent on rainfed conditions. However, underground water from a well is also used partly to irrigate for taro in the dry season. In the rainy season, rainwater can support the taro crop from June to October.

Cropping seasons and seed sources

Two crops can be grown per year: the first is from February to June and the second from July to October.

Seed sources: planting materials are usually bought from surrounding villages or districts (86%); only 14% of households save the planting materials for themselves.

Data analysis

Microsoft Excel was used for compiling data and analyzing means. The statistics (version 6.0) and Minitab (version 3.0) were used for analysis of variance (ANOVA), principal component analysis (PCA) and genetic linkage distance (Cluster variation).

Results

Variation in morphological traits among *Mon Sap* populations

Table 1 shows that some morphological characteristics are not significantly different among *Mon Sap* populations. They are rather stable in their cultivation conditions in two kinds of soil and different cropping seasons. This means that *Mon Sap* variety has high genetic stability.

It can be seen from Table 2 that two of nine characteristics are significantly different among the studied populations, namely the leaf margin colour and petiole colour (top two-thirds and basal one-third).

In particular, the colour of the basal one-third is very different among populations. There are four colours of which light green accounts for the highest ratio (67.2%), and red pink the lowest (1.6%). The variation may be affected by moisture conditions, soil pH and salinity. In the higher lands irrigated by well water in the early rain season when there is a lack of rain, the earlier crop develops better than the later crop and taro planted in the low and wet lands. The reasons may be the low pH of soil or saline water that may also result in the different sheath colours.

Some other characteristics such as leaf margin colour, petiole colour (top two-thirds), ratio of petiole top length to total sheath length, and sheath edge colour are different among populations. These differences may be affected by cropping seasons, kind of soil, acidity and salinity infection.

Soil property may play an important role in the formation of the shape, size and skin colour of corm because tubers develop underground. Thus, morphological traits are different among populations owing to soil type and other environmental factors, especially corm shapes, corm sizes and corm skin colours.

In taro, corm flesh colour is an important criterion of quality. It depends on cultural practices such as cropping season, fertilizer application, irrigation, harvesting time and environmental factors as the rain regime, infection of pests and diseases, and so on.

Table 1. Similar morphological traits among *Mon Sap* populations in Dai An Village

Characteristic	Rate of manifested characteristics (%)				
	1	2	3	4	5
Petiole attachment	1				
Leaf blade orientation		1			
Leaf margin		1			
Leaf shape				1	
Leaf waxiness (both sides)		1			
Glaucous on upper leaf surface	1				
Glaucous on lower leaf surface	1				
Emergence of leaf vein (both sides)		1			
Smoothness of corm skin surface	1				
Colour of embryo		1			
Position of corm (in relation to soil surface)		1			

Table 2. Variation in morphological traits among *Mon Sap* populations

Characteristic	**Rate of manifested characteristics (%)**				
	1	**2**	**3**	**4**	**5**
Leaf margin colour		0.89	0.11		
Petiole colour (top two-thirds)		0.063	0.734	0.203	
Petiole colour (basal one-third)	0.672	0.281	0.016	0.031	
Ratio of petiole length/ total sheath length		0.89	0.11		
Sheath edge colour		0.641		0.359	
Corm shape			0.188	0.813	
Corm size	0.578	0.422			
Corm skin colour	0.859	0.141			
Corm flesh colour				0.703	0.297

The data in Table 3 show that some morphological traits such as leaf margin colour, ratio of petiole length/total sheath length, sheath edge colour, corm size, corm skin colour, and corm flesh colour are not significantly different among observational populations. But petiole colours (top two-thirds and basal one-third), and corm shapes are different among populations at the 5% and 1% levels of significance.

Figure 1 indicates that the distance of genetic linkage among populations is divided into two linkage groups. The distance varies from 6 to 9.5. The difference of genetic linkage distance is due to a simple or complicated linkage level of morphological traits among populations. It can be seen that the genetic linkage distance is small among populations.

Kinds of off-type plants in *Mon Sap* population

Table 4 indicates five different types within 64 observed populations, of which the C type (light green thin leaf blade, green and white high leaf petiole) appears to have the highest ratio (10%) and the other four types have a lower ratio (5% each).

In the tropical weather conditions in Vietnam, taro is mainly cultivated by tubers, so that cross-pollination among plant individuals is very rare. Cormels for cultivating are bought mainly from the local market. Therefore, the emergence of off-type plants in taro populations may come from the mixed planting materials, as well as the variation in environmental conditions.

Conclusions

The *Mon Sap* populations cultivated in Dai An Village are genetically stable. Only three morphological traits—petiole colours (top two-thirds and basal one-third) and corm shapes—are significantly different.

Table 3. P-value in analysis for each morphological trait of *Mon Sap* populations

Morphological trait	**F–test**	**P-value**
Leaf margin colour	2.98^{ns}	0.058
Petiole colour (top two-thirds)	14.40^{**}	0.000
Petiole colour (basal third)	0.86^{*}	0.468
Ratio of petiole length/ total sheath length	1.14^{ns}	0.291
Sheath edge colour	0.01^{ns}	0.928
Corm shape	6.90^{**}	0.011
Corm size	2.13^{ns}	0.149
Corm skin colour	1.57^{ns}	0.216
Corm flesh colour	1.75^{ns}	0.191

Note: ns: not significant; * significant difference at 5%; ** significant difference at 1%.

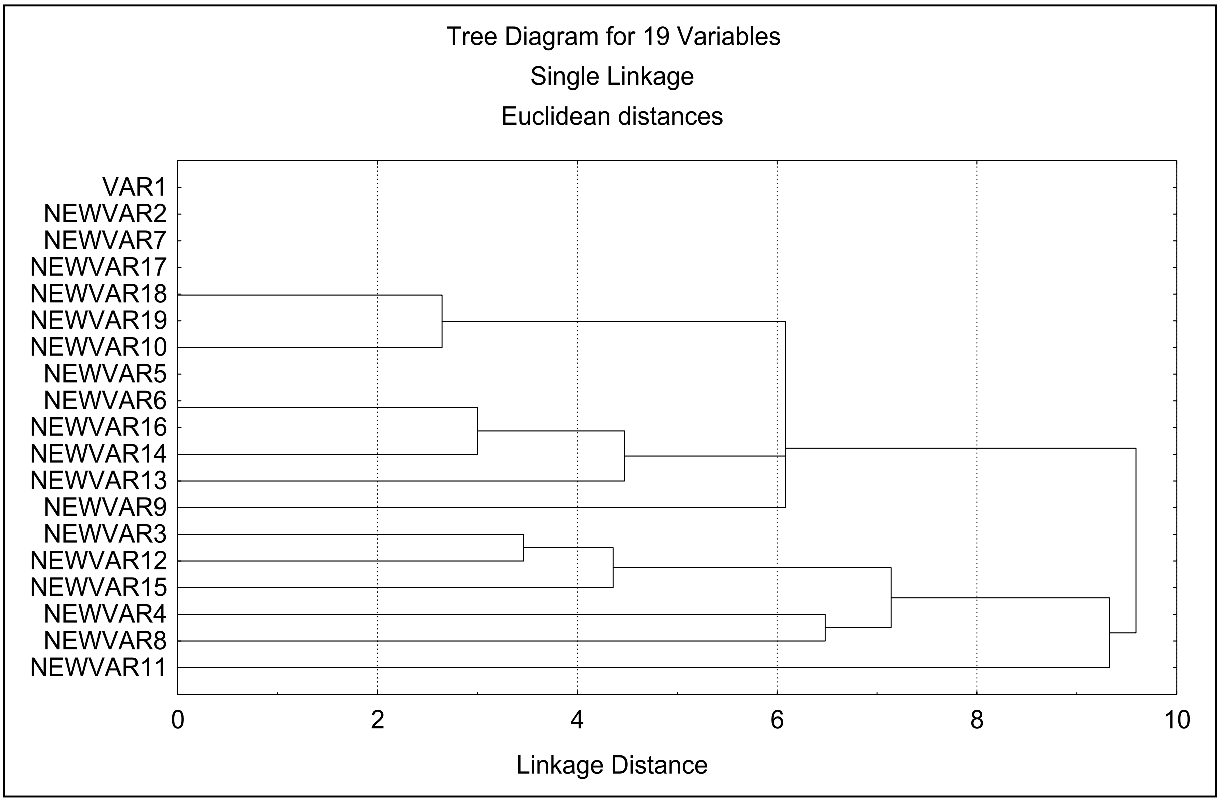

Figure 1. Analysis of the genetic linkage of morphological traits among *Mon Sap* populations in Dai An Village, Tra Cu District, Tra Vinh Province.
Notes: 1 Leaf blade orientation, 2 Leaf blade margin, 3 Leaf shape, 4 Leaf margin colour, 5 Glaucous on upper leaf blade, 6 Glaucous on lower leaf blade, 7 Emergence of leaf vein, 8 Petiole colour (top two-thirds), 9 Petiole colour (basal third), 10 Ratio of petiole length/ total sheath length, 11 Sheath edge colour, 12 Corm shape, 13 Corm size, 14 Corm skin colour, 15 Corm flesh colour, 16 Smoothness of corm cortex surface, 17 Embryo tip colour, 18 Corm position in comparison to the ground surface, 19 Corm flesh quality.

Table 4. Ratio (%) of off-type plants in *Mon Sap* populations

Code	Morphological characteristics of off-type plants	Rate of manifestation (%)
A	Longer petiole edge, low canopy and dark green leaf blade	5
B	Dark green leaf, horizontal leaf blade and dark purple petiole	5
C	Light green thin leaf blade, green and white high petiole	10
D	Low canopy, dark green petiole, leaf has some white variegations	5
E	Round leaf blade, dark green petiole and dark green leaf blade	5

Annexe 1. Descriptor list for morphological traits of *Mon Sap* variety (64 populations) in the Dai An Village, 1999

GENERAL INFORMATION

I. Farmer name: . . . . II. Address: . . . .

III. Variety name: . . . . IV. Seed source: . . . .

V. Description of soil conditions: Soil type: . . . .
Acid sulphate soil: (1) (3) (5) (7) (9)
Salinity: (1) (3) (5) (7) (9)
VI. Water condition: (1) Depth (>1 m) (2) Floating (<1 m) (3) Drought (4) Upland
VII. Cropping calendar: . . . .

DESCRIPTION OF POPULATION

Vegetative characteristics

1. Lamina orientation (see Figure 3)
   (1) In one plane-apex pointing upward (erect)
   (2) In one plane-apex pointing downward (droopy)
   (3) 3-dimensional (cup-shaped)
2. Leaf margin (see Figure 4)
   (1) Entire, smooth (2) Entire, undulate
   (3) Lobed, partly divided (4) Divided to or almost to base
3. Leaf shape (see Figure 5)
   (1) No basal lobes (2) Hastate (basal lobes flared)
   (3) Sagittate, basal lobes less than 1/8 length of leaf
   (4) Sagittate, basal lobes less than 1/8–1/4 length of leaf
   (5) Sagittate, basal lobes more than 1/4 length of leaf
4. Leaf margin colour
   (1) Non-colour (green) to the edge (2) Clear edge
   (3) Purple/red edge (4) Pale yellow/creamy
5. Leaf surface glaucous
   5a:1 Upper surface ( ) Yes ( ) No
   5b:2 Lower surface ( ) Yes ( ) No
6. Midrib and primary lateral veins in cross-section
   (1) Raised on upper leaf surface, but not lower surface
   (2) Raised on lower leaf surface, but not upper surface
   (3) Raised on both upper and lower leaf surfaces
   (4) Impressed into upper leaf surface

7. Petiole colour (upper 2/3rd)
   (1) Light green (2) Green (3) Red/purple
   (4) Green streaked with red/purple
8. Petiole colour (lower 1/3rd)
   (1) Light green (2) Green (3) Red/purple
   (4) Green streaked with red/purple
9. Petiole sheath length
   (1) Sheath less than 1/3rd the total length of petiole
   (2) Sheath 1/3rd - 2/3rd the length of petiole
   (3) Sheath more than 2/3rd the length of petiole
10. Colour of edge of petiole sheath
   (1) Same as rest of petiole sheath
   (2) Lighter than rest of petiole and sheath
   (3) Darker than rest of petiole and sheath
   (4) Pink/red/purple

Corm

11. Shape of corms
   (1) Globose (2) Ovate (3) Cylindrical (4) Elliptical
   (5) Mixed (state which of the above)
12. Corm size (at maturity) (1) Small (2) Medium
   (3) Large (length and width average of 5 corms)
13. Exterior colour of corms (1) Light or medium brown (2) Dark brown
14. Interior colour of corms
   (1) White (2) Yellow (3) Orange (4) Pink (or pale red) (6) Purple
15. Exterior surface of corms (1) Smooth (2) Fibrous/rough
16. Colour of corm apex (1) White (2) Pink/red
17. Position of corm (1) Aboveground (2) Underground

Quality

18. Eating quality (1) Aromatic (2) Sticky (3) Starchy

Preliminary study of genetic diversity in rice landraces in Ban Khoang Commune, Sa Pa District

Nguyen Tat Canh, Tran Van On, Nguyen Van Trung, Chu Anh Tiep and Hoang Van Lam

Introduction

Paddy rice (*Oryza sativa* L.) is one of the most important food crops in the world, supplying food for over 40% of its population. Asia is the main place of rice cultivation. Total annual production of rice is over 573 million tons.

Rice is the staple food crop in Vietnam. In many zones, farmers choose many local rice varieties with high quality, high resistance to the local biotic and abiotic stresses, as well as suitability to local social, economic and cultural conditions.

With the population increase, there appeared a need for modern varieties of rice having uniform population, high fertilizer response and yield capacity. The introduction of these varieties has been replacing local rice varieties in farmers' fields. This has resulted in a reduction of the genetic diversity of rice and other species and an increase in the risk of disease and pest damage.

Supported by IPGRI and VASI, we selected a research site for the project "Strengthening the scientific basis of *in situ* conservation of agrobiodiversity on-farm" in Ban Khoang Commune of Sa Pa District, Lao Cai Province. This report deals with the results of the preliminary study of genetic diversity in rice landraces at the research site.

Research methods

The study area

Ban Khoang is a highland commune in the northwest mountain region of Vietnam. Its total natural area is 5663 ha, of which the agricultural land area occupies 3.87%, forested area 25.83% and uncultivated land area 69.17% (Table 1).

There are four types of lands in Ban Khoang Commune: humus, yellow humus, feralitic and clay. The soil texture varies from sandy loam at Can Ho A hamlet to loam and clay loam at Kim Ngan and Suoi Thau hamlets (Table 2). Clay soil is more fertile than other soils. Lands with various aspects were found in the studied hamlets, where a wide range of rice and taro species adapted to the local conditions can be found. Ban Khoang Commune can be divided into three ecozones with different terrain, slope, altitude and rainfall. For example, the lowland area (Xin Chai hamlet) has an altitude of 500 masl, the middle area is at 700–1000 masl and the highland area (Can Ho hamlet) is at altitudes higher than 1200 masl.

Table 1. Structure of land use in 2000

Land type	Area (ha)	Average land area (m^2)		Average land area per one agricultural labour	Average land area per HH (m^2)
		Per capita	per agricultural capita		
Total area	5663.0	30154.42	31030.14	71956.80	227429.72
Agricultural land	219.2	1167.20	1201.10	2785.26	8803.21
Annual crop land	211.7	1127.26	1160.00	2689.96	8502.01
Rice land	118.3	629.82	648.11	1502.92	4750.20
Other annual crop land	5.0	26.62	27.40	63.53	200.80
Forest land	1463.0	7790.20	8016.44	18589.58	58755.02
Natural forest land	1338.8	7128.86	7335.89	17011.44	53767.07
Reforestation land	124.2	661.34	680.55	1578.14	4987.95
Special land	53.3	283.81	292.05	677.26	2140.56
Residential land	9.9	52.72	54.25	125.79	397.59

Source: Cadastral Department of Sa Pa District, 2000.

Table 2. Chemical characters of soil at hamlets in Ban Khoang commune

Village	Soil texture	pH_{KCl}	Organic matter (%)	N (%)	P_2O_5 (%)	K_2O (%)
Can Ho A	Sandy loam	5.2	2.6	0.15	0.12	1.20
Can Ho B	Sandy loam	5.1	2.5	0.16	0.13	1.16
Lu Khau	Loamy sand	4.7	3.0	0.13	0.13	1.14
Can Ho Mong	Sandy loam	4.6	2.9	0.17	0.14	1.26
Phin Ho	Loamy sand	4.4	2.5	0.14	0.16	1.14
Suoi Thau 2	Loam	4.3	1.9	0.11	0.15	1.35
Suoi Thau 3	Loam	4.2	1.9	0.10	0.16	1.38
Suoi Thau 1	Loam	4.2	1.6	0.09	0.15	1.36
Gia Khau	Loam	4.0	1.4	0.10	0.15	1.43
Sa Chai	Loam	4.0	1.6	0.11	0.14	1.45
Kim Ngan	Loam	4.2	1.5	0.10	0.16	1.38

Source: Cadastral Department of Sa Pa District, 2000.

The average annual temperature is 15–16°C. There are five months with temperature lower than 15°C. The total temperature accumulation is about 7500 to 7800°C a year. The annual total rainfall is 2861–3484 mm. The climate in Ban Khoang can be divided into two seasons. In rainy season, the monthly rainfall varies from 50 to 200 mm in the months from October to March (Table 3).

There are nine hamlets in Ban Khoang Commune, from Can Ho to Kim Ngan hamlets. In the commune, there are two ethnic minority groups (H'Mong and Dao). The population of H'Mong group is 190 persons (10%), and that of the Dao group is 1704 persons (90%) (Table 4).

Research methods

- PRA methods were used for survey and evaluation.
- Key informant interviews and focus group discussions were conducted to understand farmers' rice-production systems. This exercise helped to design a questionnaire for a formal household survey.
- Direct field observation of the farmers' rice-growing fields/plots, household rice-farming systems and farmers' local management practices.
- A farm household survey was conducted using structured questionnaires for a limited stratified sample of HHs (n=40) representing different agroecologies, farm size and ethnic groups to elicit farmers' priority ranking of values, evaluation criteria, constraints and opportunities of landrace production.

Results and discussion

Rice is the principal crop, providing food for more than 95% of farming households in Vietnam. In mountainous areas, the rice production potential is lower and the access to input and information are worse than in other rice-growing environments. However, rice production is common for the Dao and H'Mong groups. The site has a dominant rainfed ecosystem, but farmers plant only one crop per year, regardless of the possibility to grow two crops a year. Rice is seeded on seedbeds from 15 April to 15 May, then transplanted in May or June and harvested in late October or early November.

Identification of local names of rice varieties among Dao and H'Mong groups

The study site has a subsistence-oriented traditional rice-farming system. Farmers grow diverse rice cultivars to meet their multiple household needs. We collected many names of local rice varieties used by the Dao and H'Mong people. Then, we organized meetings with some old people and discussed the names of rice varieties with rice samples collected from farmers' houses or fields. The results showed that there were 20 local rice varieties and 1 modern rice variety in Ban Khoang Commune (Table 5).

Table 3. Climate conditions[†] in Sapa

Item	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Solar radiation	$kcal/cm^2$	5.0	5.6	8.5	11.7	10.4	11.6	5.4	8.1	5.4	4.9	3.4	6.0	86.0
Sunlight	hour	116.4	112.2	156.4	168.9	150.5	91.8	110.0	114.3	98.7	95.9	104.6	126.5	1445.3
Average speed of wind	m/s	2.0	2.3	2.3	2.2	2.1	2.0	2.0	1.4	1.0	0.9	1.1	1.8	1.8
Air temperature	°C	8.5	9.9	13.9	17.0	18.3	19.6	19.8	19.5	18.1	15.6	12.4	9.5	15.2
Maximum temperature	°C	22.5	29.2	27.3	29.8	28.5	29.4	26.3	29.6	27.2	27.2	26.7	24.0	29.8
Minimum temperature	°C	–2.0	–1.3	0.0	3.0	8.2	11.0	7.0	10.4	8.8	5.6	1.0	–3.2	–3.2
Average max. temperature	°C	12.1	13.8	18.3	21.2	22.5	22.9	23.1	23.0	21.5	18.9	15.8	13.2	18.8
Average min. temperature	°C	5.9	7.4	10.7	13.7	16.3	17.4	17.6	17.3	15.8	13.4	9.9	6.8	12.7
Average rainfall	mm	55.8	79.2	105.5	197.2	353.2	392.9	453.0	478.1	332.7	208.7	121.6	55.1	2833.0
Wet days	day	12.9	13.0	13.8	16.1	20.8	22.4	23.7	22.8	19.0	16.0	13.8	11.4	205.7
Absolute humidity	%	9.3	10.1	12.7	15.7	18.3	19.9	20.3	20.0	18.5	16.1	13.1	10.3	15.4
Relative humidity	%	88	85	82	83	84	87	88	89	90	89	90	87	87
Absolute minimum RH	%	7	13	5	16	26	28	48	30	26	18	17	11	5
Average minimum RH	%	72	72	54	52	57	72	73	74	75	76	76	71	71
Evaporation (Piche)	mm	60.3	78.8	117.6	105.5	94.2	71.1	70.8	56.4	42.1	37.1	36.8	55.5	826.2
Foggy days	day	20.1	18.6	17.4	14.0	7.7	5.0	2.6	3.1	4.1	10.2	13.9	15.5	132.2
Hoar-frost days	day	2.0	0.2	0.04	0	0	0	0	0	0	0.03	0.8	2.3	5.4
Drizzle days	day	14.1	13.6	10.6	6.6	1.9	1.0	0.5	0.3	2.3	5.4	8.1	10.5	74.9
Hail days	day	0.1	0.6	0.9	1.5	0.1	0	0	0	0.1	0	0.03	0.2	3.5

[†] Average data, 1990–1999 (Sa Pa weather station 2000).

Table 4. Structure of population in Ban Khoang Commune

Item	Unit	Dao group	H'Mong group	Total
Total number of HHs	Household	223 (86.43%)	35 (13.57%)	258
Population	Person	1704 (89.96%)	190 (10.04%)	1894
Average family size	Person/HHs	7.6	5.4	7.3

Table 5. Names of local rice varieties in Ban Khoang Commune

Dao name	Other name (Dao)	H'Mong name	Kinh name
Beo ong cu			
Beo brôt bua		Ble blan mong	
Beo brôt shi			
Beo brut chun		Ble blan cay	Nep tron
Beo brut giang	Beo y ty shi		
Beo brut pe			Nep trang
Beo chap		Ble blan cho	
Beo cu oang		Ble blan la	
Beo cu quay			
Beo con shi		Ble la cang	Te do
Beo hlau pen pang	Beo hlau peng peng		
Beo ngach ton		Me ble tou	
Beo po ay	Beo pa i (e)		
Beo song		Ble do	Te trang
Beo ta leng			
Beo tong long		Ble bla	
Tam beo mau	Beo mau ton		
Tam beo ngach		Ble tau dau	
Tam beo bua			
Beo ai			
Tam muu			Shan uu

Adaptation potential to poor soil conditions of local rice varieties

Almost all farm households grow rice in small areas that are separated from each other. In general, in Can Ho H'Mong Village each HH has five land parcels to grow rice and in Xin Chai Village each HH has eight land parcels to grow rice. The main fields of paddy rice are terraces. All parcels are narrow and have been cultivated for many years with permanent runoff of water, so the soil has lost much fertility. However, almost all local rice varieties could grow well in such poor soil.

Table 6 shows that 15 local rice varieties can grow well in poor soil, 19 varieties in medium-fertility soil and 7 varieties can grow well only in rich soil. Furthermore, 12 varieties grow well in lower wetland, 5 varieties grow well in wetlands with both higher and lower water temperature; 16 varieties grow well in warmer wetlands.

Number of local rice varieties used by Dao and H'Mong peoples

There are 21 rice cultivars in Ban Khoang Commune. When comparing between two villages or between two ethnic groups (H'Mong and Dao), the number of rice cultivars is different. In the Dao's village the number of rice cultivars is higher than in the H'Mong's village (Table 7). This is because the Dao ethnic people have been cultivating rice for a much longer time than the H'Mong people. The rice yield of the Dao people is often higher than that of the H'Mong. The number of rice cultivars grown by different ethnic groups depends upon their knowledge and understanding of the rice cultivars' characteristics and the surrounding environment. Rice cultivars in Ban Khoang Commune can be divided into two groups. The first serves as food for farming households and the second serves for festival and religious rituals. Most rice cultivars used for festivals and religious rituals are grown in better soil with advantages in water management. When interviewing the Dao people we found out that rice cultivars grown in better soil are sticky rice used for weddings, religious ceremonies and Tet holidays.

Table 6. Rice cultivars and their cultivation ecodomains

Variety name (Dao people)	Land type			Temperature resistance	
	Poor	Medium	Rich	High	Low
Beo ong cu	++	+			+
Beo brut bua	+	++			+
Beo brut shi	+	++		+	+
Beo brut chun	++	+			+
Beo brut giang		+			+
Beo brut pe		++	+	+	
Beo chap	+	++	+	+	+
Beo cu oang	+	++			+
Beo cu quay	++	+		+	
Beo con shi		++	+	+	+
Beo hlau pen pang	++	+		+	
Beo ngach ton	+	++	+	+	+
Beo po ay	++	+		+	
Beo song	+	+			+
Beo ta ling	+				+
Beo tong long	+	++		+	
Tam beo mau	+	++		+	
Tam beo ngach		++	+	+	+
Tam beo bua	+			+	
Beo ai		++	+	+	
Tam muu		+	+++	+	

Table 7. Number of rice cultivars grown by different ethnic groups

Rice cultivars grown	Xin Chai Village (Dao group)	Can Ho H'Mong Village (H'Mong group)
Beo Ngach ton	X	x
Beo cu quay	X	
Beo brut giang	X	
Beo brut chun	X	
Beo cu oang	X	X
Beo con shi	X	X
Beo brut pe	X	
Beo y ty shi	X	
Beo po ay	X	
Beo chop	X	
Tam Beo mau	X	X
Beo tong long		
Beo Sem	X	
Beo song	X	
Beo Tong peng	X	
Beo brôt bua	X	x
Beo ai	X	x
Tam muu		

Quality and resistance of rice landrace diversity

Table 8 presents the number of cultivars grown and farmers' reasons for maintenance. Both Dao and H'Mong farmers in the study site maintain on average only 1 modern rice cultivar and 3–4 to 8–9 rice landraces in each HH. Few HHs maintain more than 10 rice landraces. Medium-resource HHs (13.5 persons/HH) and large-farm HHs (having more than 2 ha of cultivated land) maintain a higher number of landraces than resource-poor HHs (having less than 0.97 ha of cultivated land). Socioeconomic factors such as total cultivable area and land fragmentation have a direct and significant influence on the number of landraces maintained at HH level.

Table 8. Number of rice cultivars grown and their reasons for maintenance, 2001

Location	Type of rice	Rich HH[†]	Medium HH	Poor HH
Can Ho	New variety	0.25	0	0.5
	Landrace variety	2.5	2	2
	Total	2.75	2	2.5
Xin Chai	New variety	0.6	0.8	0.5
	Landrace variety	4.4	3.0	2.75
	Total	5.0	3.8	3.25
Ban Khoang	New variety	0.45	0.36	0.5
	Landrace variety	3.55	2.45	2.37
	Total	4.00	2.81	2.87

[†] Rich, medium and poor household according to Commune's standard.

Farmers maintain a large number of landraces since they are highly suitable to various agroecological, socioeconomic and cultural conditions in the region. The medium and large farm HHs own and operate a larger piece of heterogeneous lands (upper wetland, medium and lower wetland) where diverse types of landraces are adapted. The large farm HHs are often the rich households who generally grow 4 or 5 rice cultivars. These households, because of adequate food production and availability of land parcels, do grow landraces for various socioeconomic reasons, whereas marginal resource-poor households normally grow few (2 or 3) cultivars, mostly high-yielding, for immediate food security needs as they have small and fewer parcels of cultivable land.

In 2000 we found that the number of rice cultivars grown in each household was less than in 2001. The number of rice cultivars of a rich household was 8; a medium household was 7 and a poor household was 4. The reason for this change is the introduction of modern varieties such as *Shan Uu* and *C70*, encouraged by agricultural extension stations. Last year the yield of *Shan Uu* variety was much higher than that of the local varieties. However, if rice production is done without fertilizer and mainly relies on exploitation of soil fertility, in future years the rice yield will certainly be reduced. This is a good reason for farmers to return to using local varieties that have higher tolerance to adverse conditions.

The specific circumstances and reasons given by farmers for specific evaluation of landraces are presented in Table 9. *Beo ngach ton* is grown in the highest area because of its highest yield and good quality. *Beo tong long* ranks second in area grown owing to its low fertilizer requirement. *Beo ai* is a modern rice variety grown as the third largest variety because of its high yield and encouragement from agricultural extension stations of the district. Some rice landraces are grown on a small area despite their low yield. Some farmers, however, want to grow them because they have high grain quality, less fertilizer requirement and resistance to pests and diseases.

Table 9. Matrix ranking of farmer selection criteria

No.	Rice cultivars	Area	High yield	High quality	Less fertilizer	Resistance to pests
1	Beo Ngach ton	1	1	2	7	8
2	Beo cu quay	6	9	7	8	1
3	Beo rang im	6	1	7	8	8
4	Beo Brut chun	7	9	7	8	1
5	Beo cu oang	8	9	7	8	1
6	Beo con shi	4	7	4	5	2
7	Beo brut pe	5	9	3	7	6
8	Beo y ty shi	5	1	1	1	8
9	Beo po ay	6	6	5	4	5
10	Beo chäp	6	3	1	3	1
11	Tam beo mau	5	6	1	8	5
12	Beo tong long	2	4	3	1	4

No.	Rice cultivars	Area	High yield	High quality	Less fertilizer	Resistance to pests
13	Beo Sem	8	9	1	8	8
14	Beo song	6	9	7	8	8
15	Beo Tong peng	5	1	1	1	8
16	Beo brut bua	5	8	1	2	1
17	Beo ai	3	2	6	6	7
18	Tam muu	4	9	2	10	5

Conclusions

1. The local rice varieties in Ban Khoang Commune have high diversity.
2. Most local varieties have high grain quality, high resistance to biotic and abiotic stresses and can grow well in poor soil conditions in the studied localities.
3. The level of rice variety diversity in medium and rich households is higher than in poor households.
4. The level of rice variety diversity among the Dao is higher than among the H'Mong people.

Assessment of crop diversity in coastal agroecosystems in Luong Vien Commune, Phu Da District, Thua Thien Hue Province

Dinh Thi Son, Truong Van Tuyen, Nguyen Thi Lan and Nguyen Thi Thanh

Introduction

The sandy soil area in Thua Thien Hue Province occupies 48 400 ha, of which the sand dune area constitutes 17% and the coastal sandy soil 83%. Diverse cropping systems are used and there still exist many valuable crop varieties with tolerance to adverse climate conditions and to pests and diseases in coastal agroecosystems. In recent years, many high-yielding varieties have been introduced but generally they have low tolerance to environmental stresses. After severe floods in 1999, many precious crop varieties—especially the traditional ones—have been lost. So, for long-term benefits of sustainable agricultural development, it is urgent to conserve local traditional crop diversity in general and in the coastal agroecosystems in particular. But to be successful in this field, a strong basis must be built through proper studies of factors affecting local crop diversity conservation, the custodians of local crop species, farmers' attitudes and reasons for choosing between modern and traditional varieties.

Objectives of the study

- To assess crop diversity at household and village levels
- To identify targeted crops for on-farm conservation
- To build local people's awareness of crop diversity and on-farm conservation
- To understand the utility crops and farmer's evaluation of crop diversity during farming processes and agricultural diversification.

Research methodology

- Participatory tools were used to involve farmers in data collecting and assessment: group discussions, semi-structured survey, mapping and observations
- Meetings, training courses and community-based activities were set up in villages, diversity contests were organized to improve local people's awareness of the methods and benefits of local crop diversity conservation.

Research contents

Site selection

Luong Vien Village, Phu Da Commune, Phu Vang District, Thua Thien Hue Province was chosen as the study site.

Assessment of crop diversity at household and village levels

This was done based on the data from 33 surveyed households, meetings with farmers and a crop diversity fair at the village.

Training courses and workshops

- Training on genetic resource conservation for researchers (twice)
- Training on crop diversity for core group at local level
- Workshop on crop diversity (once)
- Organizing crop diversity fair on 8 June 2001
- Organizing many meetings in Luong Vien Village with participation of farmers experienced in agricultural production.

Trials for in situ conservation of local crop varieties

- Trials for taro varieties: 3 households
- Trials for traditional rice varieties: 4 households
- Trials for rice varieties at group level: 4 groups.

Research results

Socioeconomic information at the study site

Luong Vien Village, belonging to Phu Da Commune, Phu Vang District, is 25 km from Hue city to the southeast and is located on the side of Tam Giang Lagoon. Almost all of the land area of the village is sandy. The total natural land area is 270 ha, of which rice areas in winter/spring and summer seasons are 62 ha and 1.5 ha, respectively. The cash crop area is 33 ha and cemetery area is 70 ha.

The total number of households in the village is 272, of which 95% are engaged in agriculture. According to the wealth ranking, 21% are poor households, 75% are medium and 4% are better-off households.

Crop diversity in Luong Vien Village

Vegetables and cash crops

The results obtained from the survey data and group discussions in Luong Vien Village are presented in Table 1.

The data in Table 1 indicate that the crops and crop varieties in Luong Vien Village are rich and diverse, especially vegetables and taro. Vegetables and cash crops are mostly grown in the winter/spring season, although some crops like taro and spices are grown year round. Cash crops such as bean, cassava and sesame are grown in the fields while salad and spices are grown in home gardens. These crops play an important role in the economic development of households and coastal agroecosystems. Among the four surveyed groups, the farmers of Groups 1 and 2 have more crop diversity than the farmers in Groups 3 and 4. This can be explained by more lands being available for the first two groups. Because of limited rice-cultivation area, the dryland crops are inevitably important income sources for the local farmers. In addition, the village is not far from Hue City, which is quite a big market for these crops. Table 2 shows how diverse these crops are.

Of the abovementioned crops, taro receives more attention from farmers because of its wide adaptation to local environments, its multiple use value and the high price of corms.

Table 1. Number of crops/cultivars defined by farmer groups in the village (data from diversity contest)

Crop	Group 1	Group 2	Group 3	Group 4
Vegetables	30	32		9
Sesame	2		1	2
Melon	4	5		4
Taro	5	4	7	8
Bean	3	6	4	4
Sweet potato	3			5
Cassava	3	4		4

Table 2. Some main vegetables and cash crop varieties in Luong Vien Village

Taro	Bean	Sweet potato	Cassava	Melon
Cham	Van	Khoai la	Cung do	Huong
Ao trang	Do/Red	Tim/Violet	Mi	Gang
Ao tim	Xanh/Mungbean	Mam	Xanh/Green	Water
Sap vang	Trang/White	Da nang	Khach la	Leo
Ngot	Den/Black	Quang binh	Ba Trang	Nut
Bac ha	Peanut	Purple	High yield	Le
Quang				

Taro is grown mostly in home gardens (Table 3). The number of taro varieties in each household is different depending mainly on soil conditions. Taro can be grown year round. The corms are used as food for humans, petioles and leaves are used for animal feed. However, the petioles of some species are a special vegetable preferred by the city people.

Households having gardens in higher elevation tend to grow more taro varieties, namely *Sap vang*, *Quang* and *Cham*, which can also be used for many purposes.

The data from a diversity contest are presented in Table 4.

The farmers of Groups 1 and 2 also plant a higher number of taro varieties than those of Groups 3 and 4. The major reasons are less garden area and less development of animal-raising in Groups 3 and 4. At present, some varieties like *Sap vang* and *Quang* are being gradually lost. Therefore, *in situ* conservation of taro varieties should be given more attention.

Rice crop

In recent years, significant fluctuation in number of rice varieties has been observed. Owing to sandy soil characteristics such as poor fertility, salinity and lack of water in the summer season, the rice-growing area in summer season is only 1.5 ha while that of rice in the winter/spring season is much larger (62 ha). Accordingly, the number of rice varieties in the winter/spring season is much greater than in summer season (Table 5).

Table 3. Taro-growing situation in Luong Vien Village

Taro varieties	No. of planting households	Area (m^2)
Cham	135	12350
Ao trang	116	17150
Ao tim	60	10700
Sap vang	12	650
Quang	17	2575
Bac ha	53	1100
Ngot	24	720

Table 4. Distribution of taro landraces by farmer group

Group 1		Group 2		Group 3		Group 4	
Variety	No. HHs	Variety	No. HHs	Variety	No. HHs	Variety	No. HHs
Cham	17	Cham	30	Bac ha	46	Tim	10
Ao	25	Ao	50	Ao	20	Cham	8
Ao tim	20	Ao Tim	50	Cham	40	Quang	3
Sap vang	10	Ngot	14			Ngot	5
Ngot	5	Quang	4			Sap vang	2
Bac ha	5					Ao tim	1
Quang	10						

Table 5. Change in rice varieties in Luong Vien Village (33 HHs)

Season	1996	2000
Winter/spring		
Total varieties	16	8
Traditional varieties	56%	50%
Modern varieties	44%	50%
Summer rice		
Total varieties	3	3
Traditional varieties	67%	0
Modern varieties	33%	100%

Before 1996, rice varieties in Luong Vien Village were only traditional varieties. Since 1996 and after severe floods in 1999, many traditional rice varieties have been lost and damaged. In addition, the Government supported the planting of modern rice varieties. This has led to genetic erosion of local traditional rice varieties. Comparing the number of rice varieties of 33 households in 1996 and 2000, we can see their very rapid erosion, especially the local traditional varieties (0% in summer season of the year 2000). In 1996, most households grew 4–5 varieties, some of them had 8 rice varieties. All households grew traditional rice varieties of which 89% of households grew *Hau* variety, 24% grew *Nuocman* and 21% grew *Chienthai*. In 2000, 30% of households grew 1 rice variety, most households grew 2–3 varieties and modern varieties became dominant. Most households started to grow modern varieties like *Khangdan* (100%) and *X21* (52%). In the meantime, traditional varieties like *Hau* and *Nuocman* occupied only 9% of households and only 3% for *Chienthai* variety.

Improving local people's knowledge on crop diversity at Luong Vien Village

Through workshops, training courses and a crop diversity contest organized at local level with farmers' participation, the local people have improved their knowledge on crop variety diversity. Based on production experiences, local people can distinguish crop varieties and know the relevant values of each variety, so they can select the varieties needed to meet their own demands (Tables 6 and 7).

Conclusions and recommendations

Conclusions

1. There was very rich crop diversity at Luong Vien Village including rice, taro, bean, vegetables, sweet potato and cassava.
2. Taro has good adaptation to sandy soil and plays an important role in raising pigs, in increasing cash income and alleviating food shortage.
3. The diversity of traditional rice is being eroded at a very fast rate. So, actions must be taken immediately to conserve this very precious genetic diversity.
4. Local people can distinguish crop varieties and know the relevant values of each variety, so they can select the varieties needed to meet their own demands.

Recommendations

To facilitate *in situ* conservation of agricultural biodiversity on-farm, it is necessary to:

- Enhance local people's capacity through improving their knowledge and skills in farm practices and seed management

Table 6. Farmers' knowledge on crop characteristics for classification and utilization

Crop	Ecology	Descriptors	Valuable traits
Rice	Dry, waterlogged lands	Plants, seeds	Salinity, acidity tolerance
Taro	Dry, wet lands, ponds	Plants, roots	Drought and waterlogging tolerance
Cassava	Dry lands	Plants, roots, leaves	Drought tolerance
Sweet potato	Dry, lowlands	Stems, roots	Drought tolerance

Table 7. Comparison between traditional and modern varieties of rice in Luong Vien Village

Traditional rice variety		Modern rice variety	
Advantage	**Disadvantage**	**Advantage**	**Disadvantage**
Adaptation to local soil and weather	Low yield	High yield	High investment
Low investment and less labour input to take care of the fields	More labour input for transplanting and harvesting	Direct seed and less labour for harvesting	Many pests and diseases
Fewer pests and diseases	Lodging	Less lodging	Very fragile to poor harvest

- Maintain and expand crop diversity fairs between household groups and households
- Build local models for integrated crop diversity conservation for field study and exchange among farmer groups, namely for taro and rice landraces, through collecting, on-farm trials, on-farm characterization, variety exchange, re-introduction of adapted varieties, adding value, benefit, economic comparison, etc.

Inventory and evaluation of rice genetic diversity at Da Bac site

Nguyen Thi Thanh Tuyet, Luu Ngoc Trinh, Nguyen Thi Ngoc Hue, Tran Van The, Dang Van Nien and Do Thi Hoai Phai

Introduction

Vietnam is located in South East Asia, known as one of the world's crop biodiversity centres. The Asian Centre is the centre for cultivation of *Oryza sativa*, spreading from Nepal to North Vietnam, so the latter has very high rice biodiversity. Biodiversity conservation has played an extremely important role in stabilizing agricultural production. So, the biodiversity study to serve conservation and rational use of crop genetic resources, as well as to build a scientific base and strategy for crop genetic resources conservation and use, is of prime importance. Agrobiodiversity conservation is also a means to increase the sustainability of agricultural production, and to contribute to hunger eradication, poverty reduction, food security and environment protection. Since the 1960s, a number of scientists from various institutions have conducted surveys, inventories, collecting, evaluation (Trinh *et al.* 1995) and conservation of plant genetic resources, of which rice is the biggest germplasm in South East Asia.

However, the methods used to conserve germplasm in genebanks are not appropriate for conservation of the dynamic evolutionary processes of crops. *In situ* conservation is therefore described as a dynamic alternative, and could be an effective tool for programmes with insufficient resources to conserve germplasm *ex situ*. *In situ* conservation of genetic resources also provides a living laboratory which can allow insights into population structure evolution and ecological processes fundamental to global sustainability.

In order to come up with good results for *in situ* conservation, we should collect data of genetic diversity and evaluate crop genetic resources to understand the extent of within-species and intravarietal diversity. Genetic diversity has close links with traditional farming systems, selection and storage of seeds by farmers.

The results of this study on rice landraces at two microsites in Da Bac District may serve as a means for designing common *in situ* conservation methods to be used by other partners in Vietnam.

Materials and methods

Materials

Rice samples collected from HHs at Tat Village of Tan Minh Commune and Cang Village of Doan Ket Commune included:

- 206 samples of 42 rice varieties of which 34 are local varieties from 50 HHs at Tat Village
- 246 samples of 37 rice varieties of which 32 are local varieties from 62 HHs at Cang Village.

Methods

Survey and collecting

Biodiversity survey forms and common germplasm-collecting methods of the PGR Center of VASI were used (PGRC 2000). RRA and PRA methods to collect information about socioeconomic conditions, farming practices, methods of seed storage and maintenance and agrobiological characteristics of rice landraces were used following the PGR Center of VASI and IPGRI forms.

Evaluation

Morphological characterization and evaluation methods of IRRI and IPGRI, as well as VASI forms were used. Classification of subspecies rice was made by phenol solution (Oka 1958). Determination and evaluation of farmer-based characterization of rice varieties were conducted by PRA, including growth duration, growth ability, cold tolerance, drought tolerance, pest and disease resistance, post-storage quality and development trends.

Coefficients

Varietal diversity coefficient: $H_g = 1 - \sum f^2_{(xi)}$

$f_{(xi)}$: Percentage of a variety area (i) to total area of all varieties

Intravarietal diversity coefficient: $H_{tg} = 1 - \sum f^2_{(xi)}$

$f_{(xi)}$: Percentage of a sample type (i) to total types of the variety.

Time and place of study

Time: from December 1998 to August 1999
Place: Tat Village of Tan Minh Commune and Cang Village of Doan Ket Commune of Da Bac District, Hoa Binh Province.

Results and discussion

Inventory of plant genetic resources at Tat and Cang Villages, Da Bac site

Inventory of plant genetic resources

Inventory of plant genetic resources was carried out at Tat Village of Tan Minh Commune and Cang Village of Doan Ket Commune representing the mountainous areas of Hoa Binh Province. These microsites belong to a region with the characteristics of subtropical and monsoon climate with distinct dry and wet seasons. Many microclimate areas exist thanks to topographic separation consisting of medium mountains, low hills, streams and valleys. The artificial factors and diverse farming practices contributed an important part in diversity conservation of plant species as well as local crops. Our survey results show that there are over 60 and 80 plant species at Tat and Cang Villages, respectively. Plant genetic resources in general and crop genetic resources in particular at the two microsites are rather diverse. The diversity of main crops like rice, taro, cassava and maize is also great (Table 1).

Table 1. Area and quantity of main cultivated crops at Tat and Cang Villages (by cultivated area)

Crop	Tat Village			Cang Village		
	Area (m^2)	%	No. varieties	Area (m^2)	%	No. varieties
Rice (*Oryza sativa*)	217500	52.9	42	241800	56.5	37
Maize (*Zea mays*)	22100	5.4	3	56650	13.2	3
Cassava (*Manihot esculenta*)	98110	23.8	2	85950	20.1	2
Canna (*Canna edulis*)	59210	14.4	2	34550	8.1	2
Ginger (*Zingiber officinale*)	7990	1.9	2	900	0.2	2
Mung bean (*Vigna radiata*)	150	0.05	2	250	0.06	2
Soya bean (*Glycine max*)	250	0.06	1	400	0.11	1
Taro (*Colocasia esculenta*)	300	0.9	8	500	0.13	8
Others	5780	1.4	–	7000	1.6	–
Total cultivated area	411400	100		428000	100	–

Natural conditions such as topography, soil fertility, climate and weather are favourable for crop cultivation. However, the socioeconomic factors such as infrastructure, technical knowledge, labour quality and environmental degradation remain major constraints to maintaining multicrop cultivation systems. Improvement of the situation may play an important role in conservation of plant genetic resources diversity in Da Bac District.

Variation of plant genetic resources

Prevalent shifting cultivation following slash-and-burn practices leads to severe forest destruction and soil erosion resulting in increased area of bare hills. This also inevitably leads to depletion of natural resources involving genetic erosion of plant genetic resources.

Among the main crops, rice is the most diverse species. Upland rice has seriously suffered from genetic erosion; most high-quality varieties have been wiped out together with many precious traits. Lowland rice also shares the same fate owing to the introduction of many improved varieties, which have higher yield but are inferior to local varieties in many aspects like adaptation to specific conditions, or resistance to local pests and diseases.

Cassava and maize have lower variability but also a lower rate of genetic erosion.

Local rice varieties have been collected at the two study sites. Fortunately, they still contain considerable diversity and complicated genetic structure. Varieties include upland rice, lowland rice, glutinous rice, non-glutinous rice, *japonica* and *indica*.

Evaluation of diversity on local rice varieties at the two microsites

Some indicators of seeds

Diversity of rice genetic resources is expressed through some parameters:

Seed weight: the highest weight of 100 seeds is 4.01 g (*Mac buom* variety), and the lowest is 2.42 g (*Khau lao* variety). The diversity index is 13.4.

Seed width: The highest value of seed width is nearly two times in comparison with the lowest (2.44 mm of *Khau lao* seeds). The diversity coefficient is 12.2. The highest length to width (L/W) ratio is 3.67 and the lowest is 2.21 with the CV% of 10.3. This means that the seed shapes vary from long to oblong to almost round. The rice varieties at both villages are highly diverse in terms of maximum and minimum values and CV% (Table 2).

Table 2. Some grain characteristics of rice varieties at Tat and Cang Villages

Season and character	Average		Maximum		Minimum		Coefficient of variation	
	Tat	Cang	Tat	Cang	Tat	Cang	Tat	Cang
Wet season								
Upland rice								
P100 (g)	3.14	3.13	4.01	3.61	2.57	2.42	11.41	13.4
Seed length (mm)	9.20	8.73	10.69	10.50	7.82	7.82	9.7	9.10
Seed width (mm)	3.13	3.21	4.22	3.74	2.44	2.44	11.20	1.20
L/W	2.93	2.71	3.67	3.94	2.21	2.22	10.08	10.30
Lowland rice								
P100 (g)	2.70	2.77	3.19	3.16	2.04	2.15	11.10	12.28
Seed length (mm)	8.27	8.16	9.85	8.90	7.24	7.44	7.30	9.35
Seed width (mm)	2.94	3.11	3.62	3.50	2.20	2.30	10.20	11.33
L/W	2.81	2.62	2.83	3.72	2.61	2.27	6.30	7.81
Dry season								
P100 (g)	2.76	2.82	3.48	3.34	2.04	2.30	10.87	10.02
Seed length (mm)	8.04	7.95	8.70	8.90	7.36	7.30	6.22	6.28
Seed width (mm)	2.89	3.22	3.61	3.92	2.30	2.40	9.30	9.30
L/W	2.78	2.46	3.49	3.72	2.41	2.27	8.45	7.83

Diversity index

The level of genetic diversity of rice varieties is expressed by cropping season, morphology and types of diversity index (Table 3). The diversity indices of local rice varieties are highest (H=0.9453) while that of improved varieties are lower (H=0.6788). Diversity index in wet season (H=0.9001) is higher than in dry season (H=0.6657), in which local rice varieties have H=0.8578, higher than improved ones (H=0.3121). Upland rices have H=0.9031, higher than that of lowland rices (H=0.8794). Glutinous rices have H=0.8774, higher than non-glutinous rices (H=0.7981). The higher the diversity index, the larger the genetic diversity.

Identifying japonica and indica

Most cultivated rice varieties at the two microsites are *japonica* (>60%) including tropical and temperate *japonica*, in which the percentage of upland rice *japonica* is higher than lowland rice. The percentage of glutinous *japonica* is also higher than non-glutinous rice. At Tat Village, there are 66.7% *japonica*, of which tropical *japonica* accounts for 40.5% and temperate ones only 26.2%. At Cang Village, there are 67.6% *japonica* of which 29.7% are tropical *japonica* and 37.9% are temperate (Table 4). These results show why almost all rice varieties at the two microsites with high elevation (600–800 masl) and 23.5°C average temperature are *japonica*.

Evaluation of intravariety diversity of rice landraces

The results of analysis of local rice samples showed that almost all samples have numerous types performing differently in phenotypes. Percentage of varieties that have over two types was over 65% (Table 5). The percentage of glutinous having two types is higher than that of the nonglutinous ones. At Tat Village the percentage of upland rice having two types is higher than that of the lowland rices, but at Cang Village this percentage is similar. There are samples that do not have differences by phenotypes but could be found different by biochemical analyses.

The local rice varieties are often multiline varieties, thus their genetic diversity has granted them high horizontal resistance to pests and diseases, good adaptation to adverse conditions and stable yield despite the environment changes.

Table 3. Diversity coefficient† of rice varieties by seasons and types at Tat and Cang Villages

Type of variety	Both sites	Tat Village	Cang Village
Yearly	0.9520	0.9227	0.8264
By season			
Wet season	0.9001	0.8935	0.7904
Upland rice	0.8136	0.9196	0.6022
Lowland rice	0.8112	0.6243	0.8180
Glutinous	0.8715	0.8129	0.7478
Non-glutinous	0.8142	0.8346	0.6143
Landrace	0.8578	0.9396	0.7449
Improved	0.3121	0.1669	0.3003
Dry season	0.6657	0.7791	0.4021
By upland and lowland			
Upland	0.9031	0.9196	0.6022
Lowland	0.8704	0.8443	0.8329
By glutinous and non-glutinous			
Glutinous	0.8774	0.8528	0.8353
Non-glutinous	0.7985	0.8965	0.5789
By indigenous and improved			
Indigenous	0.9453	0.9544	0.8058
Improved	0.6788	0.7407	0.4180

† Diversity levels of cultivated rice varieties by season, terrain and types are expressed in this table by diversity coefficients. As can be seen, local rices have highest coefficients of diversity and the improved rices have the lowest ones.

Table 4. Identifying *indica*, *japonica* rices and separation of temperate *japonica* from tropical *japonica* rice varieties at Tat and Cang Villages

Types of varieties	Total vars.	*Indica*		*Japonica*						Not identified as *japonica* or *indica*	
		No. vars.	%	Total vars.	%	Temperate		Tropical			
						No. vars.	%	No. vars.	%	No. vars.	%
Tat Village	42.0	13	31.0	28	66.7	11	26.2	17	40.5	1	2.3
Upland rice	25.0	2	8.0	23	92.0	8	32.0	15	60.0	0	0.0
Lowland rice	17.0	11	64.7	5	29.4	3	17.6	2	11.8	1	5.9
Glutinous	21.0	4	19.0	16	76.1	9	42.8	7	33.3	1	4.8
Non-glutinous	21.0	9	42.9	12	57.1	2	9.5	10	47.6	0	0.0
Cang Village	37	8	21.6	25	67.6	14	37.9	11	29.7	4	10.8
Upland rice	17	1	5.9	15	88.2	5	29.3	10	58.9	1	5.9
Lowland rice	20	7	35.0	10	50.0	9	45.0	1	5.0	3	15.0
Glutinous	21	2	9.5	16	76.2	12	57.1	4	19.1	3	14.3
Non-glutinous	16	6	37.5	9	56.3	3	18.8	6	37.5	1	6.2

Table 5. Intravariety diversity of rice landraces at Tat and Cang Villages, 1999

Type of variety	Tat Village			Cang Village		
	Total no. vars.	No. of vars. with over 2 types	%	Total no. vars.	No. of vars. with over 2 types	%
Total	34	21	61.7	32	21	65.6
Upland rice	25	14	41.1	17	9	28.0
Glutinous	13	5	14.7	8	4	12.4
Non-glutinous	12	9	26.4	9	5	15.6
Lowland rice	9	7	20.6	15	12	37.6
Glutinous	7	5	14.8	13	11	34.6
Non-glutinous	2	2	5.8	2	1	3.0

The farmers' identification of rice varieties

Differences between farmers' identification and scientific identification of some rice varieties

Data from Table 6 show that according to farmers' identification at Tat Village the number or percentage of non-glutinous and glutinous are equal (21 and 21). However, at Cang Village there are 21 glutinous varieties (56.8%) and 16 non-glutinous varieties (43.2%). The KI-I solution reactions show that at Tat Village out of 21 farmer-identified glutinous varieties, only 17 changed to red purple colour (glutinous), and 20 out of 21 farmer-identified non-glutinous varieties changed to dark blue (non-glutinous). So in total, only 18 varieties are

glutinous, and 24 varieties are non-glutinous instead of 21 and 21 as farmers believed. At Cang Village only 18 of 21 varieties of farmer-identified glutinous group are glutinous and 15 of 16 varieties of farmer-identified non-glutinous are non-glutinous. So, at Cang Village in total, there are 19 glutinous and 18 non-glutinous varieties. Obviously, KI-I reactions can identify glutinous and non-glutinous groups differently from the farmers' identification.

The same-name varieties at Tat and Cang Villages

There are 13 rice varieties having the same name which include 10 varieties in wet season and 3 varieties in dry season (12 landrace varieties and 1 improved). There are few differences in morphology of the varieties with the same name. However, the differences between various types of the same variety are easily to identify, e.g. *Cam nuong* (upland rice) at Tat Village and *Cam ruong* (lowland rice but can be grown in the uplands) at Cang Village. Some descriptors for grains are similar for two varieties such as seed shape and dimension, but *Cam nuong* has a black lemma colour, purple stigma and black seed coat, whereas the *Cam* varieties at Cang Village have a purple lemma, yellow stigma and varied purple seed coat. The *Khau khuyet* at Tat Village has a brown apex, but *Khau khuyet* at Cang Village has a clearly purple apex. Agricultural production at Tat and Cang Villages has a self-supply character, so seed storage and exchange between households are common phenomena. A long time ago, the farmer usually grew many rice varieties in the same sloping field. Owing to soil erosion, the sown seeds were taken away from their place and mixed with those sown in other places. With time, this created genetically close relations between varieties, resulting in different types of a variety. Farmers gave names to various varieties based on characteristics they observed in the varieties. For example *Khau Tang san* was taken from another area and its growth ability was very good, providing high yield in new local conditions, so farmers called it *Khau tang san* (meaning rice with high yield). For modern varieties, the farmers considered them as improved ones, so they called them *Cai tien* (meaning modified and improved). They do not distinguish *CR203* from *Khang dan* or *Tap giao;* consequently in some cases many varieties have the same name, even though farmers know that they are different varieties.

Farmers' opinion on using local varieties

Characteristics of rice varieties have been marked by farmers' groups. The results of our survey show that more than 60% of the good varieties need to be developed, for example *Khau do* and *Khau khinh*. Utilization at 30% of total varieties helps keep a biological balance and guarantees a stable harvest.

The analyses of farmers' criteria at the two microsites show that the farmers do understand their varieties deeply and their general selection criteria are good: drought tolerance, disease resistance, high quality and perhaps yield (Table 7). This means that rice genetic resources at the Da Bac site still contain many varieties with different characteristics. Some are grown in smaller fields for specific use, and others are grown in large areas for food security. The *Nep Cam* variety, although having a low yield, is still cultivated because of its special quality, providing traditional food and medicinal materials.

Table 6. Comparison between farmer identification and reaction of seeds to KI-I solution

Type of variety	Farmer identification		Result of KI-I reaction	
	No. of varieties	%	No. of varieties	%
Tat Village	42	100.0	42	100.0
Glutinous	21	50.0	17	40.5
Non-glutinous	21	50.0	20	47.6
Not identified	0	00.0	5	11.9
Cang Village	37	100.0	37	100.0
Glutinous	21	56.8	18	48.6
Non-glutinous	16	43.2	15	41.4
Not identified	0	00.0	3	10.0

Table 7. Results of farmer evaluation† of main rice varieties at the two microsites of Da Bac, Hoa Binh in 1999

Variety name	Yield	Growth duration	Quality	Cold tolerance	Drought tolerance	Pest/ disease tolerance	Storage duration	Farmer's idea
Cam	3	3	3	3	5	5	3	Maintain
CR203	6	9	8	4	5	3	3	Maintain
Hang mu	4	7	7	–	7	7	7	Maintain
Khau do	8	7	9	3	9	8	9	Develop
Khau khuong	8	7	8	3	8	7	8	Develop
Khau khinh	4	7	7	–	5	7	8	Develop
Khau khuyet	8	7	9	5	8	8	8	Develop
Khau lao	7	6	5	–	4	6	7	Develop
Khau mon	9	8	3	–	9	7	6	Develop
Khau mon nieu	8	7	3	–	9	7	7	Develop
Khau toi	5	6	8	–	5	6	8	Develop
Luong quang	5	9	7	7	3	3	3	Maintain
Lech luong	7	4	8	3	5	5	7	Develop
Mac cai	7	3	5	3	7	7	7	Develop
Mac co	3	7	5	–	3	5	7	Maintain
Mac mau	8	3	6	9	9	9	6	Develop
Mai huong	9	9	9	5	6	3	3	Develop
Tang san nieu	5	5	5	–	5	9	7	Develop
Thuong hai	6	8	3	–	4	4	5	Maintain
Tram con dau	5	9	5	–	5	3	3	Maintain
Tram khao	5	7	7	–	7	8	8	Develop
Tram pom	5	7	6	–	7	7	7	Maintain

† 1=the worst, least or lowest; 9=the best, most or highest.

Although the studied sites were small, they still possess a high level of genetic diversity maintained by local HHs. For certain reasons, some rice landraces are not grown in one season, but are grown in another season. Or one group of farmers maintains some varieties and the other groups keep other varieties for their precious traits. Obviously, local varieties will be maintained over time thanks to their suitability, adaptation and tolerance to biotic and abiotic stresses.

Conclusions

There is high diversity in quantity and types of rice varieties in both dry and wet seasons among both upland rices and lowland rices. Genetic variation between varieties is very high. The structure of the rice population was found to differ between the two microsites.

Within-variety diversity at two Villages (Tat and Cang) was confirmed at high level (over half of the studied varieties have two morphological types). There exist different reasons for making local varieties adaptable to and sustainable in local ecological conditions.

Farmers evaluate their selected rice landraces by the following descriptors: high quality, stable yield, good tolerance to environmental stresses and adaptability to local ecological conditions. The preference of farmers for high-yielding varieties serves as a good indicator for participatory plant breeding.

Suggestions

- Strengthen *in situ* research and conservation of landrace rice varieties in Da Bac site to propose models for sustainable *in situ* conservation of agricultural biodiversity on-farm in Vietnam.
- Encourage PPB for upland rice improvement to ensure sustainable yield and agrobiodiversity conservation, as well as environment protection in specific ecozones.

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In situ characterization of rice morphological traits and effects of traditional farming systems on variety diversity in Da Bac site

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Introduction

Vietnam is located in one of the world's crop diversity centres. This diversity is expressed both between and within species. Rice is a typical Vietnamese crop with a long cultivation history and great diversity.

Recently, Vietnam's rice producers have introduced numerous improved varieties, which is one of the main reasons for genetic erosion of indigenous landraces, leading to a narrowing of the rice genetic base. Thus, studies on conservation of rice landraces both *ex situ* and *in situ* are urgently needed to prevent further erosion and serve sustainable breeding programmes.

In situ conservation is a complementary approach to support *ex situ* conservation in maintaining natural evolution and plant genetic diversity. On-farm conservation as a means for growing and maintaining farmers' crop populations has great advantages in conservation of genetic diversity of local crops in their original ecosystems.

Da Bac District of Hoa Binh Province is a typical site for mountainous ecosystems. Strengthening the scientific basis of *in situ* conservation of some crops is very important to establish models of *in situ* conservation. Plant genetic diversity studies and socioeconomic surveys were conducted during the first phase of the project. Study of the effects of intravariety diversity, cultivation seasons and traditional farming systems on the conservation of plant genetic diversity need to be conducted during the next phase. Rice is one of the major crops to be conserved first.

Study objectives

- Study the morphological diversity of common rice landraces and farming systems among farmers' households at two microsites of Da Bac District.
- Analyze the effects of farming management on maintenance of rice genetic diversity.

Materials and methods

PRA and RRA were applied to survey and collect information about the quantity of rice varieties, cultivated areas, cultivation methods and to determine variety names given by farmers.

In situ characterization forms were used by field staff who visited each plot of specific varieties to record rice genetic resources *in situ* and document the habitats of each landrace. The custodians of rare rice varieties were also interviewed for acquisition of indigenous knowledge for further studies.

Surveys were carried out in 30 households in two villages to form the list of rice diversity. Four varieties that have large cultivated areas and are cultivated by many HHs in each village have been selected and studied for morphological diversity in the farmers' fields. Each variety has been distributed to three HHs at different distances and terrains.

Results and discussion

Rice variety variation over time

From Table 1, it can be seen that rice landrace structure has changed over time. Compared with the years 1999 and 2000, the number of landraces in 2001 was reduced in both Cang and Tat Villages. Possible reasons for the reduction include:

- The government policy on changing swidden lands into forest production
- The introduction of modern rice by extension offices
- Some rainfed lands in Tat Village are better irrigated thanks to improved irrigation systems, so they became intensively cultivated with modern varieties.

Table 1. Rice variety variation over time at Cang and Tat Villages of Da Bac District, Hoa Binh Province

Variety	Cang Village			Tat Village		
	1999	2000	2001	1999	2000	2001
Upland rice	21	14	14	28	21	17
Lowland rice	18	15	13	13	8	7
Total	39	29	27	41	29	24

However, the Tay farmers in the two villages still grow many local rice varieties that are suited to the marginal environment and have multi-use value in these sites. Also, the market demands for high-quality traditional rice have reappeared as a consequence of so much progress in the country's socioeconomic development during the last two decades.

Utilization status of common rice varieties

At Cang Village, four common varieties (*Khau Mon, Khau khinh, Khau Hang mu* and *Khau Cai hoc*) are most popular. Among them *Khau Mon* occupies the biggest growing area.

At Tat Village, among local 24 rice varieties, four (*Khau khinh, Khau tram luong, Khau lao* and *Tang san nieu*) are grown in larger areas than the others. *Khao lao* occupies the largest area and is grown by the greatest number of households.

There are glutinous and non-glutinous varieties with short and long growth durations, different structure and performance in Da Bac site.

Table 2. The common rice varieties at two microsites in Da Bac District

Name of variety	Type of variety	Growth duration	No. of cultivating HHs	Area (m^2)
Cang Village				
Khau hang mu	Upland – Glutinous	Medium	4	3485
Khau mon	Upland – Non-glutinous	Short	20	14265
Khau khinh	Upland – Glutinous	Long	5	4200
Khau Cai hoc	Lowland – Glutinous	Medium	9	3700
Tat Village				
Khau khinh	Upland – Glutinous	Long	9	3900
Khau tram luong	Upland – Non-glutinous	Medium	5	2650
Khau Lao	Upland – Glutinous	Short	11	7300
Tang san nieu	Upland – Glutinous	Long	6	4100

Main characteristics of common rice varieties evaluated by farmers

The study results in Table 3 show that the main farmers' selection criteria for rice are high yield, grain quality, pest and disease resistance, as well as their adaptation to local farming conditions. Da Bac farmers have maintained and used diverse rice varieties to ensure sustainable agricultural production.

Morphological diversity of common rice varieties

The information in Tables 4a and 4b shows that there is high diversity in upland rice varieties at both microsites. Although the number of surveyed fields is not large (3 fields/household), many different types can be found within the same variety. Perhaps this is due to private and different seed selection and maintenance methods among farmers. Some morphological characteristics have close links to genotypes, so the study of intravarietal variations and their effects is necessary in the next phase of the project.

At Cang Village, almost all common rice varieties vary in culm angle and panicle type. The *Khau khinh* varieties have two types of grains. For the first type most panicles have short and partly awned grains with yellow furrows. For the other type, awns are absent and the furrows are brown (Table 4a).

Table 3. Farmers' evaluation† of the main characteristics of common rice varieties

Variety name	Suitability for: Local fields	Farming practices	self supply	Use demand	Yield	Quality	Scent	Fertilizer requirement	Pest/disease resistance
Cang Village									
Khau hang mu	1	1	1	2	3	2	2	4	1
Khau Mon	1	1	1	2	2	4	3	1	1
Khau khinh	1	1	1	1	1	1	1	4	1
Khau Cai hoc	1	1	1	1	2	1	2	2	1
Tat Village									
Khau khinh	1	1	1	1	1	1	1	4	1
Khau tram luong	1	1	1	2	1	3	3	2	1
Khau Lao	1	2	1	2	2	2	3	2	1
Tang san nieu	1	1	1	2	3	1	2	1	1

† 1=the highest, the best, the lowest fertilizer requirement; 4=the lowest, the worst, the highest fertilizer requirement.

Table 4a. Some morphological characteristics of common rice varieties in HH fields at Cang Village of Doan Ket Commune, Da Bac District

Characteristic	Variety name: *Khau hang mu*	*Khau mon*	*Khau khinh*	*Khau cai hoc*
Flag leaf angle	Drooping	Erect	Drooping	Erect, drooping
Culm angle	Erect, intermediate	Erect	Erect, intermediate	Erect
Panicle type	Intermediate	Intermediate	Compact, intermediate	Intermediate
Seed shape	Big, long	Round	Round	Round
Apiculus colour	Black	Straw	Straw	Straw
Lemma colour	Black spots	Gold furrows	Brown furrows, gold furrows	Straw
Awning	Long and partly awned	Absent	Short and partly awned, absent	Short and partly awned
Growth ability	Good	Good	Good	Good
Population uniformity	Bad	Good	Bad	Good

Table 4b. Main morphological characteristics of common rice varieties in farmers' fields at Tat Village of Tan Minh Commune, Da Bac District

Characteristic	Variety name: *Khau khinh*	*Khau tram luong*	*Khau Lao*	*Tang san nieu*
Flag leaf angle	Drooping, horizontal	Horizontal. drooping	Erect	Drooping, erect
Culm angle	Erect	Erect	Erect, intermediate	Erect, intermediate
Panicle type	Intermediate	Intermediate	Intermediate, compact	Compact
Seed shape	Big, round	Oblong, round	Small, long	Oblong
Apiculus colour	Straw	Straw	Purple	Straw
Lemma colour	Gold furrows	Straw	Straw	Purple furrows, black furrows
Awning	Short and partly awned. Absent	Absent	Short and fully awned (a lot), short and partly awned (few), absent	Absent
Growth ability	Very good	Good	Good	Good
Population uniformity	Good	Good, intermediate	Good, intermediate	Good

Most of the common varieties at Tat Village have many types. The differences between types are expressed through many morphological descriptors such as culm angle, flag leaf angle, panicle type and especially through grain descriptors.

Traditional farming systems' effects on variety diversity in Da Bac site

Upland rice diversity by growth duration

The farmers in Da Bac District have grown many upland rice varieties in difficult growth conditions to spread the harvest time (Table 5), thereby avoiding harvest failure in harsh agroclimatic circumstances. This habit is one of the main factors affecting rice variety diversity in mountainous areas of Northern Vietnam.

Upland rice diversity by fertilizer requirement

Table 6 shows that there are three types of varieties, grouped by fertilizer requirement. Some varieties are suitable only for high-fertility soils, e.g. *Khau khinh, Khau tram khao, Khau cao su*. Other varieties have good growth ability and stable yield in low-fertility soil, e.g. *Khau mon, Khau thuong hai*. This explains why *Khau mon* with low quality is still grown in large areas by many households at Cang Village.

Upland rice diversity by use value in Da Bac site

Table 7 shows that farmers keep local rice varieties not only for daily food but also as traditional food for holidays, New Year "Tet" celebration and festivals, as well as for medicinal materials. Some typical rice landraces are maintained for good taste and cooking quality, and others for processing purposes.

Table 5. Classification of upland rice diversity by growth duration at two microsites in Da Bac District

Growth duration		
Short	**Medium**	**Long**
Khau mon tram	Khau khinh	Khau dam ca
Khau mac buom	Khau mon nieu	Khau lech luong
Khau tram pom	Khau hang ngua	Khau cam pi
Khau nam ma	Khau hang mu	Khau yen the
Khau tram sai	Khau tram khao	Khau mac cai
Khau thuong hai	Khau cao su	Khau mac co
Khau lao	Khau toi	Khau luong cong
Khau hang don	Khau tram hom	
Ke de tram	Tang san nieu	
Khau tram nanh	Ca lan danh	
	Ca lan khao	

Table 6. Classification of upland rice diversity by fertilizer requirement at two microsites in Da Bac District

Soil fertility		
High	**Medium**	**Low**
Khau mac buom	Khau tram sai	Khau mon tram
Khau nam ma	Khau lao	Khau tram pom
Khau khinh	Khau tram nanh	Khau thuong hai
Khau toi	Khau hang ngua	Ke de nieu
Khau tram khao	Khau tram hom	Ke de tram
Khau dam ca	Ca lan danh	Khau mon nieu
Khau luong cong	Ca lan khao	Khau hang mu
Khau cam pi	Khau lech luong	Tang san nieu
	Khau mac co	Khau cao su
	Khau mac cai	
	Khau hang don	
	Khau yen the	

Table 7. Classification of upland rice diversity by use value in Da Bac site

Use	Variety
Food (rice, gleam)	Khau mon, Khau mac cai, Khau ca lan, Khau tram khao, khau tram nanh, Khau tram pom, tang san nieu, Khau cao su, etc.
Gleam, sweet gleam, cakes	Khau khinh, Khau lao, Khau do, Khau mac cai, Khau hang mu, etc.
Medicine	Khau cam pi
For traditional festivals	Khau tram hom, Khau khinh, Khau lech luong, Khau toi, Khau Lao, etc.

Conclusions

- Da Bac farmers have maintained rice diversity over time for their livelihood in relation to strict demands for quality, adaptation to local socioeconomic and environmental conditions, as well as to traditional farming practices.
- Traditional practice diversity is one of the main reasons for the creation of rice genetic diversity. The farmers' descriptors used to realize, select, produce and maintain rice varieties are significant and consistent. The descriptors are useful for scientists in rice genetic diversity and rice landrace conservation studies and on-farm conservation.
- Traditional practices have significantly affected rice genetic diversity in the two study villages. In the production process the farmers have selected and conserved appropriate rice landraces based on the specific topography, soil fertility, utilization demands, preferences and cultural customs.

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Taro cultivar diversity in three ecosites of North Vietnam

Nguyen Ngoc Hue, Luu Ngoc Trinh, Nguyen Phung Ha, Bhuwon Sthapit and Devra Jarvis

Introduction

Taro diversity and food culture of taro have been traditionally rich in Vietnam. Although the area of taro cultivation is small in comparison with other food crops, it is widely grown by Vietnamese farmers in most home gardens and larger fields of all agroecological zones of the country. Germplasm exploration and collection activities have already characterized about 350 accessions (Hue 2001). Variation in shape, colour of corms, leaf, petiole, plant height and cooking quality was reported. However, there is little information available on diversity of use value of local taro cultivars and its impact on the extent and distribution of taro diversity on-farm. This study aimed at understanding why Vietnamese farmers grow diverse types of taro cultivars with distinct farmer units of diversity. Information from such basic study will assist the national plant genetic research programme to formulate options for taro on-farm as well as *ex situ* conservation strategies.

Materials and methods

Amount of taro varietal diversity and their distribution by CBR

The population structure of taro varietal diversity *in situ* is measured by the local names (if they are distinct and consistent in their names and description). However, such cultivars vary in plot sizes and number of farmers growing each cultivar. This figure may vary at village, commune, district and province levels.

The Simpson Index for quantifying taro diversity in the study sites was calculated using the following formula:

$$H=1-\sum f^2 i$$

where *fi* is the frequency proportion of the farmer-named variety found in category *i*.

From the CBR database, taro landraces could be classified into four broad categories in terms of area cultivated and the number of farmers maintaining them at village level. This approach could be done at species level or variety level (see below).

Large area, many households	Small area, many households
Large area, few households	Small area, few households

Taro cultivars were categorized in groups of large and small area (based on the average area) and many and few (based on number of households growing each cultivar). Average number of farmers growing each cultivar was used to categorize many or few households. Similarly, average taro land area of each cultivar was used to group cultivars into large or small area.

A key information survey was also used to understand the use value of taro diversity, the propagation method of various taro cultivars and informal germplasm supply systems.

In situ characterization was conducted to verify the data of diversity fair and document the indigenous knowledge on taro by interviewing farmers in the fields.

Results and discussion

Total number of taro cultivars

The names of taro cultivars used by farming communities are the first indicators for the amount of diversity at a given location. The information from the CBR (Table 1) was used in this study to estimate taro diversity and genotype diversity index. The highest number

of taro cultivars was reported in Tat Village of Da Bac mountain sites, followed by Cang Village of Da Bac and Yen Minh Village of Nho Quan midlands; lowest number of taro cultivars was found in Dong Lac of lowland Red River Delta site. A validation exercise carried out by experienced genebank curators showed that there was a high degree of consistency among farmers in farmer-named cultivars and farmer description of local cultivars. Farmer descriptors for each cultivar have been documented. Hue (2001) found that consistency of local names is more reliable within the village than between the villages. Actually, the number of taro varieties in the study site has not changed during 2000-2001.

Number of farming households growing taro

The number of growers varied from village to village and this may change over time. The average area recorded under taro varied from 287 to 980 m^2 in the studied sites (Table 2). Among six *in situ* villages, Yen Minh Village had the largest area under taro (0.78 ha) followed by Quang Mao (0.42), Tat Village of Da Bac (0.30 ha) and Kien Thanh of Nghia Hung (0.29 ha).

Genotypic diversity index in each study site

Genotypic diversity indices for taro diversity were computed using Simpson Index (SI) to compare varietal diversity of taro, i.e. the frequency of farmers growing each taro cultivar at village level. Table 3 illustrates the comparison between sites for diversity indices (SI) for taro. Analysis results indicate that the SI by study site of cultivars was highest in Da Bac site followed by Quang Mao and Yen Minh Villages of Nho Quan. The results showed that Da Bac site is richest in taro genotype diversity.

Area covered by each taro variety

CBR data showed that the plot sizes for taro ranged from 190 m^2 to 1115 m^2 whereas the average number of farmers growing each taro cultivar ranged from 1 to 21 and therefore the definitions of "large and small area" as well as "many and few farmers" are relative to the specific villages. Analysis of diversity distribution patterns showed that villages with a large taro area are not necessarily also rich in taro diversity (Tables 3 and 4). Research results suggest that the extent and distribution of taro cultivars may vary with natural ecology, farmer's specific preferences, socioeconomic conditions, market forces and cultural values. Some varieties are considered to be a common type. In Dong Lac Village, *Khoai nuoc* and *Khoai tia rieng* occupy large areas because these cultivars are well adapted to low-lying moist land and produce good yields. They also have high market demand. *Phuoc kip, Phuoc hom, Phuoc dan* and *Phuoc luong* are important cultivars in Tat Village of Da Bac because they are grown alongside the roads and they gain market preference in Hanoi. These cultivars also have multiple uses for food and feed. *Khoai so trang* has specific and best quality trait, and therefore has high market demand in Yen Minh Village of Nho Quan District.

Table 1. Amount of taro diversity measured by CBR method

Geographic region	Macrosite name	Village	No. of cultivars 2000	No. of cultivars 2001
Lowland	Nghia Hung	Dong Lac	4	4
		Kien Thanh	5	5
Midland	Nho Quan	Yen Minh	8	8
		Quang Mao	7	7
Mountain	Da Bac	Cang	8	8
		Tat	10	10

Table 2. Varietal diversity and area coverage of different varieties in different ecosites of Vietnam in 2001 (30 households)

Geographic region	Macrosite name	Village	No. of cultivars	Total taro area (m^2)	Average taro area (m^2)	Total taro growers at a village
Lowland	Nghia Hung	Dong Bac	4	2004	501	20
		Kien Thanh	5	2932	586	21
Midland	Nho Quan	Yen Minh	8	7840	980	20
		Quang Mao	7	4248	607	18
Mountain	Da Bac	Cang	8	2294	287	17
		Tat	10	2980	298	18

Table 3. Simpson Index of taro varieties in different ecosites of Vietnam

Geographic region	Macrosite name	Village	SI	Rank (evenness)
Lowland	Nghia Hung	Dong Lac	0.289	3
		Kien Thanh	0.468	5
Midland	Nho Quan	Yen Minh	0.645	4
		Quang Mao	0.715	6
Mountain	Da Bac	Cang	0.811	2
		Tat	0.789	1

Table 4. Characterization of varietal dynamics of taro in selected *in situ* sites, North Vietnam

Macro-sites	*In situ* villages	Varietal class			
		Large area, many HHs	Large area, few HHs	Small area, many HHs	Small area, few HHs
Nghia Hung	Dong Lac	Khoai nuoc	Khoai tia rieng	NA	Khoai mot doc, mung trang
	Kien Thanh	Khoai nuoc, Khoai so	NA	NA	Khoai, Khoai tia rieng
Nho Quan	Yen Minh	Khoai so doc xanh	Khoai so doc tia	khoai nuoc doc xanh, khoai nuoc doc tia	Khoai Tam dao, Mung trang
	Quang Mao		Khoai so dia phuong doc trang	Khoai nuoc	Khoai tam dao
Da Bac	Cang	Phuoc hom	Phuoc dam	Phuoc kip, Phuoc tay	Phuoc danh, Mac phuoc, Phuoc mong, Phuoc luong
	Tat	Phuoc kip, Phuoc hom	Phuoc danh	Phuoc be, Phuoc luong	Phuoc ca, Phuoc kinh, Phuoc khan, Bon hom, Phuoc luong nang

However, in diversity-rich areas, for instance in Cang and Tat Villages, five varieties are grown by few households in small areas. They fall into a rare and local category. It is, however, important to understand why specific taro growers plant such rare types.

The results of a study on indigenous uses of farmers at six villages can answer this question.

Indigenous uses

In Vietnam taro is a good example to illustrate that conservation of crop genetic resources is possible through use. The ethnobotanical survey results indicate that farmers have maintained different kinds of taro because of their different use values. Taro is used locally for different purposes. The petioles of both wild and cultivated taro plants can be used as pig

feed. In Nghia Hung District, when the production of taro tuber is too much for family consumption but the market price is low, many households do use taro tubers for pig feed. The use value of taro in the study sites is presented in Table 5. Some varieties have multiple uses, whereas other varieties are maintained for specific purposes.

In Vietnam, basically taro cultivar diversity is maintained by farmers for their preferred traits and uses (Table 5). There are three major uses: food, medicinal materials and animal feed. Farmer preferences for taro cultivars vary with local food culture. For example, *Bac ha* and *Phuoc mong* are preferred to cook vegetable noodle soup with pig ribs locally known as *bun suon*.

Bac ha taro cultivar is specially required for preparing local cuisine *lau* (a kind of sweet and sour soup containing fish, mushroom and pineapple). The petiole of *Bac ha* taro can be eaten with various green vegetables.

Table 5. Comparative use value of taro varieties maintained at *in situ* study sites in Vietnam

Local name	Meaning of local name	Uses
Bac ha	Silver coloured petiole	Petiole used for sweet and sour fish and vegetable soup locally known as *lau* cuisine
Bon hom	Flowering taro	Medicine for headache, ornamental value and feed for pig
Hau doing	Yellow taro	Corm used for various food and high local market demand
Khoai dia phuong	Egg tuber plant	Corm used for various food and preferred in local markets
Khoai nuoc tia	Aquatic purple taro	Feed to pig
Khoai so trang	Many escape cormel with white flesh colour	Corm for seed, cake food and grown for commercial production
Khoai tia rieng	Ginger looking purple taro	Good-quality corm used for food and petiole for pig feed, low yield
Phuoc Be	Pig taro	Feed for pig
Phuoc ca	Many stolons	Feed for pig
Phuoc Dam	Purple flesh corm	Corm for various soups and petiole for pig feed
Phuoc Danh	Aquatic taro	Feed for pig
Phuoc do	Aquatic violet colour	Petiole for feed use
Phuoc don	Green taro	Corm for boiled snacks
Phuoc hom	Aromatic taro	Corm for sweeten soup, boiled snacks and breakfast cake (*banh khoai*)
Phuoc hom dam	Aromatic purple petiole	Corm for cake, boiled, soup and sweeten soup
Phuoc hom sang	Aromatic yellow taro	Corm for various food (soup, curry, snacks)
Phuoc kip	Yellow flesh colour corm	Corm used for food (curry, snacks, soup, etc.) and petiole for pig feed
Phuoc luong	Big round corm	Corm for boiled snack and petiole for pig feed
Phuoc luong nang	Big yellow flesh corm	Corm for different soups
Phuoc mong	Petiole taro	Petioles are used for pickle preparation and vegetables
Phuoc nanh	Round big purple corm	Corm for boiled taro for breakfast food
Phuoc tay	Big violet corm	Corm for boiled taro food and petiole for pig feed
Phuoc tay	Itchy taro	Feed to pig as it is fast growing
Phuoc tim	Purple taro	Feed value
Phuoc trang	White taro	Corm for cake, soup and snacks
Ray nha	House aroid	Tuber as medicine, petiole for pig, corm can be eaten
Tam dao xanh	Tam dao mountain	Cormel used for soup and petiole for vegetable soup and pickle

Bon hom, a flowering taro, has specific value such as medicinal material for headache, ornamental plant and feed for pig. An aromatic taro variety *Phuoc hom* is grown for multiple uses like food for soup, cake and snacks but its most preferred product is breakfast cake (*banh khoai*). There are many taro cultivars maintained for pig feed and there are varieties preferred for pig feed only. The young emerging shoots from sucker taro are used for a special vegetable dish (*bup khoai so kho tuong*) in Vietnam. In general, the corms and cormels are used for food whereas petioles and leaves are used for feeding animals. *Bac ha* and *Phuoc mong* are specially kept for petiole use. *Khoai so trang* is good for special food as *canh cua khoai so rau rut*. However, the choice of taro cultivars by farmers and their extent and distribution are often guided by multiple uses of taro cultivars and farmers' ecological circumstances.

Conclusions

The number of taro cultivars ranged from 4 in Dong Lac Village of Nghia Hung to 10 in Tat Village of Da Bac site. The SI by the study sites of cultivars was found highest in Da Bac site (SI ranges from 0.789 to 0.811) followed by Quang Mao and Yen Minh Villages of Nho Quan (0.645–0.715). The results showed that Da Bac site is richest in taro genotype diversity. Farmer-named cultivars can be used as farmer units of diversity and local names were consistent at village level.

Farmer and market preferences of taro cultivars for specific Vietnamese food culture have been contributing to *in situ* conservation of large taro diversity. The choice of taro cultivars by farmers and their extent and distribution is often guided by multiple uses of taro cultivars and farmers' ecological circumstances.

Taro varieties are valued for multiple uses such as food, feed, medicine and ritual purposes. Currently all taro cultivars in use by Vietnamese farmers are local varieties or landraces that are uniquely adapted to home garden conditions in different parts of the country.

Public awareness of the use value of taro diversity can be a strategy for *in situ* conservation along with the cross-sites deployment of new diversity.

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Quantity and distribution of crop genetic resource diversity in Nam Nung, Daklak

Pham Van Hien and Tay Nguyen University Diversity Group

Introduction

Daklak is a new site established following the National Workshop on the first phase implementation and the second phase workplan of the project for "Strengthening the Scientific Basis of *In situ* Conservation of Agrobiodiversity On-farm: Vietnam Country Component" held in Hoa Binh, Vietnam. The Daklak pilot site was opened by Tay Nguyen University's Diversity Group and Community Management Committee together with the participation of 90 households in Nam Nung Commune, Krong No District, Daklak Province.

Daklak is one of the four provinces in the Central Highland region of Vietnam. The province has a monsoon tropical climate, is 400–800 masl, and has a total temperature of 8000–9000°C per year. There are two distinct seasons: the rainy season lasts from May to October, with average rainfall of 1400–2000 mm/year, and the dry season lasts from November to April of the next year, with very little rain, and a hot and windy climate.

Nam Nung Commune has been selected to be a representative for the province of its natural, socioeconomic and crop diversity characteristics that meet the project objectives. The commune elevation is about 760 masl, with an average rainfall of 2252 mm/year, and relative humidity of 87%.

The total natural area is 22 135 ha, of which arable and forest areas account for 12.2% and 72.5%, respectively. The commune has 1481 households, 7876 persons and 8 ethnic groups (data of the year 2000).

The crop systems in the commune are quite rich and diverse. There are many growing areas for industrial crops that require intensive and sophisticated cultivation techniques. There are also areas where people still use traditional cultivation techniques for various local varieties and crops, especially for upland rice and local vegetables. Crop diversity is a result of both traditional cultivation practices and socioeconomic factors. However, the crop genetic diversity tends to be decreased, which is causing many problems for agricultural production.

The study objectives of *in situ* conservation of agrobiodiversity in Nan Nung commune are to provide scientific foundations for on-farm conservation of diverse crops, to diversify crop varieties and to stabilize the living conditions for the local people.

Methodology

Participatory Rural Appraisal, Variety Network Analysis and IPGRI's BioDiversity Assessment were the main methods applied to the study in Nam Nung site in the year 2001. Some of the following tools were used:

- A questionnaire was properly designed according to the study objectives, with comments from Dr Devra Jarvis and based on the Can Tho site questionnaire developed by Mr De. A total of 90 voluntarily participating households in three villages was interviewed by the project research group and students.
- Meetings of 30 households in each village: several meetings were held to (1) interview on the diversity of crops in the village, (2) classify households by economic conditions because each type of household has a different quantity of crops, opinions, conservation methods and cultivation techniques, (3) conduct SWOT (strength, weakness, opportunity and threat) analysis, (4) find out solutions for improvement of variety network in the village, (5) identify reasons for crop diversity and the threat to diversity erosion, and (6) find solutions for *in situ* crop diversity conservation.
- Field trips for mapping and assessing cultivation practices in each village were organized with the participation of local farmers.

- A Diversity Fair was organized to improve knowledge of local people on crop diversity and to collect and practically assess crop diversity in each community.

Results and discussion

Natural conditions of Nam Nung Commune, Krong No District

Nam Nung natural conditions are typical in Krong No District. There are two seasons: the wet season from May to October and the dry season from November to the next April. The average annual rainfall is 2253 mm. The average temperature is 22.3°C, average relative humidity is 87%, and evaporation is 824.4 mm annually. The total natural land area of the village is 22 135 ha including: forest land area = 16 040 ha (72.5%), agricultural land area = 2708 ha (12.2%), of which perennial crop land area is 54.9%, annual crop land area is 18% and wetland area for rice is 22.6%.

Crop diversity in Nam Nung Commune

Survey study

In each village, 30 households were selected for interview, each for one questionnaire, and a total of 90 households in three villages were interviewed. The survey recorded all kinds of local crops and newly introduced ones in Nam Nung Commune (Table 1).

Table 1 shows that the area has a diversified collection of crops, with more than 30 different local crops. They are only from surveyed households interviewed by the study group. In fact, crop diversity is much higher. Local people like to preserve these different crops for different reasons such as natural, economic, custom and personal preference. Besides traditional, local crops, farmers also bring in new crops and varieties for economic and income purposes.

Table 1. Crop varieties in Nam Nung

Variety	Local name	Bio-characteristics	Reason for preference
Traditional crops			
Upland rice	Ba Hma	Very diversified and different	Used for different purposes
Upland sticky rice	Met	Very diversified and different	Used for different purposes
Local corn	Mbo	White, yellow, purple, red-yellow, purple stripe	Good taste, sticky, can be substitute when rice not harvested yet
Local beans	Tuh lang	Purple, green, white, long	Can be used as vegetables
Bitter fruit plant	Blin tang	Horn or non-horn stem, big and round fruit	Traditional foodstuff, highly preferred
Non-bitter fruit plant	Blin	Big, round, long fruit	Traditional foodstuff, highly preferred
Tomato	Blin Mkur	Small, round fruit	Flavour, sour, good taste
Gourd	Nong	Long, round fruit	Flavour, sweet taste
Pumpkins	Kpoal Dum	Long, round fruit	Starchy, sweet, can be stored a long time
Green melon	Kroal prah	Big or small, long fruit	Sweet, plenty of fruits
Squash	Buin	Long, round fruit	Flavour, sweet
Water cucumber	Kpung	Bell-shaped fruit	Eat fresh as vegetable
Cucumber	Kpung tok	Long small fruit	Vegetable
Cassava	Bum Blang	Purple, white roots	Hunger alleviation, cooking alcohol
Sweet potato	Bum prum	Purple, white roots	Starchy, sweet, hunger alleviation
Taro	Bum Mtrao	Purple, white corms	Starchy, sweet, hunger alleviation
Canna	Bum Mtrao can	Starchy, sweet rhizomes	Starchy, sweet, flavour, hunger alleviation

Variety	Local name	Bio-characteristics	Reason for preference
Banana	Prit	Small, long fruit	Good taste, flavour
Sugarcane	Tao	Green, purple stem	Sweet and soft
Pineapple	Play co	Green, purple	Sweet, flavour
Papaya	Plang mung	Long or round fruit	Sweet, flavour, plenty of fruits
Ginger	Cha	Small rhizomes	Flavour, hot taste
Millet	Oc o	Small, black grain	Good for making alcohol
Small onion	Diem day	Small white tube	Foodstuff, spice
Cucumber	K'pang leo	Small, long fruit	Good taste, crunchy, soft
Chili	Mree	Small, big, long fruit	Hot, good taste
Small garlic	yaut	Round, long fruit	Bitter taste, flavour
Lemon grass	Plang	Small stem and leaf	Flavour, hot
Tobacco	Hat djo	Small and long leaf	Bitter taste, flavour
Thorn chervil	Gil	Small, short leaf	Good flavour, use as spice
Newly introduced crops			
Robusta coffee	Tom ca phe	Big, round, even fruit	Economic purpose
Black pepper	Tieu	Black, small seed	Economic purpose
Cashew	Dieu	Red fruit	Economic purpose
Hybrid corn	Mlo chang	Red-yellow	Economic purpose
Green bean	Tuh il	Big, round seed	Economic purpose
Black been	Tuh	Big, black seed	Economic purpose
Groundnut (peanut)	Tuh neh	Big, long seed	Economic purpose
Watermelon	Biang Kai	Big, round fruit	Good taste, use as beverage
Sesame	Ngunga	Small, black seed	Flavour, eat with sticky rice
Rubber	Cao su		Economic purpose
Avocado	Bo	Big, round fruit	Good taste
Durian	Sau rieng	Big fruit	Economic purpose
Mango	Xoai	Big fruit	Sour, good taste
Other newly introduced fruit trees		Fruit	Economic purpose

Diversity fair

In order to assess the practice of crop diversity and improve people's knowledge about crop diversity, the study group together with the District People Committee and District Extension Office organized a Crop Diversity Contest in November 2001, in Nam Nung. Through the contest, the study group recorded the crop diversity in three participating villages and the results are shown in Table 2.

Table 2. Quantity of crops and varieties presented at Diversity Fair

	Village		
Crop	**Yut Zu**	**Ja Ra**	**R'Kap**
Upland rice	34	33	35
Upland sticky rice	11	9	9
Corn	3	5	7
Bottle gourd	3	3	3
Beans	8	8	10
Corn	5	5	8
Chilli	3	5	4
Fruit plant	6	8	10
Banana	5	4	7
Canna	6	5	9
Sugarcane	3	3	4
Fruit trees	6	8	10
Tuber crops	8	7	9
Other crops	13	9	12
Total	114	110	135

Table 2 shows that in the three studied villages, the number of crops is very large (110–135 different crops). In particular, upland rice and sticky rice are highly diversified. For example, in R'Kap village, there are 35 different varieties of upland rice and 9 different upland sticky rice varieties. Local beans and vegetables are also highly diversified and plentiful. However, this diversity is only based on the external morphological characteristics. The difference of genetic characteristics still needs to be further studied and evaluated.

Diversity of upland rice varieties

In Nam Nung, crop diversity is high, especially for upland rice. A 1995 study showed that there were 64 samples of different upland rice varieties in Krong No District. In order to assess the diversity of upland rice varieties in Nam Nung Commune, the study group collected and described characteristics of upland rice varieties in the three studied villages. There was a difference in number of varieties among the villages (Table 3).

There is a significant difference in growth duration. There are four short-term varieties with a growth duration of 3 months. The major characteristics of this group are early ripening, low quality, hard and non-sticky, and low yield. This group has a high threat of erosion due to early ripening so is easily attacked by birds and rats.

The medium-term group has a growth duration from 4 to 4.5 months. There are four varieties in this group. The cooked rice is hard, but its taste is not so good. However this group gives high yield.

The long-term group has a growth duration from 5.5 to 6 months. This is the main group of varieties cultivated by indigenous people, having very high yield, wide adaptation, good response to fertilizer, but easy lodging on fertile soils. The phenotypic characteristics are diverse and the quality is generally good, it being sticky, of good taste and highly preferred by indigenous people. As a result, this group of varieties has been well taken care of and preserved.

Table 3. Characteristics of upland rice variety collection in Nam Nung Commune

	Characteristics		
Variety	**Visible (morphological)**	**Quality**	**Need improvement**
Short-term crops (3 months)			
Ba Bok	Round grain, short hair	Expanded, not very sticky, low yield	Yield, flavour, taste
Ba Kre	Round grain, short hair	Expanded, not very sticky, low yield	Yield, flavour, taste
Ba Ka	Small grain, hairless	Flavour, not very sticky, expanded	Taste
Ba tal	Small, long grain, hairless	Sticky, not expanded, low yield	Sticky
Medium-term crops (4.5 months)			
Ba ke lao	Large grain, hairless	Not expanded, low yield	Sticky
Ba ke	Small long, hairless	Flavour, sticky, not expanded	Expanded, low stem
Ba ke lang	Hairless, easy break	Not expanded, flavour, sticky, high yield	Expanded
Ba and Dlung	Long grain, yellow, hairless, difficult to break	Not flavour, low yield	Expanded, high yield
Long-term crops (5-6 months)			
Ba ang	Large, long grain, hairless	Flavour, sticky, expanded, high yield	Sticky, flavour

Variety	Characteristics		
	Visible (morphological)	Quality	Need improvement
Ba me ra heh chai	Long hair, large grain, high stem	Hard, expanded, high yield	Sticky, flavour
Ba me heh	Short hair, large round grain, high stem	Hard, expanded, high yield	Sticky, flavour
Ba me chang ra heh	Short hair, difficult to break	Hard, not flavour, expanded, high yield	Sticky, flavour
Ba dak	Long grain, hairy, difficult to break	Hard, expanded, high yield	Sticky, flavour
Ba n'ting	Long, large grain, hairless, difficult to break	Not expanded, sticky, flavour	Expanded
Ba gleh Jung	Large grain, hairless, easy to break	Flavour, expanded, hard	Sticky
Ba prit	Large, round, hair, difficult to break	Hard, high yield	Sticky
Ba krak	Short hair, long curvy grain	Hard, high yield	Sticky
Ba kir	Short hair, ground, flat grain	Hard, high yield	Sticky
Ba n'konh	Large, round grain, hairless, difficult to break, high stem	Hard, expanded, high yield	Sticky, low stem
M' it Kneng	High stem, long grain, brown cover	Sticky, flavour, not expanded, high yield	Expanded, low stem
M' it tonh thai	Small, long grain, hairless, high stem	Sticky, flavour, not expanded	Expanded, low stem
M' it Knen	Small, long grain, hairless, high stem	Sticky, flavour, not expanded	Expanded, low stem
M' it la	Small, long grain, hairless, high stem	Sticky, flavour, not expanded, low yield	Expanded, low stem
M' it nik	Small, long grain, hairless	Sticky, flavour, not expanded, low yield	Expanded, low stem
Ba de	Hairless, easy to break	Expanded, hard, high yield	Sticky, difficult to break
Ba kit	Flat grain, stripe, hairy	Expanded, hard, high yield	Sticky

Distribution of variety groups by household groups

Socioethnic characteristics also affect the activities related to keeping seeds and conservation of upland rice varieties. There is a difference in thought and opinion about variety conservation between high- and low-income groups. The former group has the resources and ability to take care of high-yield crop varieties and animal breeds. In addition, they have enough labour, capital and knowledge to invest in production in order to achieve high yield, good quality and obtain high economic efficiency. In contrast, owing to limited resources the poor have different ways of crop diversity conservation in comparison with the medium- and high-income groups. To prove this argument, the study group has classified the households into three groups—rich, the medium and the poor—using a participatory matrix method. After classification, 90 households in the three villages have been classified by four major rice varieties. The results are presented in Table 4.

Table 4. Upland rice variety distribution by income class in Nam Nung

Variety group	Households use (%)	Households do not use (%)	Household group (%)		
			Rich	Medium	Poor
Hairy rice	86.7	13.3	15.4	23.1	61.5
Short stem rice	33.4	66.6	–	10.0	90.0
Hairless rice	62.6	37.4	20.0	15.0	65.0
Sticky rice	46.7	53.3	28.6	21.4	50.0

The short stem rice has low average yield and bad quality, but is highly adaptable to cultivation conditions. Up to 90% of households in the poor group use and preserve this variety group while the rich group do not do so. Generally speaking, upland rice varieties are grown and preserved by the poor group. The rich group mainly selects and preserves high-quality varieties that are good for traditional activities and customs of the M'Nong minority group such as deaths and seasonal ceremonies. They also tend to grow more new and high-yield varieties that give high economic efficiency.

Identifying popular and potentially threatened crops

The participatory approach at the conservation study site aims to identify valuable crops that need genetic conservation while at the same time identifying the crops strongly affecting household income in order to design a suitable approach for conservation and development. Meetings were organized to identify crop groups that affect economic development and groups that are valuable and need to be preserved (Table 5).

Table 5 shows that the crop groups that are grown by many households in large areas strongly affect the income and living standard of the people in Yuk Yu Village, for example: upland rice, hybrid corn, coffee and new bean varieties. Crop groups that are grown by few people in small areas—for example, very short growth duration upland rice (less than 3 months) and some pharmaceutical material crops like ginger and lemon grass—need to be studied and preserved both *ex situ* and *in situ*.

Table 6 shows that the crop groups grown by many households in large areas for economic purposes in R'Kap Village are upland rice, coffee and new peanut varieties. Crop groups that are grown by few people in small areas are very short growth duration upland rice and some pharmaceutical material and spice crops like ginger, lemon grass, green garlic and garlic, which need to be studied and preserved.

Table 5. Crop groups in Yuk Yu village

Grown by many households with large area	**Grown by many households with small area**
▪ Upland rice (from 5 to 6 months) ▪ Local corn (intercrop with rice) ▪ Hybrid corn (monoculture) ▪ Green bean, groundnut (for sale) ▪ Coffee	▪ Vegetables as foodstuff: bitter fruit plant, chili, squash, cucumber, pumpkins, sweet potato, canna, banana ▪ Local beans as foodstuff: dragon bean, mungbean, red bean, white bean ▪ Tobacco, sugarcane
Grown by few households with large area	**Grown by few households with small area**
▪ Cassava	▪ Short growth duration upland rice variety (less than 3 months) ▪ Pharmaceutical material crop: ginger, lemon grass ▪ Millet

Table 6. Crop groups in R'Kap Village

Grown by many households with large area	**Grown by many households with small area**
• Upland rice (from 5 to 6 months) • Hybrid corn (monoculture) • Green bean, groundnut (for sale) • Coffee	• Vegetables as foodstuff: Chilli, squash, cucumber, pumpkins, sweet potato, canna, green mustard • Local beans as foodstuff: dragon bean, mungbean, red bean, white bean.. • Fruit tree: Bo, mango, durian
Grown by few households with large area	**Grown by few households with small area**
• Upland rice (4.5 months)	• Short term upland rice (less than 3 months) • Pharmaceutical material and spice crop: garlic, green garlic, ginger, lemon grass • Tobacco

Table 7 shows that the crop groups grown by many households in large areas in Ja Ra village are upland rice, hybrid corn and new red bean varieties. Crop groups that are grown by few people in small areas are very short growth duration upland rice, canna, ginger and lemon grass.

Among the three villages, there is a difference in crop distribution and grown area. The Ja Ra Village people have remote fields and more difficult living conditions. The crop groups grown by many people in large areas are mainly based on the natural soil fertility, so they have low productivity. The other villages grow various crops such as coffee, hybrid corn and new bean varieties for income-generation with high investment. This difference is shown through area statistics in 2001 (Table 8).

In Ja Ra Village, upland rice is the major crop, covering 81.6% (165 ha), while coffee and other cash crops such as hybrid corn occupy a very limited area. Yuk Yu and R'Kap Villages have the largest coffee areas: 64 and 58 ha, respectively. The introduction of industrial crops is an important reason for changes and decrease in the diversity of indigenous crops.

Biophysical, ethnocultural and economic aspects of diversity

The goal of conservation of crop genetic diversity of the M'Nong people in Nam Nung Village in particular, and in Daklak in general, is to conserve a combination of crops that have resulted from crop biophysical and natural conditions, as well as ethnocultural and socioeconomic characteristics.

Biophysical characteristics

- The diversity of the natural climate and geotopography have been important factors in the creation of plant species diversity. Each species has a different level of adaptation to local ecological conditions. So, the ability to adapt to severe weather conditions including drought, and the pest and disease resistance of many local crops is generally high.
- The high ability of adaptation to a wide range of soil fertility is expressed through the fact that many varieties can grow in poor soil and can keep high nutritive values, while others can grow in poor soil and still give high yield.
- The early ripening and hairy characteristics of short-duration rice helps to reduce the attack of birds and rats, hence enhancing their diversity.
- Fast growth provides good soil coverage to compete with weeds, creating local microclimates right on the field that help develop the root system.
- The ability of rice to produce antibacterial substances helps control insects and diseases.

Table 7. Crop groups in Ja Ra Village

Grown by many households with large area	Grown by many households with small area
• Upland rice (from 5 to 6 months) • Upland rice (4.5 months) • Local corn (intercrop with rice) • Red bean	• Vegetables as foodstuff: chili, squash, cucumber, pumpkin, canna • Local beans as foodstuff: dragon bean, mung bean • Tobacco, banana, cassava • Wet rice, upland rice (3 months)
Grown by few households with large area	**Grown by few households with small area**
• Hybrid corn • Coffee	• Short term upland rice variety (less than 3 months) • Millet, ginger, lemon grass • Sugarcane • Canna, pod, small tuber

Table 8. Cultivated area of some major crops in the three studied villages

Crop	Yut Zu	Ja ra	R'Kap
Annual crops	48	202	191
Upland rice	25	165	152
Local corn	5	26	22
Hybrid corn	12	1	2
Beans	6	10	15
Perennial crops			
Coffee	64	5	58

Ethnocultural characteristics

- Daklak contains 37 of the 54 ethnic groups in Vietnam. This ethnic diversity creates diversity in crop genetic resources.
- Multiple religions and the holy ceremony customs of minority groups are very rich and diverse. Each ethnic group has different ceremonies, using different plant species and varieties. This is also a very important reason for the high crop diversity in Daklak.
- The custom of using the mother's last name (maternal system) is a special characteristic of M'Nong traditional culture. Traditionally, when the daughter gets married, the mother usually gives her some rice seeds. This is a gift of the holy motherhood and a means for conservation of family unity.

Socioeconomic characteristics

- Most traditional crops are grown based on natural fertility and rainfed conditions with low external investment. As a result, the yield is low but the net benefit and labour efficiency are also relatively high.
- Traditional crops are usually grown in remote areas where it is difficult to transport food so producing local food is still efficient for local people.
- In order to be self-sufficient, people need to produce many different products.
- Many varieties have different growth durations and harvesting times, so they can provide enough food year round and ease the labour requirements.
- Many new high-yielding varieties have been introduced to the area, but with the limited labour, financial resources and technical skills of minority groups, they are not quite suitable and their adoption by the local people is difficult.

Diversity of plant genetic resources

Plant genetic resources are quite rich and diverse, especially in upland rice. This is the genetic diversity of different varieties within the same rice species (*Oryza sativa*), and has been proven through our collecting trips for upland rice varieties (from August to November 1994) in five districts, representing 5 of the 7 ecological regions of Daklak Province. The trips collected 291 rice samples (Table 9). However, at that time it was difficult to keep all these varieties. Efforts must be made to promote the conservation of these valuable plant genetic resources.

Table 9. Result of collecting in five districts of Daklak Province in 1994

District	Lowland	Middle	Upland	No. of samples
Krong Ana	11	22	07	40
Dak Mil	01	03	51	55
Krong Buk	01	38	26	65
Ea Kar	02	44	14	60
Krong No	02	43	26	71
Total	17	150	124	291

Erosion of local genetic resources

Fast increase of industrial crop areas

The economic efficiency of an industrial crop in a land unit is high. That is why the area for industrial crops has increased quickly at the expense of the area for local food crops, especially the upland rice varieties. Many households who have resources are more likely to give up food crops and grow industrial crops. The recent industrial crops area in Daklak Province is presented in Table 10.

Table 10 shows that the area for rubber and coffee has increased significantly (in 8 years, 1990–1998, coffee area has increased by 100 000 ha, averaging a 12 500 ha increase annually). This number is conservative in Daklak Province. The increase in industrial crops means that the forest area is decreasing, and the environment is degrading. The field area for traditional crops is also decreasing owing to the switch to coffee, rubber, etc. All these result in the decrease of the local crop genetic resources.

Besides the increase in coffee planting area, the coffee-harvesting time coincides with that of long-duration upland rice. Owing to the lack of labour, many people give up long-term upland rice cultivation for the sake of the coffee harvest, leading to the loss of this rice group.

Table 10. Area and production of coffee and rubber in Daklak

Year	Coffee		Rubber	
	Area (ha)	Production (MT)	Area (ha)	Production (MT)
1985	10.890	4880	–	–
1990	69.600	28.580	13.957	2.020
1995	131.120	154.590	19.149	4.574
1998	169.630	246.956	25.999	7.887

Conclusions and suggestions

- The crop genetic resources in the studied villages are very rich and diverse. This diversity is dependent on many agroecological and socioeconomic conditions in the region and has numerous precious traits that need to be conserved for food security, sustainable agriculture and rural development.
- At present, the crop genetic resources in Daklak are eroding at an increasing rate because of the introduction of high-yield crop varieties, fast development of industrial trees like coffee and rubber for the sake of income increase, climate changes leading to unexpected loss by drought, floods, forest fire, etc.
- The proper understanding of the abovementioned reasons and the needs for local traditional crops and species may help promote their *in situ* conservation on-farm.

Agromorphological variation of *Trang Tep* rice populations in the Mekong River Delta of Vietnam: role of on-farm conservation

Vo Minh Hai, Huynh Quang Tin and Nguyen Ngoc De

Introduction

Dai An Village is diverse in edaphic conditions in a saline-acid sulphate area of Tra Vinh Province where soil is classified into three main groups: sandy ridge soils, saline-alluvial soils, and saline-acid sulphate soils. Rice production is mostly cultivated in the saline-alluvial and saline-acid sulphate soils and is completely dependent on the rain. Rainfall distribution is usually from May to November with the highest rainfall in September-October (300-400 mm/month) when the water depth is 40–60 cm in the rice fields. Intrusion of saline water is from December to June, and the highest salinity in February-March is 15–20‰ (De 2000).

Local rice is the most important local food crop, and grown over large areas up to 1300 ha (80% of the villages' natural land area). The *Trang Tep* rice variety is specifically adapted to local conditions, hence has been commonly cultivated in more than 80% of the rice area in the whole Dai An Village for a long time. This process is called the "dynamic conservation method" (Bellon *et al.* 1997) because the variety that farmers manage continues to evolve in response to natural and human selection. A recent study (Tin 1998) on genetic differences of *ex situ* and *in situ* rice germplasm showed that most qualitative traits of both populations are the same whereas most quantitative traits and grain quality of *in situ* populations are significantly different from those of *ex situ* populations. Nevertheless, genetic variation among rice populations within the same variety in on-farm conservation has not been studied.

A case study on *Trang Tep* rice variety was conducted at an IPGRI *in situ* project site in Dai An Village, Tra Cu District of Tra Vinh Province of the Mekong Delta to test whether or not there are significant differences in agromorphological characteristics among *Trang Tep* populations that have been conserved in farmers' fields (on-farm conservation).

Methods

Secondary data collection for site selection

The related documents and maps of Dai An Village were collected and analyzed. Based on the administration and soil maps, as well as the crop distribution in the village, the surveys were conducted in six hamlets: Giong Lon A, Giong Dinh, Tra Kha, Cay Da, Me Rach E and Me Rach B where diversity of agroecosystems like soils, cropping patterns and cultural practices were representative for the region where samples were gathered.

Sampling methods

Sixty farms were surveyed in six hamlets. Ten target farms growing the *Trang Tep* variety were chosen for the study. Farm size averaged 3000 m². This ensured adequate measurement of morphological variations of individual plants in the studied populations.

Sample sizes

On each farm an area of 100 m² was randomly selected to observe and classify diversity of plant types in each population (off-type plants or mixed plants). Ten common plants that have the same agromorphological traits with other *Trang Tep* populations were marked at flowering stage to measure and describe their characteristics.

Data collection

- For off-type plants: separation of various kinds of off-type plants and recording mainly morphologically different characteristics to make classification among observed types.

- For common plants: 15 characteristics of each population were measured and described at different times in the field.

Data analysis

- The analysis of variance (F-statistics) of data on quantitative and qualitative characteristics was used to compare differences among each trait in the studied populations. A multivariate Principal Component Analysis (PCA) was carried out using value and full cross-validation of all traits (14 agromorphological variables × 60 populations). The data matrix was standardized, using the MINITAB program version 12.2.
- The cluster analysis of linkage distance of all data (60 populations × 14 traits) was carried out using STATISTICA program version 6.0.

Results

Variations in agromorphological characteristics

Analysis of variance

Fifteen agromorphological characteristics such as leaf length, leaf width, blade colour, culm length, culm strength, panicles per plant, panicle exertion, apiculus colour, grain colour and grain width, described and analyzed among 60 *Trang Tep* populations are almost similar (insignificantly different) in statistical analysis. Five characters are significantly different (Table 1).

- Flowering time: All populations of *Trang Tep* variety are photosensitive, and enter the maturity stage in December to January. Populations of *Trang Tep* in Me Rach B (MRB) hamlet were significantly different at 5% level (P=0.045) from populations in Giong Dinh (GD), Me Rach E (MRE) and Giong Lon A (LA) hamlets (Table 1). Difference in flowering time of these populations may be a consequence of changing cropping patterns and planting times: one rice crop per year in MRE hamlet but two rice crops per year in other hamlets.
- Flag leaf angle: The flag leaf angle usually is a varietal characteristic and stable over time. In intensive cultivation, the varieties with horizontal flag leaf angle will not be suitable. Therefore, *Trang Tep* populations in CD hamlet could be selected for improvement of this trait. The observed flag leaf angle varied from code 1 to code 3 (erect to intermediate) and was significantly different at 1% level (P=0.000) from the populations in other hamlets (code 5 or equal to horizontal leaf angle), except those populations in MRE hamlet.
- Panicle length: Panicle length varied among populations of different hamlets. Panicle length of the *Trang Tep* populations in GD hamlet (24.4 cm) significantly differed at 1% level (P=0.000) from those in CD and LA hamlets (22.1 cm and 22.5 cm, respectively), but was insignificantly different from the populations in MRE, MRB and TK hamlets.
- Grain characteristics: Grain shape of *Trang Tep* variety is round and averages around 8 mm long. The average grain length of *Trang Tep* populations in Tra Kha (TK) hamlet was longer (8.7 mm) and significantly different at 5% level (P=0.012) from the populations in GD and LA hamlets. The 1000-grain weight among populations differed very little (0.9 g). However, the 1000-grain weight of the *Trang Tep* populations in Cay Da (CD) hamlet was different at 1% level from that of the populations in GD and MRB hamlets. Grain size is also a varietal characteristic but is influenced by environmental and cultural conditions. Differences in grain length and grain weight could be affected by a farmer's distinctive cultural practices, soil fertility or pest and disease damage.

Table 1. Analysis of variation for morphological traits of *Trang Tep* populations

Character	Average values of populations in the studied hamlets†						F	P
	TK	GD	MRE	CD	LA	MRB	value	Value
Flowering time (Thangs sau gieo)	2.5	2.6	2.6	2.4	2.6	2.0	2.45*	0.045
Flag leaf angle (code)	4.2	4.4	4.4	2.4	4.2	2.8	5.36**	0.000
Panicle length (cm)	23.6	24.4	23.2	22.1	22.5	23.2	5.79**	0.000
Grain length (mm)	8.7	8.1	8.6	8.3	8.1	8.3	3.24*	0.012
1000-grain weight (g)	23.3	22.6	23.3	23.5	23.4	22.6	3.38**	0.010

* significant at 5% level; ** significant at 1% level.

† TK=Tra Kha; GD=Giong Dinh; MRE=Me Rach E; CD=Cay Da; LA=Giong Lon A; MRB=Me Rach B.

Linkage distances

The dendrogram in Figure 1 shows the relationship between populations. Clusters are joined by the close distance between them and the corresponding similarity level. Sixty populations of *Trang Tep* variety were clustered in 14 morphological characteristics (variables).

Figure 1 reveals populations which could be combined by very small linkage distance (TK1 and TK6), whereas TK2 and MRB9 populations were very distinctive in linkage distance: 1.1 and 6.5, respectively. Differences in linkage distances among clusters related to similarity or dissimilarity levels in morphological traits among populations. In general, a small linkage distance between populations exposes their high similarity level.

Multivariate analysis (principal component analysis = PCA)

Principal component analysis was used to understand the underlying data structure of uncorrelated variables. It is evident from previous descriptions that changes were observed for certain variables when analyzed individually. Figure 2 reveals distribution of variations from their distant positions in the dendrogram. Most variables clustered closely to the centre.

The first principal component had a variation value (Eigen value) of 1.9512 and explained the 13.9% difference among related variances. The coefficients listed under PC1 show how it was calculated. It is related mainly to correlated variables: number of panicles per plant, apiculus colour, grain weight, culm strength vs. culm length, leaf width, etc. On the other hand, the (—) coefficients expressed the homogeneity. The principal components 2nd, 3rd and 4th consisted of variance values (Eigen value) greater than 1.4644 and accounted for more than 10.6% of the difference between related and unrelated variances for each component.

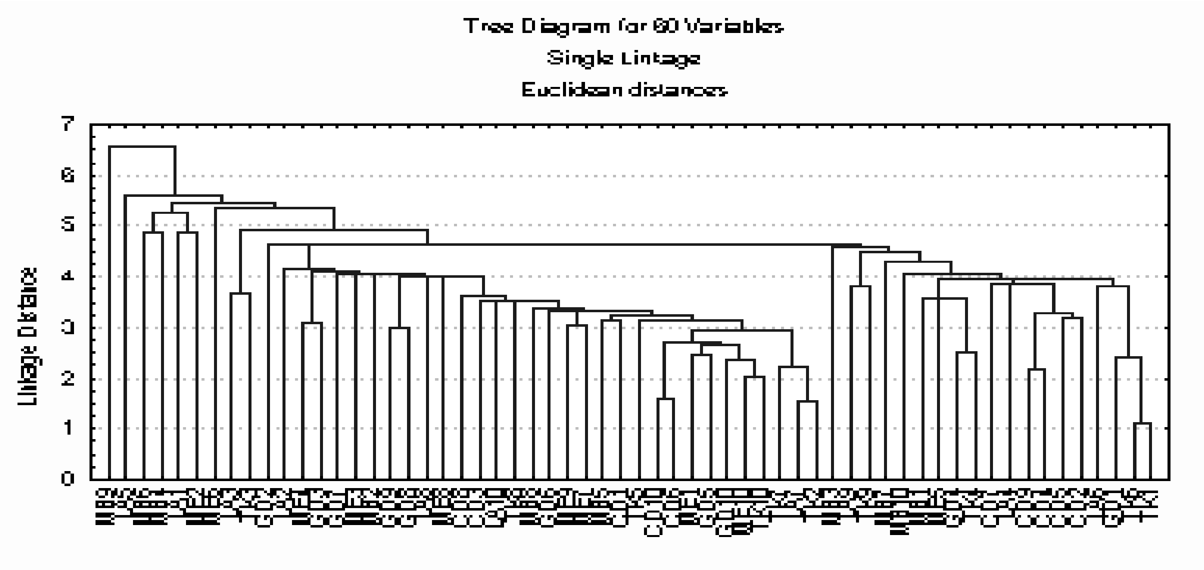

Figure 1. Dendrogram of 60 *Trang Tep* populations based on 14 morphological variables.

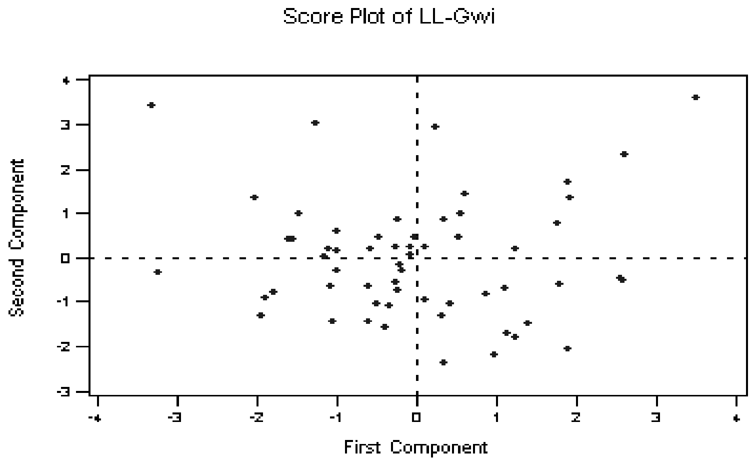

Figure 2. Diagram of principal component analysis of 60 populations based on 14 variables.

Together, four principal components represented 48.7% of the total variability that could differ among populations. Thus, most of the data structure can be captured in some underlying variations. The remaining principal components account for a very small proportion of the variability and are probably unimportant (or not significantly different).

Diversity of plant types in populations

The plants having any abnormal or different traits from common plant population are called "off-type plants". Nine kinds of off-types were found (Table 2) of which five appeared commonly in all populations (A, B, C, D, F and G).

In general, types A and B have high a occurrence ratio (6.28% and 7.36%, respectively) vs. the off-type K that was found only in CD and LA hamlets (0.01% per each) (Table 3).

Diversity of off-type plants in *Trang Tep* populations varied in each hamlet. Eight kinds of off-type plants appeared in all populations, except MRB hamlet with seven kinds. The presence frequency of each off-type was different in various hamlets. Type B had highest rate (2.21%) in Tra Kha and 1.85% in MRE; type A rated 1.90% in CD hamlet. The smallest rate of off-type plants (0.001%) was found in GD hamlet with types C and H. Otherwise, the populations of *Trang Tep* variety in GD hamlet (1.65%) were more uniform in phenotype than populations in the other hamlets.

Table 2. Description of nine different plant types found in *Trang Tep* populations in Dai An Village

Plant type	Description
A	Black apiculus
B	Tall and strong stem (140–165 cm), dark green leaf sheath, large panicle
C	Opened panicle, tall stem (12–145 cm), narrow leaf blade
D	Lemma and palea have purple furrows on straw colour
E	Lemma and palea have purple furrows on straw colour, brown apiculus
F	Brown lemma and palea, purple sterile lemma
G	Tall stem (140–160 cm), green, wide and short leaves, large panicle and bold grain
H	Short stem, dark green leaf sheath, short and partly awned grain, purple sterile lemma
K	Opened panicle, lemma and palea have purple furrows on straw colour, black apiculus

Table 3. Average percentage of mixed plants in *Trang Tep* populations per hamlet

Hamlet[†]	Kind of off-type plants									Total
	A	B	C	D	E	F	G	H	K	
CD	1.90	0.002	0.29	0.27		0.08	0.03	0.01	0.01	2.59
GD	0.28	0.60	0.001	0.185	0.33	0.12	0.14	0.001		1.66
GLA	0.90	1.50	0.02	0.03	0.43	0.14	0.01		0.01	3.04
MRB	0.71	1.20		0.01	0.31	0.04	0.06	0.01		2.33
MRE	1.04	1.85	0.02	0.04	0.07	0.22	0.37	0.002		3.62
TK	1.45	2.21	0.02	0.07	0.10	0.04	0.03	0.05		3.97
Total	6.28	7.36	0.35	0.60	1.24	0.64	0.64	0.06	0.02	

[†] TK=Tra Kha; GD=Giong Dinh; MRE=Me Rach E; CD=Cay Da; LA=Giong Lon A; MRB=Me Rach B.

Discussion

Within each crop, genetic diversity in a system depends on the varieties or landraces grown. At this level we need to know the genetic diversity within variety, and its spatial and temporal distribution. This study shows all on-farm populations at the village scale. Differences in observed agromorphological characteristics were found among populations in the traits of flowering time, flag leaf angle, panicle length, grain length and grain weight. It could be due to sampling errors or effects of *in situ* conditions (farmer's management) that the population structure has been changed as a response to selection and cropping pattern changes.

Farmer's selection methods have not been systematically studied in relation to this study. However, information provided by the farmers in GD hamlet indicates that mass selection is annually used to maintain phenotypic uniformity. This reflects a small ratio of off-type plants within the populations in GD hamlet (1.66% in Table 3). In addition, selection criteria also may be important to identify a new population to adapt to changes in intensive cultivation conditions as the flag leaf angle of almost all *Trang Tep* populations in CD hamlet has been improved (possessing erect or intermediate angle, instead of horizontal angle).

Changes in cropping patterns and associated change in planting time have resulted mainly in later flowering. All *Trang Tep* populations are influenced by photosensitivity in terms of flowering time. They usually flower in November and are harvested in December before saline water penetrates into the field. Therefore, the change to two rice crops per year in TK, GD, LA, MRE and CD hamlets delayed the planting time, leading to later flowering (more than 30 days) than in MRB hamlet with one rice crop per year.

Environmental conditions can directly affect the quantitative and qualitative traits between populations like the grain weight and grain size in this study. Almost all populations in TK and MRE hamlets have longer and heavier grains than populations in other hamlets because they were grown after dryland crops (first crop) like soyabean, groundnut or taro and sweet potato while the *Trang Tep* populations in MRB hamlet were grown in poor fertility soils and saline-acid sulphate soils.

Conclusion

The value of crop genetic resources depends on two diversity aspects: genetic diversity and adaptation *in situ*. This study demonstrated evidence that on-farm conservation of *Trang Tep* populations has evolved to adapt to growing conditions at Dai An Village. The agromorphological traits are significantly different among populations in various agroecosystems.

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Preliminary study of genetic diversity in rice (*Oryza sativa* L.) by isozyme analysis

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Introduction

Intraspecific variation in *Oryza sativa* L. is remarkably extensive and subspecific classification has always been a matter of importance for rice breeders and geneticists (Glaszmann 1987). The classification of cultivated rice (*O. sativa*) into *indica* and *japonica* subspecies contributes significant value for germplasm conservation activities as well. Oka (1958) classified rice germplasm into *indica* and *japonica* based on seed reaction to phenol solution and other morphological traits.

In the 1960s, isozyme analysis was found and developed. Isozyme analysis has provided valuable tools for rice geneticists to better understand the genetic structure of rice. Recently, isozyme identification has often been applied for the classification of rice varieties. Glaszmann (1987) identified six groups among 1688 traditional rices from Asia by using 15 polymorphic loci coding for eight enzymes. Other authors such as Second (1982) and Nakagahra (1977) also used isozymes to classify and evaluate the genetic diversity of rice.

In the present study five loci coding for three enzymes were used to analyze 11 local rice varieties collected from Nho Quan District, Ninh Binh Province and 44 rice landraces collected from Da Bac District, Hoa Binh Province.

Materials and methods

Materials

Fifty-five rice varieties collected from Nho Quan District, Ninh Binh Province and from Da Bac District, Hoa Binh Province were subjected to isozyme analysis. Two varieties were used as control: Mahue (*japonica*) and IR36 (*indica*).

Methods

Sample preparation

Ten seeds of each variety were put in each Petri dish lined with moist filter paper; then the dishes were placed in an incubator at 30°C for 5–10 days. The young leaves of three seedlings were cut into small pieces and ground in a solution of 0.01% Mecaptoethanol. Small strips of Whatman No.3 filter paper were placed in each depression to absorb crude extract. The paper strips were then inserted side-by-side on 12% starch gel (gel buffer: 0.0085M Trizma base; 0.0015M Histidine-HCl; pH8.0).

Electrophoresis

Electrophoresis was run at 50mA and 180V for 5 h in buffer solution (0.4M Trizma base; 0.1M citric acid; pH8.0).

Staining

The staining procedures were described by Glaszmann *et al.* (1988). Three enzymes were stained including: Phosphoglucose isomerase (0.29M Fructo-6-phosphate, 0.5M Tris-HCl buffer pH8.5, 0.1M MgCl2, 10 units Glucose-6-phosphate dehydrogenase, 0.024M MTT, 0.003M PMS), Leucine aminopeptidase (0.017M L-Leucyl-β-napthylamide, 0.2M Tris maleate buffer pH3.3, 0.0007M Fast black K salt), Arginine aminipeptidase (0.015M L-Arginyl-β-naptylamide, 0.2M Tris maleate buffer pH3.3, 0.0007M Fast black K salt).

Data analysis

Analysis was done using a simplified method to classify rice varieties developed by Glaszmann (1987) and with software of the NTSYS (Numerical Taxonomy System).

Results and discussion

Identifying alleles of loci

Bands of alleles were scored as numerical number when present and were compared with the alleles of control varieties IR36 and Mahue. The results are shown in Table 1.

There are two alleles ($Pgi\text{-}1^1$ and $Pgi\text{-}1^2$) in the *Pgi-1* locus, three alleles ($Pgi\text{-}2^1$, $Pgi\text{-}2^2$ and $Pgi\text{-}2^3$) in the *Pgi-2* locus, three alleles ($Amp\text{-}1^1$, $Amp\text{-}1^2$ and $Amp\text{-}1^3$) in the *Amp-1* locus, three alleles ($Amp\text{-}3^1$, $Amp\text{-}3^2$ and $Amp\text{-}3^4$) in the *Amp-3* locus and two alleles ($Amp\text{-}4^1$ and $Amp\text{-}4^2$) in the *Amp-4* locus (Table 1). In all loci, apart from predominant alleles there are other alleles. For example, at the *Amp-3* locus, not only is $Amp\text{-}3^1$ a predominant allele but also $Amp\text{-}3^2$ and $Amp\text{-}3^4$ alleles. This result indicates that there is a difference of alleles among analyzed varieties in the same locus.

Table 1. Allele analysis of loci (*Pgi-1*, *Pgi-2*, *Amp-1*, *Amp-3*, *Amp-4*) among the investigated varieties

Code	Variety name	Place collected	Pgi		Amp-1	Amp-3	Amp-4
			Pgi-1	Pgi-2			
1M	Mahue		2	1	3	1	1
2M	IR36		1	2	1	1	1
3K	Bao thai	Doan Ket, Da Bac	1	2	1	1	1
3N	Bao thai	Nho Quan	1	2	1	1	1
3T	Bao thai	Tan Minh, Da Bac	1	2	3	4	2
4K	Bao thai trang	Doan Ket, Da Bac	1	1	1	1	1
5T	Ca lan	Tan Minh, Da Bac	2	1	1	1	1
6T1	Ca lan danh	Tan Minh, Da Bac	2	1	1	1	1
6T3	Ca lan danh	Tan Minh, Da Bac	2	1	1	1	1
6T4	Ca lan danh	Tan Minh, Da Bac	2	1	1	1	1
7T1	Ca lan khao	Tan Minh, Da Bac	2	1	1	1	1
7T2	Ca lan khao	Tan Minh, Da Bac	2	1	1	1	1
8K	Cai hop	Doan Ket, Da Bac	2	1	1	1	1
9K	Cao su	Doan Ket, Da Bac	2	1	1	1	1
9T1	Cao su	Tan Minh, Da Bac	2	1	1	1	1
9T2	Cao su	Tan Minh, Da Bac	2	1	1	1	1
10T	Cong ton	Tan Minh, Da Bac	2	1	1	1	2
11T	Chiem den	Tan Minh, Da Bac	1	1	1	1	1
12K	Dam ca	Doan Ket, Da Bac	2	1	1	4	1
14Y	Du nghen	Yen Quang, Nho Quan	2	4	1	4	1
17T	Hang don	Tan Minh, Da Bac	2	1	3	1	1
21D	Khau ca lan danh	Doan Ket, Da Bac	2	1	3	1	1
22T	Khau cam pi	Tan Minh, Da Bac	2	1	1	1	1
25D	Khau hang mu	Doan Ket, Da Bac	1	2	1	1	1
26T	Khau he	Tan Minh, Da Bac	1	2	2	1	2
27K	Khau ke de nieu	Doan Ket, Da Bac	2	1	1	1	1
28T	Khau ke de tram	Tan Minh, Da Bac	2	1	3	2	2
34D2	Khau lech luong	Doan Ket, Da Bac	2	1	1	1	1
35D1	Khau mac cai	Doan Ket, Da Bac	2	1	1	1	1
38D	Khau nam	Doan Ket, Da Bac	2	1	3	1	1
36K	Khau mon	Doan Ket, Da Bac	2	1	1	1	1
38K	Khau nam	Doan Ket, Da Bac	2	1	3	2	2
41D	Khau thuong hai	Doan Ket, Da Bac	1	2	1	1	1
41K	Khau thuong hai	Doan Ket, Da Bac	2	3	1	2	1
44T1	Mac buom	Tan Minh, Da Bac	2	1	1	1	1
48N	Moc tuyen	Nho Quan	1	1	1	2	1
48Y	Moc tuyen	Yen Quang, Nho Quan	1	1	1	2	1

Code	Variety name	Place collected	Pgi		Amp-1	Amp-3	Amp-4
			Pgi-1	Pgi-2			
49T	Nam ma	Tan Minh, Da Bac	2	1	1	1	1
52N	Nep cau	Nho Quan	2	1	1	1	1
53K	Nep cam	Doan Ket, Da Bac	1	1	1	2	1
54N	Nep ®oi	Nho Quan	2	1	1	1	1
56N	Nep ken ken	Nho Quan	2	1	3	2	2
59Q	Nep rau	Quang Mao, Nho Quan	2	1	1	2	1
60Y	Nep se	Quang Mao, Nho Quan	2	1	1	1	1
60Q	Nep se	Quang Mao, Nho Quan	2	1	1	1	1
63N	Nep vang ong	Nho Quan	1	2	1	1	1
66T	Tang san	Tan Minh, Da Bac	1	2	1	2	1
68K	Tram con dau	Doan Ket, Da Bac	1	1	1	1	1
69K	Tram he	Doan Ket, Da Bac	2	1	3	1	2
71K2	Tram khao	Doan Ket, Da Bac	2	1	3	1	1
71T1	Tram khao	Tan Minh, Da Bac	2	1	3	1	1
71T2	Tram khao	Tan Minh, Da Bac	2	1	3	1	1
72T	Tram luong	Tan Minh, Da Bac	2	1	1	1	1
73T	Tram muom	Tan Minh, Da Bac	2	1	3	1	1
74T	Tram nanh	Tan Minh, Da Bac	2	1	1	1	1
75T	Tram pom	Tan Minh, Da Bac	2	1	1	1	1
77T	Tram sai	Tan Minh, Da Bac	2	1	1	1	1

For rice varieties of Dabac District, the *Pgi-1*^{2}, *Pgi-2*^{1}, *Amp-1*^{1}, *Amp-3*^{1} and *Amp-4*^{1} alleles are predominant alleles which are found in *japonica* rice. In addition, there are other alleles such as *Pgi-2*^{3} (2.27%), *Amp-1*^{2} (2.27%) and *Amp-3*^{4} (4.54%) which are of very low frequency.

Classifying rice varieties by simplified method

The results of classifying varieties by simplified method are presented in Table 2. The results show that most of the analyzed varieties are *japonica* rices (67.27%), the *indica* rices comprise 27.27%, and the rest are in the intermediate group.

Table 2. Group classification based on simplified method of Glaszmann (1987)

Code	Variety name	Place collected	Group	Remarks
1M	Mahue		*Japonica*	Tester variety
2M	IR36	Doan Ket, Da Bac	*Indica*	Tester variety
3K	Bao thai	Nho Quan	*Indica*	
3N	Bao thai	Tan Minh, Da Bac	*Indica*	
3T	Bao thai	Doan Ket, Da Bac	*Indica*	
4K	Bao thai trang	Tan Minh, Da Bac	*Indica*	
5T	Ca lan	Tan Minh, Da Bac	*Japonica*	
6T1	Ca lan danh	Tan Minh, Da Bac	*Japonica*	
6T3	Ca lan danh	Tan Minh, Da Bac	*Japonica*	
6T4	Ca lan danh	Tan Minh, Da Bac	*Japonica*	
7T1	Ca lan khao	Tan Minh, Da Bac	*Japonica*	
7T2	Ca lan khao	Doan Ket, Da Bac	*Japonica*	
8K	Cai hop	Doan Ket, Da Bac	*Japonica*	
9K	Cao su	Tan Minh, Da Bac	*Japonica*	
9T1	Cao su	Tan Minh, Da Bac	*Japonica*	
9T2	Cao su	Tan Minh, Da Bac	*Japonica*	
10T	Cong ton	Tan Minh, Da Bac	*Japonica*	
11T	Chiem den	Doan Ket, Da Bac	*Indica*	
12K	Dam ca	Yen Quang, Nho Quan	*V*	Group maintained Ngokywe and Bosmati 370
14Y	Du nghen	Tan Minh, Da Bac	*V*	Group maintained Ngokywe and Bosmati 370
17T	Hang don	Tan Minh, Da Bac	*Japonica*	
21D	Khau ca landanh		*Japonica*	

Code	Variety name	Place collected	Group	Remarks
22T	Khau cam pi	Tan Minh, Da Bac	*Japonica*	
25D	Khau hang mu	Doan Ket, Da Bac	*Indica*	
26T	Khau he	Tan Minh, Da Bac	*Indica*	
27K	Khau ke de nieu	Doan Ket, Da Bac	*Japonica*	
28T	Khau ke de tram	Doan Ket, Da Bac	*Japonica*	
34D2	Khau lech luong	Doan Ket, Da Bac	*Japonica*	
35D1	Khau mac cai	Doan Ket, Da Bac	*Japonica*	
36K	Khau mon	Doan Ket, Da Bac	*Japonica*	
38D	Khau nam	Doan Ket, Da Bac	*Japonica*	
38K	Khau nam	Doan Ket, Da Bac	*Indica*	
41D	Khau thuong hai	Doan Ket, Da Bac	*Indica*	
41K	Khau thuong hai	Tan Minh, Da Bac	*II*	Group maintained Dulor, N22
44T1	Mac buom	Nho Quan	*Japonica*	
48N	Moc tuyen	Yen Quang, Nho Quan	*Indica*	
48Y	Moc tuyen	Tan Minh, Da Bac	*Indica*	
49T	Nam ma	Nho Quan	*Japonica*	
52N	Nep cau	Doan Ket, Da Bac	*Japonica*	
53K	Nep cam	Nho Quan	*Indica*	
54N	Nep ®oi	Nho Quan	*Japonica*	
56N	Nep ken ken	Quang Mao, Nho Quan	*Japonica*	
59Q	Nep rau	Quang Mao, Nho Quan	*Japonica*	
60Y	Nep se	Yen Quang, Nho Quan	*Japonica*	
60Q	Nep se	Nho Quan	*Japonica*	
63N	Nep vang ong	Tan Minh, Da Bac	*Indica*	
66T	Tang san	Doan Ket, Da Bac	*Indica*	
68K	Tram con dau	Doan Ket, Da Bac	*Indica*	
69K	Tram he	Doan Ket, Da Bac	*Japonica*	
71K2	Tram khao	Tan Minh, Da Bac	*Japonica*	
71T1	Tram khao	Tan Minh, Da Bac	*Japonica*	
71T2	Tram khao	Tan Minh, Da Bac	*Japonica*	
72T	Tram luong	Tan Minh, Da Bac	*Japonica*	
73T	Tram muom	Tan Minh, Da Bac	*Japonica*	
74T	Tram nanh	Tan Minh, Da Bac	*Japonica*	
75T	Tram pom	Tan Minh, Da Bac	*Japonica*	
77T	Tram sai	Tan Minh, Da Bac	*Japonica*	

Classifying rice varieties by NTSYS

To compare with the simplified method, we scored the bands and classified rice varieties by NTSYS. The results showed that there is a similarity of isozyme loci among rice varieties.

A tree diagram showed that there are two main groups at the similar coefficient of 0.696, including the first group and control variety Mahue (1M–*japonica* rice). The second group resembles *IR36* (2M) which is a tester variety of *indica* rice. This result shows that most of the analyzed varieties are of the *japonica* group. Thus, we could use both methods for classifying rice varieties.

Conclusion

- There are allele differences among the studied rice varieties in the same locus.
- Da Bac rice varieties have alleles characterizing the *japonica* subspecies.
- Of 48 studied varieties, most varieties belong to *japonica*, some belong to *indica*, 2 and 1 belong to V and II groups, respectively.
- The group classification by software NTSYS combined with the simple method will accurately describe the isozyme.
- There is significant diversity among the studied rice varieties. Upland rice is more diverse than lowland rice.

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Chapter 3. Farmers' management practices for maintaining rice and taro diversity

Farmer management of crop diversity in coastal agroecosystems of Hue region, Vietnam

Le Thieu Ky, Truong Van Tuyen and Nguyen Thi Lan

Introduction

Agrobiodiversity can be defined as a part of biodiversity on which man directly depends for food, fuel and fiber, including plants, animals, trees and other organisms that are of direct importance to agricultural production development.

Diversity in general and that of crops in particular brings about many benefits, for example, limiting the risks and sensitivity to natural calamities, pests and diseases, and maintaining food security. Genetic diversity is the basis for varietal selection and improvement, making the most use of resources available and maintaining the agroecological balance in a stable and sustainable way.

Coastal agroecosystems are characterized by adverse and diverse agroecological conditions such as sandy and poor-fertility soil, marine effects and climate fluctuation. The main constraint for agriculture is the lack of water in the dry season and often severe flooding in the wet season. Therefore, the cropping time in a year is short. The local villagers are accustomed to growing various crops or varieties to make full use of the land and to meet their increasing needs. The main income source of farmers is rice and animal production. Rice intensification and agricultural diversification have strong impacts on rice and crop diversity.

Research objectives (mainly on rice)

- To identify changes in rice diversity in an integrated area (Phu Da) and an isolated area (Quang Thai) within the coastal agroecosystem
- To assess changes in socioeconomic factors related to rice diversity
- To understand the roles of community groups, services and agrosupports for rice production favouring rice diversity conservation
- To build awareness of rice diversity and on-farm conservation value.

Research methodology

Research sites

To build on the research findings in 1996 of IRRI and Hue University of Agriculture and Forestry through survey, collection and experiments on characterization of rice varieties in the Central coast, in 2001 we conducted research in the same sites (Quang Thai and Phu Da). Quang Thai is representative for the coastal area, 50 km NE from Hue. Phu Da is near the city, comfortable for transportation, and about 20 km SE of Hue. The population density in Phu Da is higher than that of Quang Thai. The two are located in sandy areas along the coast, where lots of difficulties in peoples' livelihood have existed for a very long time. Irrigation relies only on the rainwater. The main income source is agriculture (rice) and 90% are pure farming HHs.

Research methodology

Participatory tools were used for involving farmers’ participation in data collection and assessment: group discussions, semi-structured survey, mapping and observation. In each site, 3 villages were selected, and 20 HHs randomly chosen for the survey in each village.

Meetings, training and community-based activities, e.g. set up working mechanism at village, diversity contests organized to improve the local peoples' awareness of crop diversity.

Research findings

General information

Climate conditions
Thua Thien Hue is located in a monsoon tropical region. The rainfall is 2930 mm per year, concentrated in September, October, November and December. Storms and flood often occur on *Tiet tieu man* (May 21) and end after October 23 of the lunar calendar.

The annual average temperature is over 25°C. In winter/spring growing season, the temperature sometimes falls to 10°C, affecting rice blossom. In contrast, in the summer season, the rice crop is abortive with low and unstable yield due to the hot southwest wind and the temperature may rise to higher than 40°C.

Socioeconomic information at the research sites

	Quang Thai	Luong Vien Village – Phu Da
Location	About 50 km NE from Hue; far from the market; uncomfortable transportation	About 20 SE from Hue; near the market; comfortable transportation
Soil type	Sandy, sandy loam	Sandy soil (100% sand)
Key crops	Rice, then peanut, chili, tobacco, sweet potato, sesame, taro	Crops are diversified with rice, taro, chili, potato and all kinds of vegetables
Rice-growing area	60.3 ha	–
Growing season	Winter/spring: 36.3 ha (25 ha of modern varieties and 11.3 ha of traditional varieties) Summer: 24 ha (mainly of traditional varieties)	Winter/spring: 62 ha of rice Autumn/summer: 1.5 ha of rice
Soil	Sandy area: 200 ha (farmland)	Rich soil: 33 ha
Household number	143; over 90% are farming HHs	272; 95% are farming HHs
Poverty level	35% poor HHs, 65% medium HHs	21% poor, 75% medium and 4% better-off HHs.
Attitude	Eager to learn and to cooperate with scientists, technicians, etc.	Eager to learn and to cooperate with scientists, technicians, etc.

Research findings
It can be seen from Table 1 that:

- In winter/spring and summer seasons, the total number of varieties in Quang Thai and Phu Da has decreased since 1996, especially the traditional varieties.
- The distribution of modern varieties in each household has a tendency to increase, while the reverse is true for the local ones.
- Number of HHs using modern varieties less than 50% has also decreased, and consequently the traditional varieties become rarer and rarer.

So, research for facilitating conservation of rice varieties diversity on farm is an urgent issue.

Table 1. Rice varieties used at community and landscape level for different growing seasons

Criteria	Quang Thai		Phu Da		Total	
	1996	2001	1996	2001	1996	2001
Winter/spring growing season						
Total number of variety names	15	13	23	19	31	25
Number of modern varieties (MV)	9	8	12	12	17	14
Number of traditional varieties (TV	6	5	11	7	14	9
MV distribution range (# HHs/ MV)	1–12	1–41	1–5	1–33	1–12	1–74
TV distribution range (# HHs/ TV)	1–15	1–17	1–25	1–3	1–24	1–20
Number of rare MV (≤5% HHs)	5	6	11	9	11	13
Number of rare TV (≤5% HHs)	1	4	7	7	5	7
Summer growing season						
Total number of variety names	18	6	14	4	30	8
Number of modern varieties (MV)	16	5	7	4	21	7
Number of traditional varieties (TV)	2	1	7	0	9	1
MV distribution range (# HHs/ MV)	1–19	1–35	1–6	1–8	1–25	1–43
TV distribution range (# HHs/ TV)	2–23	37	1–3	–	1–37	37
Number of rare MV (≤5% HHs)	12	3	5	3	17	5
Number of rare TV (≤5% HHs)	1	0	7	–	8	0

The data in Table 2 show that in the 1996 winter/spring growing season in Quang Thai and Phu Da, the number of HHs growing many varieties per season was high (although the proportion was not the same). The proportion of HHs growing 2–3 varieties was higher and the highest was that of HHs (80.5%) growing 2 varieties in 2001 in Quang Thai. In 1996 the proportion of HHs not growing rice in summer season was highest (47.5%) in Quang Thai, but the peak of that (70%) was observed in 2001 in Phu Da.

The data in Table 3 indicate that in 1996, the percentage of HHs in Quang Thai growing 1–2 modern rice varieties per season was 61%, and those not growing modern varieties accounted for 39%. In 2001, 100% of HHs grew 2–3 modern rice varieties per season, while the number of HHs growing 1 variety accounted for a greater percentage with time. In summer 1996, the percentage of HHs in Phu Da growing the traditional rice varieties was 50%, equal to those growing modern varieties. In 2001, the number of modern varieties grown increased from 1 to 4 per household and the proportion of HHs growing 1 modern variety increased to 85% and 100% in Quang Thai and Phu Da, respectively. As a result, there was no place for traditional varieties, and their genetic erosion is inevitable. So, it is necessary to conduct research for conservation of traditional varieties diversity.

Table 2. Rice varieties used at household level for different growing seasons in the coastal ecology of Hue region, Vietnam

HH category	Quang Thai		Phu Da	
	1996	2001	1996	2001
Winter/spring growing season	N = 41	N = 41	N = 40	N = 40
Growing 1 variety (% of N)	7.3	19.5	7.5	25.0
Growing 2 varieties (% of N)	19.5	46.3	42.5	47.5
Growing 3 varieties (% of N)	48.8	26.8	32.5	20.0
Growing 4 varieties (% of N)	14.6	7.3	17.5	5.0
Growing 5 varieties (% of N)	9.8	0.0	0.0	2.5
Summer growing season	N = 41	N = 41	N = 40	N = 40
Growing 1 variety (% of N)	4.9	7.3	40.0	30.0
Growing 2 varieties (% of N)	48.8	80.5	12.5	0.0
Growing 3 varieties (% of N)	34.1	9.8	0.0	0.0
Growing 4 varieties (% of N)	12.2	0.0	0.0	0.0
Not growing summer rice	0.0	2.4	47.5	70.0

Table 3. Modern rice varieties used at household level in the winter/spring and summer/autumn seasons in the coastal ecology of Hue region, Vietnam

HH category	Quang Thai		Phu Da	
	1996	2001	1996	2001
Growing MV in winter/spring rice season	N = 41	N = 41	N = 40	N = 40
Growing 1 MV (% of N)	39.0	56.1	35.0	32.5
Growing 2 MVs	22.0	39.0	12.5	50.0
Growing 3 MVs	0.0	4.9	2.5	15.0
Growing 4 MVs	0.0	0.0	0.0	2.5
Not growing MV	39.0	–	50.0	–
Growing MV in summer rice season	N = 41	N = 41	N = 21	N = 21
Growing 1 MV (% of N)	53.7	85.0	61.9	100.0
Growing 2 MVs	34.1	12.5	9.5	0.0
Growing 3 MVs	12.2	0.0	0.0	0.0
Not growing MV	–	2.5	28.6	–

Table 4 shows that in winter/spring growing season, the proportion of HHs growing 1 traditional variety per season was higher than that of those growing 2–3 varieties/season. When the number of varieties per season increased, the proportion of HHs growing them decreased significantly, even to 0%. In short, there is a clear trend of decreasing the number of traditional varieties by space and time. So, our suggestion again is to pay immediate attention to conservation of local rice germplasm.

***In Quang Thai*:** in 1996 farmers' concerns were yield, time for growing, growth duration and salinity tolerance, then disease and insect resistance and submersion tolerance, etc. In 2001, the most important concern was rice yield capacity, followed by growth, yield stability, disease resistance and finally the grain quality (Table 5).

In Phu Da: yield and yield stability were the most important concerns, then drought tolerance and disease resistance.

In order to provide service and support for rice production in the regions of the coastal ecology, it is necessary to have the close coordination and cooperation of many related departments and branches such as farming HHs, cooperatives, people who have the same interests, scientists, credit bank, decision-makers, etc. (Table 6).

Decisions related to rice production are different in different ecological areas (Table 7). In Quang Thai 70% of decisions depended on cooperatives, the rest (30%) depended on farmers. In Phu Da decisions related to rice production were 90% dependent on HHs and

Table 4. Traditional varieties used at household level in winter/spring and summer growing seasons in the coastal ecology of Hue region, Vietnam

HH category	Quang Thai		Phu Da	
	1996	2001	1996	2001
Growing TV in winter/spring rice season	N = 41	N = 41	N = 40	N = 40
Growing 1 TV (% of N)	22.0	58.5	40.0	15.0
Growing 2 TVs	46.3	7.3	32.5	5.0
Growing 3 TVs	26.8	0.0	22.5	0.0
Growing 4 TVs	4.8	0.0	5.0	0.0
Not growing TV	0.0	34.1	0.0	80.0
Growing TV in summer rice season	N = 41	N = 41	N = 21	N = 21
Growing 1 TV (% of N)	90.2	92.5	33.3	0.0
Growing 2 TVs	2.4	0.0	4.8	0.0
Not growing TV	7.3	7.5	61.8	100.0

Table 5. Rice variety characteristics of concern to farmers for variety management in the coastal ecology of Hue region, Vietnam

Variety characteristic	Quang Thai		Phu Da	
	1996	2001	1996	2001
Characteristics as important concerns (% of N)	N = 29	N = 41	N = 27	N = 40
Yielding capacity	100	100	100	95
Yield stability	–	95	–	93
Duration	100	100	74	73
Drought tolerance	100	54	89	88
Submersion tolerance	93	85	48	35
Poor soil tolerance	93	42	82	75
Salinity tolerance	100	81	82	73
Insect resistance	97	59	82	75
Disease resistance	97	93	89	83
Eating quality	93	83	48	78
Milling quality	93	32	78	30

household groups with the same land types of rice fields (10%). This proves that HHs and cooperatives play important roles in making decisions related to production in different ecological areas.

In order to distinguish the traditional varieties, farmers rely on their experience and the following basics: characteristics of plant types and colour, resistance to biotic and abiotic stresses, growing season, etc. Of these, farmers consider plant types and colour the most important because they can be recognized very easily (Tables 8 and 9).

Table 6. Service and agricultural input providers for rice production

Type of service and agrisupport	Quang Thaï N = 41	Phu Da N = 40
Agricultural extension support	2 (2)[†]	1 (1)
Seed and variety supply	2 (2)	1 (1)
Chemical input supply	4 (4)	4 (4)
Water management service	2 (2)	3 (3)
Agricultural machinery service	1 (1)	1 (1)
Crop production protection	2 (3)	3 (3)
Loan and capital supply	3 (1)	5 (5)

[†] Numbers in parentheses indicate: 1. Farmer, 2. Cooperative, 3. Village-commune, 4. Shop owner, 5. Bank.

Table 7. Decision-making on rice production at household level

Type of decision	Quang Thaï	Phu Da
Allocating land to various crops	2 (2)[†]	1 (1)
Allocating rice land to varieties	2 (2)	1 (1)
Cultivar set for winter/spring season	2 (2)	1 (1)
Cultivar set for summer season	2 (2)	1 (1)
Seasonal calendar for rice growing	2 (2)	3 (3)
Seasonal calendar for other crops	2 (1)	1 (1)
Adoption of a specific variety	1 (1)	1 (1)
Farm technique application	1 (1)	1 (1)
Water management	2 (2)	1 (1)
Utility of farm products	1 (1)	1 (1)

[†] Numbers in parentheses indicate: 1. farmer, 2. Cooperative, 3. Village-commune.

Table 8. Characteristics used by farmers to distinguish traditional from modern varieties

Type of variety	Characteristic							
	Growing land	**Plant height**	**Nursery duration**	**Flag leaf**	**Insect resistance**	**Fertilizer requirement**	**pH, salinity tolerance**	**Yield (t/ha)**
Modern 13/ 2, CR_{203}, NN_{4B}, IR_{38}, MTL_{61}, TH_{30}, CN_2, DH_{60}.....	high, medium, irrigated	Short (<120)	30-35	short, straight	bad, medium	much	Bad	High (>5)
Traditional Heo, nuocman, ngang co, chien, chum Dau, hau, ven, nep ran, nep sao vang, heo chum....	low, waterlogged, hollow, not irrigated	Tall (>120)	45-60	long, stretched	Good	little	Good	Low (<4)

Table 9. Characteristics by which villagers distinguish traditional varieties

Characteristic	**Variety**					
	Ngang co	**Heo**	**Nuocman**	**Heo chum**	**ChumDau**	**Chien**
Stem	Hard, tall	Tall	Tall	Short	Tall	Short, thin
Panicles	Medium	Exposed	Exposed	Hidden	Hidden	A bit exposed
Rice ear	Medium	Thin	Thin	Thick	Thick	Thin
Grain	Round	Big, long	Big, long	Big, round	Yellow	Brown
Awn	No	Purple	White, long	Little	No	Long
Polished grain	White	White	Red	White	White	Red
Node colour	Green	Violet	White	Purple	Purple	White
Resistance to:						
pH, salinity	Good	Medium	Very good	Medium	Medium	Very good
Lodging	Little	Much	Much	No		Little–medium
Fertilizer input	Medium	Little	Little	Little	Little	Little
Growing season	Winter/spring	Winter/spring	Winter/spring	Winter/spring	Winter/spring	Summer

Farmers know well the characteristics of varieties, and it is an advantage to explore and encourage them in the conservation of agrobiodiversity on-farm.

Conclusions and recommendations

Conclusions

Through the research findings from 1996 to 2001 at two research sites—Quang Thai and Phu Da—on the coastal ecology, we can come up with the following conclusions:

1. Quang Thai and Phu Da are two appropriate research sites representing the coastal ecological conditions in Thua Thien Hue and Central regions.
2. Quang Thai and Phu Da, however, still meet lots of difficulties in livelihood. Rice is the key plant and the main income source. Before 1996, the diversity of traditional rice varieties was considerably higher, but now these precious resources are in danger of extinction owing to the introduction of modern rice varieties, as well as the fluctuation of climatic conditions (more floods and drought, hot and cold). So, it is necessary to promote conservation and utilization of this invaluable germplasm.
3. In the studied areas, farmers know well their crops in general and rice in particular. They are eager to learn and apply new technological advances. They want to participate in research and conservation of agrobiodiversity on-farm to serve the common benefits.

4. Farmers give values to certain variety characteristics valuable for crop diversity and on-farm conservation.

Recommendations

To promote the on-farm conservation of agrobiodiversity, it is necessary to:

1. Establish demonstration plots for both rice seasons: winter/spring and summer.
2. Provide technical assistance to farmers to increase the yield, quality of rice and efficiency of diversity conservation.
3. Propose suitable policies supporting local rice diversity conservation:
    - Adding values to TVs and the well-adapted cultivars
    - Training on seed and variety management facilitating diversity conservation
    - Increasing seed and variety exchanges among farmers and communities for better access to rice genetic resources.

Management of taro planting material in some studied ecosites of North Vietnam

Nguyen Ngoc Hue, Dinh Van Dao and Nguyen Phung Ha

Introduction

Taro (*Colocasia esculenta*) belongs to the Araceae family and has a long history of cultivation. In Vietnam taro is a common food crop. It can be cultivated in rainfed uplands, in forest and in paddy fields. Some taro types are particularly well adapted to difficult lands such as swamps. In Vietnam, taro is mostly found as a mixed crop along with upland rice, ginger and maize in shifting cultivation systems in mountainous areas, and as an intercropping species with sweet potato, legumes or vegetables in the lowlands and midlands. Taro can also be grown in rotation with rice. Up to now, the people in taro-growing areas throughout the country still use the varieties which are selected and propagated by farmers, who plant taro just for self-consumption as food or vegetable, and these varieties are suitable for the natural and economic conditions of their areas.

The status of taro genetic resources in Vietnam varies across the major regions, where it is important in production and consumption and across various areas of diversity. The taro genetic conservation study was initiated in 1995. Taro is one of three crops targeted by the Global Project for Strengthening the Scientific Basis of *In situ* Conservation of Agricultural Biodiversity on-farm in Vietnam. In three ecosites—the mountains in Da Bac, the midlands in Nho Quan and the Red River Delta in Nghia Hung—the high level of taro diversity has been identified (Nguyen Ngoc Hue 2001). However, information on farmer management of taro production, especially the data on planting materials of taro crop, is not available. As part of the project activities, a study on management of taro planting material in study ecosites was conducted in 2001. The results of the study can help answer the questions why, who and how farmers manage taro resources.

Materials and methods

Participatory Rural Appraisal method

Participatory Rural Appraisal tools were used to collect information on the number of taro cultivars, the area under taro varieties and the number of households growing taro in the study sites.

Focus group discussions were held to document the list of taro cultivars, their use value and farmers' propagation methods. This information was then used to assess preliminary planting material management of taro in each village of the study ecosites.

Baseline survey

The surveys of 39 to 140 household (45 to 95% of total households) were carried out in six villages of three districts to gather the list of farmer-named taro diversity and their use value. The indigenous knowledge on the different aspects of taro planting materials was also documented.

Results and discussion

Local seed supply system

Taro seldom flowers but its spread is dependent on vegetative propagation. There has been very little formal breeding of taro in Vietnam. As a result, the landraces currently grown are the products of local exchange, selection, isolation and natural mutation.

In Nho Quan most (95.4%) households obtain the first taro planting materials from their relatives, the rest from the market. In Da Bac and Nghia Hung, all farmers have taro sources from their ancestors and relatives. Thus for taro the self-supply seed system is dominant.

Table 1. Role of gender in decision-making of taro cultivation

Decision-making	Gender distribution (%)		
	Husband	Wife	Both
Decision-making on selecting crops	14	59	27
Decision-making on varietal selection	16	57	27
Labour on cultivation practices	15	65	20
Labour on harvesting	14	63	23
Decision-making on selling products	19	54	27
Labour on selling products	9	54	37
Labour on seed multiplication	7	40	53
Decision-making on using income	15	55	30
Decision-making on extending the cultivation	20	53	27

Currently, the diversity blocks and local markets are common new sources of taro genetic resources. The farmers in Da Bac, Nho Quan and Nghia Hung are also encouraged to exchange their taro planting materials between and within farming communities along with the associated knowledge of such resources.

Gender role in making decisions on taro cultivation

Preliminary results show that female farmers make most decisions relating to cultivation of root and tuber crops including taro. It seems to be the work domain of women. In these three sites taro is mainly planted and managed by women. Their crop species are of no doubt the most important for home consumption and seem to be closely related to the daily meal preparation work of women. This can be demonstrated by a high percentage of mothers who originally planted taro in home gardens and in the fields in all three sites.

In taro farming, there are some differences between males and females. The men give more attention to intensive farming with larger area and have a clear plan of investment for the highest benefit based on the market demand or their experiences. The women always have a tendency to plant high-quality varieties, intercropping them with other species or in their home gardens, so they are more concerned about the family consumption, like making cakes, soups and other meals. Thus, they have more power in decision-making related to taro cultivation in small fields or in home gardens.

Methods of taro propagation

Over a long period of taro cultivation, local people in the study sites have accumulated rich indigenous knowledge and experience in the use and management of taro resources, and their methods of taro propagation are a good example. The farmers in Nho Quan store the "seed" taro in jute bags. The farmers in Da Bac maintain the whole plants with corms or cormels in the on-site hut or underground in winter rather than keeping them at home.

It was found that many households could propagate taro cultivars in at least six ways (Table 2) and this flexibility of propagation might also reflect a relative preference for growing in a large area. A similar observation was also reported in Nepal (Baniya *et al.* 2001). However, it is yet to be identified whether such variations in propagation have some implication on maintenance of diversity *in situ*.

It can be seen from Table 2 that the planting materials used by farmers can be cormels, heads of corms, eyes of corms, stolons, suckers and corms with very small cormels. Management of taro planting material is totally informal and almost 100% of farmers in the study sites save these materials for their use, replacing them mostly after 3–5 years.

In addition, the farmers have experience in choosing the seedlings for their planting purpose and they have some traditional methods for cleaning corms or cormels before planting. In Nho Quan, the farmers usually soak the seed-cormels in a solution of urine for 12 h before planting to provide protection from aphids. For promoting the germination of a cormel bud, sometimes the farmers cover the "seed" taro with moist ash before planting.

Table 2. Farmer methods of propagation of clonally grown taro diversity in three sites of Northern Vietnam

Method of propagation	Cultivar	Agroecosystem[†]	Distribution pattern[‡]
Cormels and suckers	Khoai doc trang	Lowland	Widespread
	Khoai lui doc tia	Lowland	Widespread
	Mac phuoc mong	Upland	Widespread
	Khoai mung tia	Upland	Widespread
	Mon tia	Lowland and home garden	Widespread
Young suckers	Nuoc tia	Moist area around the water well	Widespread
	Nuoc xanh	Moist area around the water well	Widespread
	Bac ha	Home garden	Narrow
	Tam dao xanh	Upland, home garden	Narrow
Stolons	Man hua vai	Upland	Widespread
	Khoai nuong	Upland	Widespread
	Khoai doi	Lowland	Widespread
Heads of corms	Kao pua	Upland	Narrow
	Mon	Upland	Widespread
	Mat qui	Upland	Widespread
Eyes of corms	Phuoc kip	Upland	Widespread
	Phuoc oi	Upland	Widespread
Seeds and suckers	Kay nha	Home garden and upland	Widespread

† Lowland refers broadly to low-lying fields of the Red River Delta below 50 masl and Upland represents broad fields situated above 50 m in mid to high mountain areas.

‡ Widespread distribution refers to cultivars found in other provinces of Vietnam and narrow distribution refers to cultivars specific to a certain village or commune.

Conclusions

In Vietnam taro is a good example to illustrate that conservation of crop genetic resources is possible through use. The ethnobotanical survey results indicate that farmers have maintained different kinds of taro because of their different use values.

Management of taro planting material is totally informal and almost 100% of farmers in the study sites save these materials for their use.

Preliminary results show that women farmers make the most decisions relating to cultivation of root and tuber crops including taro.

It was found that taro cultivars can be propagated in at least six ways: cormels, heads of corms, eyes of corms, stolons, suckers and corms with very small cormels.

Farmers have experience in choosing the seedlings for their planting purposes and they have some traditional methods for cleaning corms or cormels before planting.

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Seedflow monitoring for major crops in Dai An, Tra Cu, Tra Vinh Province, 1998–2001

Nguyen Ngoc De and Vo Minh Hai

Introduction

Dai An Village, located in the rainfed saline area of Tra Cu District, Tra Vinh Province, was officially established on 1 January 1998. It consisted of eight hamlets. Total land area is 750.24 ha. People have settled in this area for more than 300 years.

Dai An was classified as one of the poorest villages by national standards with the average per capita income of less than 120.000 VND/month. Its total population is 4857 people with 835 families. The Khmer ethnic group accounts for about 80%, Chinese 10% and Vietnamese 10%. Agriculture is the main source of income. Other minor occupations are handicrafts, tailoring, hired labour, etc. According to a survey in 1998, the education level of local people was very low: illiteracy accounted for 18%, and those with elementary, secondary and high school plus higher education were 36%, 23% and 6.5%, respectively. The irrigation systems were undeveloped, and agricultural production was poor. The major crops were rice and some kinds of upland crops. Before 1998, only a single crop per year with local traditional rice was possible in the rainy season. After 1998, farmers could grow two rice crops per year in some parts of the village (one early rice crop in early rainy season followed by local traditional rice). Upland crops such as taro, cassava, sweet potato, mungbean and groundnut were grown after the rice harvest in a limited area owing to a water shortage. Crop diversity in the area was still high in comparison with other areas. Traditional crop varieties of rice and root crops had been maintained by farmers for many years.

An understanding of seed flow in the village could help to plan for more effective conservation and development activities. The study was carried out to monitor the seed flows of some major crops in the village since the project started in 1998.

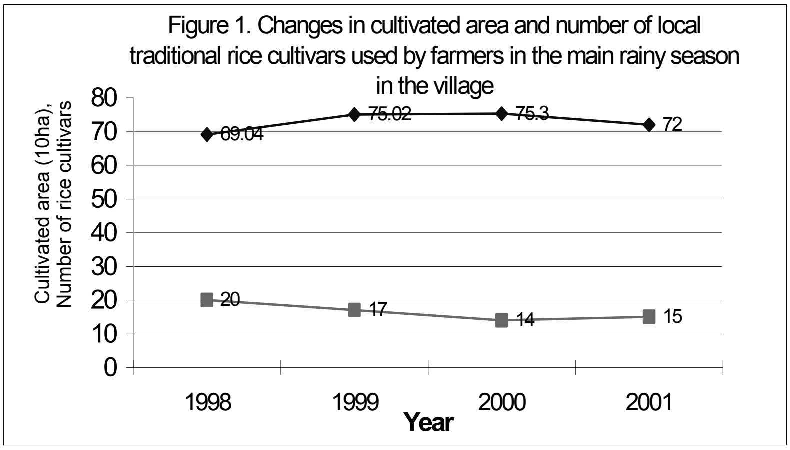
Secondary data, community biodiversity record and seasonally focused group discussions were used to collect data.

Changes in cultivated areas and number of cultivars of some major crops in the village

Local traditional rice

The local traditional rice is chiefly grown in the main rainy season in rainfed conditions. The total number of local traditional rice cultivars in the village was 20 in 1998 when the *in situ* conservation project started. They were *Phi Rang, Trang Tep, Trang Lun, Den Bui, Nep* (glutinous), *Go Cong, Lun Can, Mot Tep An Giang, Troi Bien, Mot Bui, Nep* (glutinous) *Than, Tay Lieu, Keo Xiem, Phi Trang, Lem Lun, Clay Muong, Nang Lay, Nep* (glutinous) *Dai Loan, Hai Hoanh, Tai Nguyen* and *Bong Dua*. There were 17 non-glutinous and 3 glutinous rice cultivars. This number reduced to 14 from 1998 to 2000 while their cultivated area still remained from 700–770 ha in the village (Figure 1). Six cultivars were lost (*Lun Can, Mot Bui, Nep* (glutinous) *Than, Tay Lieu, Clay Muong, Nang Lay*) owing to very late maturity, and their not being suitable for early salinity intrusion.

In 2001 the project reintroduced one special glutinous rice cultivar (*Nep Than*) to the community because the villagers needed it for special wine processing. This cultivar was special because its grain kernel is dark purple which gives the wine a special taste and good colour. Furthermore, this glutinous rice is also important in preserving local traditions, serving special family needs such as first birthday or death memory ceremony for their ancestors.



Modern rice

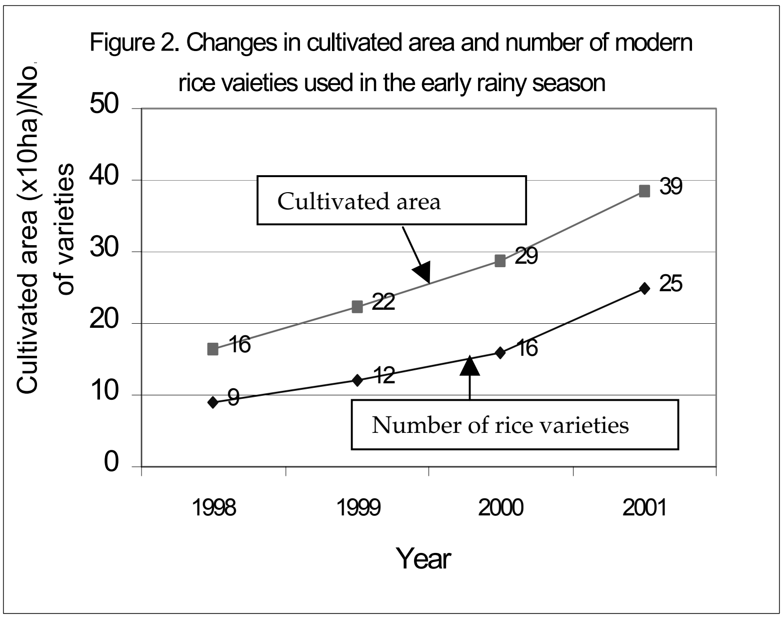
The modern rice is grown in the early rainy season before local traditional rice in a limited area by dry direct seeding technique; it relies on the rain for water.

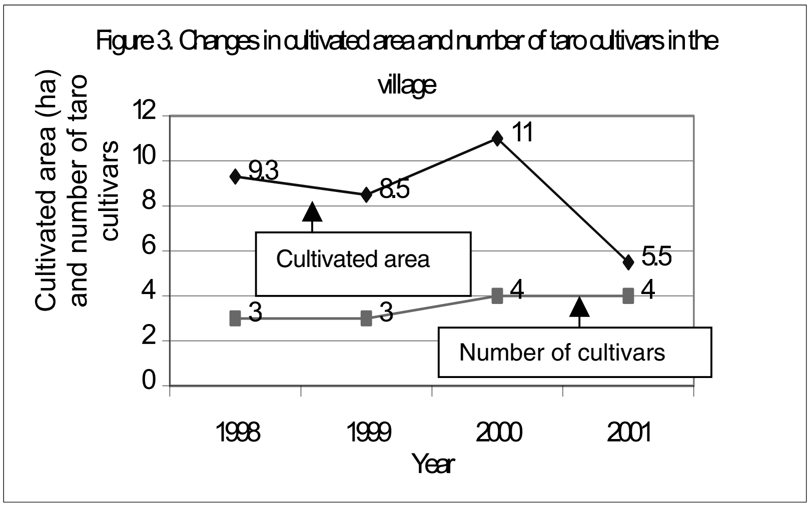
The total cultivated area in the village increased from 160 ha in 1998 to 390 ha in 2001 with the development of short-duration rice varieties (Figure 2).

The number of modern rice varieties selected and used by local farmers has rapidly increased from 9 in 1998 to 25 varieties in 2001. These varieties from research institutions have been introduced by the project and local agricultural extension network and then selected by the local community through PPB (Participatory Plant Breeding) and PVS (Participatory Varietal Selection) activities of the *in situ* conservation project. PPB and PVS have made great contributions to the local diversity of modern rice.

Taro

Taro is the main crop after rice in the village. It is mainly grown in the sand ridges where land elevation is rather high and easy to drain. However, the cultivated area varied very much depending on the weather and market fluctuations. In years with good weather and market the cultivated area increased. Taro is one additional source of farmers' income in the village. Total cultivated area of taro ranged from 5 to 11 ha and the biggest area was in 2000 (Figure 3).





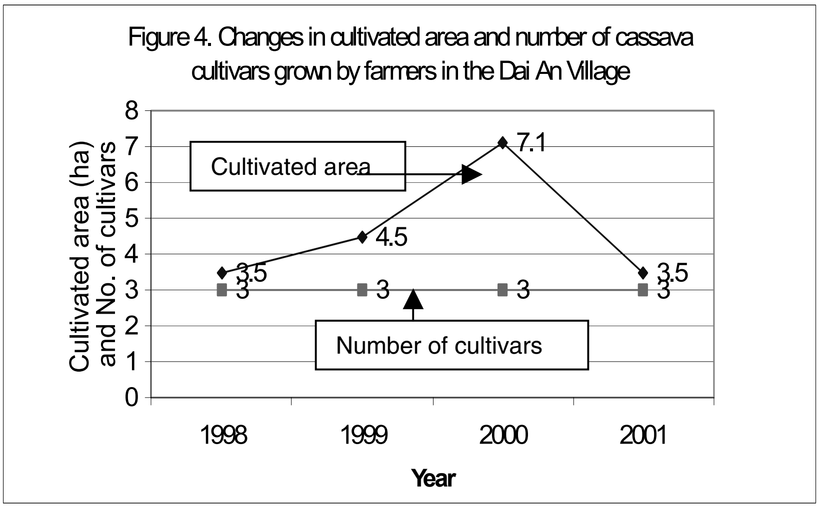
Diversity of local taro is low. Only three local cultivars (*Mon cao, Mon sap, Mon min*) were commonly grown in the village in 1998. One more taro cultivar (*Mon cao Da Lat*) was accepted by local farmers in 2000-2001 through the *in situ* conservation project.

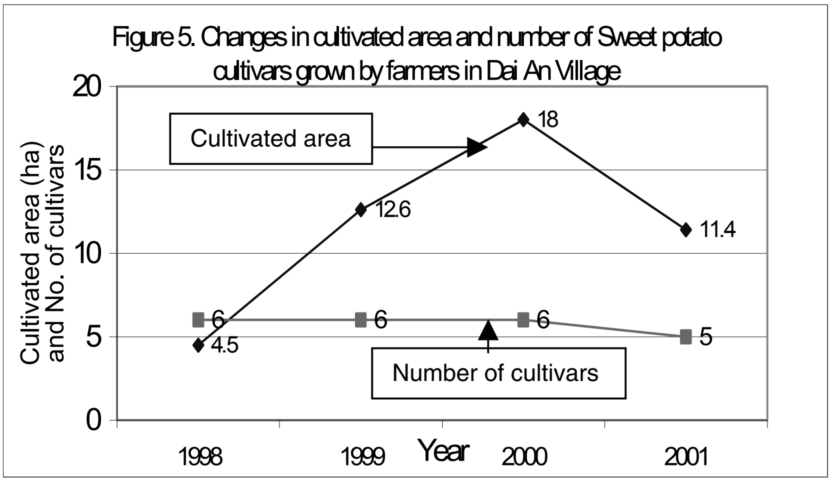
Cassava

Cassava is a good drought-tolerant crop. It is grown mainly in home gardens. In Dai An Village it is a minor crop. Its total cultivated area was limited, from 3 to 7 ha in the village (Figure 4). In 2000, it reached the highest production area. Three cultivars of cassava have been grown by local farmers in this village since 1998: *Mi ke, Ma cuong* and *Mi gon*.

Sweet potato

Like taro, sweet potato is also an additional source of income for local farmers. Its total cultivated area was highest (18 ha) in 2000 (Figure 5). There were six local cultivars grown in the village: *Lang bi, Tau ngen, Duong ngoc, Trang giay, Binh Tuy* and *Bot duong*. *Bot duong* cultivar was lost due to flooding in 2000.





Seed flow of some major crops in Dai An Village

The monitoring of the changes in varieties and seed sources used by local farmers has been conducted by the project field staff in close cooperation with farmer leaders in each hamlet. The results from this monitoring reveal the farmers' preference and their adoption of crop varieties, crop genetic diversity and sources of seed available in the community over time. Rice is the most important crop and also enjoys rapid change in adoption of new technology; the monitoring of seed flow, therefore, was focused on this crop.

Local traditional rice

Seeds of local traditional rice were selected and kept by local farmers from season to season. So far, there has not been much improvement except seed purification of preferred local cultivars by farmers as a result of seed selection training provided by the project. In 2001, the *in situ* conservation project reintroduced a glutinous rice, namely *Nep Than*, collected from the village back to the community as the seeds of this variety had been lost before. *Trang Tep* variety, a common local traditional rice variety, also has been purified by pure line selection in the village in the main rainy season of 2001. Its quality seeds were provided to local farmers for 2002 seed multiplication.

Modern rice

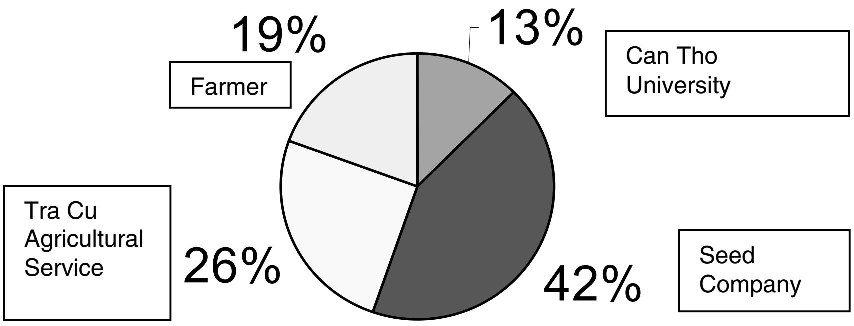
Through PPB/PVS, genetic diversity of modern rice has been improved year after year since 1998. Farmers now have more choices of preferred varieties. In 1998, there were nine modern rice varieties—*Cang Long, Bac Lieu, Cuu Long 8, MTL61, C42, OM5, IR61, Tai Nguyen DB,* and one unknown variety. In 1999, three more rice varieties (25% of the total number of varieties grown in the village) were added through community yield trials (*MTL232, MTL250* and *MTL99*). In 2000, farmers selected four more varieties, increasing the total number of varieties to 16. The newly adapted varieties accounted for 43.7%.

In 2001, 25 modern rice varieties were grown by local farmers. Of these, the seeds of 14 varieties (56%) were preserved and exchanged on-farm among farmers; the seeds of the remaining 11 varieties (44%) were provided by the formal sector:

- *MTL232, MTL250, MTL99* and *MTL281* (4 varieties) were from Can Tho University
- *OM1490, S969B, MTL250* and *VND95-20* (4 varieties) were from Tra Vinh Seed and Agricultural Services Company
- Three varieties (*IR56279, IR59606* and *OM1889*) from Tra Cu Agricultural Services.

The newly adapted varieties (11 varieties) were rapidly adopted by many local farmers and they occupied up to 81% of the total cultivated area in the early rainy season. Old varieties (14 varieties) occupied only 19% (Figure 6).

Figure 6. Cultivated areas of modern rice varieties differed by seed sources in 2001 early rainyseason



Seed companies played an important role in supplying seeds of new varieties (42% of the total cultivated area in 2001). These seeds were considered as first stock for farmers to multiply in the following years.

Discussion

The result from the study showed the existence of genetic diversity in rice.

The major cropping systems in the paddy fields have gradually changed from single rice cropping to double rice cropping. The number of traditional rice varieties has been gradually reduced by time. It is clearly seen that the tendency is increasing in terms of good grain quality, adaptability, stable yield and short growth duration. Only cultivars with early maturity, good grain quality and high market value have been maintained and developed. Nevertheless, the local traditional rice is still a main crop in the village.

Rapid change was observed in the number of modern rice varieties owing to the market demand and availability of research findings from many sources in the region. The diversity of modern rice varieties has been enriched since 1998 thanks to the effects of PPB and PVS. Modern rice varieties have been increased in both the number of varieties (from 8 in 1998 to 25 varieties in 2001) and cultivated area.

Root crops are minor crops in Dai An Village. However, they are an important source of additional income for local farmers after rice. They have low species diversity and a low level of varietal improvement. In the period 1998–2001, the number of taro varieties has increased by one thanks to the *in situ* conservation project. The number of cassava varieties was constant while that of sweet potato has reduced by one variety because of flooding. The seed materials exchange could be the most practical way for diversification of root crops. In addition, the improvement of irrigation systems might help increase the production scale of root crops, especially taro and sweet potato.

Concluding remarks

The *in situ* project has a strong impact on increasing diversity of early rice varieties in the village through participatory plant breeding (PPB/PVS) activities. The number of early rice varieties has been increased from 8 in 1998 to 25 varieties in 2001. Thanks to the suitability of new varieties selected through PPB/PVS, their cultivated area has been increased rapidly. The understanding of changes in seed flow at village level offers help in adjusting our activity plan to meet project objectives and strategies.

The conservation and improvement of local traditional rice are very important to the local community. The introduction of local traditional rice varieties collected from other parts of the Mekong Delta could help increase diversity and enrich the farmers' choice of local rice varieties.

Seed quality improvement practices through PPB/PVS can contribute to the increase in productivity and quality of local rice.

The improvement of cultural practices for local traditional rice could also increase the rice yield and the income of rice growers.

More training on PPB/PVS and improved cultural practices for root crops is also needed to encourage farmers to conserve and develop these minor crops.

Chapter 4. Who maintains diversity of taro and rice and how?

Variety network and variety preservation in the communities of Nam Nung Commune, Krongno District, Dak Lak Province

Pham Van Hien and Tay Nguyen University Diversity Group

Introduction

A study of variety networks and crop variety preservation methodologies in a community is important in research on *in situ* crop diversity to draw out effective and participatory solutions to biodiversity conservation. However, that work was not done in the first year of the Nam Nung *in situ* conservation project. This report deals with the biodiversity survey in Yuk Yu, Rkap and Jara Villages, Nam Nung Commune, Krongno District, Daklak Province.

Variety network of farmers in Nam Nung

The crop variety network of farmers in Nam Nung Commune depends on many socioeconomic, cultural and marketing factors. Many indigenous categories of crops have been linked with traditions, shared among community members in terms of biodiversity conservation on-farm, and it seems that there is an informal variety network in the community where most farmers' varieties are kept and exchanged by farmers. The importation of new crop varieties narrows the biodiversity of traditional varieties. The local government and the Provincial Center for Agricultural Extension support the variety improvement programmes, so all farmers, regardless of their needs and preferences, are provided with seeds of new varieties to grow in their fields. Biodiversity conservation should assess the positive and negative aspects of the supply and importation of new crop categories from external sources to find the best way to combine biodiversity conservation and crop improvement programmes.

Positive aspects

- New improved crop varieties help diversify cropping patterns and increase the crop yield and production, contributing to improvement of living standards of the local people.
- More options for farmers to select good crop categories for cultivation, helping them reduce the risks.
- Genetic materials become richer for enhancing artificial breeding and natural hybridization for cross-pollination of species.
- Increased income and economic development for the local people.

Negative aspects

- Increased threat of genetic resource erosion of the local crop categories, as farmers may choose the ones with high productivity and economic efficiency to solve their living problems.
- New improved varieties may have less resistance to specific diseases and pests, as well as lower adaptation to local agroclimatic conditions, so they cannot be grown in every niche.

So, farmers have to keep and use local varieties that have special traits which the improved ones lack. To facilitate local crop conservation on-farm, it is necessary to strengthen the scientific and practical basis of *in situ* conservation on-farm. Research should be conducted to find the amount and distribution of agricultural biodiversity, to identify negative and positive features of traditional varieties and the best ways to use them, so as to generate benefits from

agricultural biodiversity conservation on-farm. The results of the crop diversity survey and the crop diversity contest conducted in Nam Nung Commune are shown in Tables 1 and 2.

Table 1. Crops in Nam Nung Commune

Crop	Local name	Characteristics and colour	Reasons for cultivation
Upland rice	Ba Hma	High diversity, differences	Different purposes
Sticky upland rice	Met	High diversity, differences	Many purposes
Local corn	Mbo	White, yellow, violet, red-yellow and violet-striped bean	Delicious, sticky and for hunger relief when not having rice
Local bean	Tuh Lang	Violet, green, white and long	Good vegetables
Bitter eggplant	Blin Tang	With or without thorns, big and small round fruit	Delicious , traditional foods
Eggplant	Blin	Round, big, long	Delicious, traditional foods
Tomato	Blin Kur	Round and small fruit	Delicious, sour and good smell
Gourd	Nong	Round, long and oval	Good smell and sweet
Red squash	Kpoal Dum	Round, long and oval	Friable, sweet and long storage
Green squash	Kpoal Prah	Long, big fruit, and long, small fruit	Sweet, many fruits
Loofah	Buin	Round, long fruit	Good smell, delicious and sweet
Watermelon	Kpung	Oval fruit	Fresh eating like vegetables
Large cucumber	Kpung Tok	Long, small fruit	Vegetables and refreshing
Cassava	Bum blang	Violet, white	Hunger relief or wine making
Sweet potato	Bum prum	Violet, white	Sweet, tasty, hunger relief
Taro	Bum Mtrao	Violet, white	Sweet, tasty, hunger relief
Red taro	Bum Mtrao can	Violet, white	Tasty, sweet and good smell
Banana	Prit	Long, round and small fruit	Delicious and good smell
Sugar cane	Tao	Violet, green	Sweet and good smell
Pineapple	Play co	Green, violet	Sweet and good smell
Papaya	Plang Mung	Long, round fruit	Sweet, good smell and much fruit
Ginger	Cha	Small and many nicks	Good smell and chilli
Millet	Oco	Small and black seeds	Good for making wine
Small onion	Diem day	Small, white	Eating and spicy
Climbing melon	K'pang Leo	Small, long fruit	Delicious, soft
Chili	Mree	Small, big, long fruit	Good, chilli
Biter melon	Yaut	Round, long fruit	Good bitter taste and smell
Citronella	Plang	Small body and small leaf	Good smell and for chilli
Tobacco	Hat djo	Small and long leaf	Biter, good smell
Thorn chervil	Gil	Small, short leaf	Good smell for spice
Imported crops			
Robusta coffee	Tom ca phe	Round, uniform cherries	Economic purpose
Pepper	Tieu	Black, small seed	Economic purpose
Cashew nut	Dieu	Red fruit	Economic purpose
Hybrid maize	Mlo chang	Red, yellow	Economic purpose
Green bean	Tuh il	Big, round seed	Economic purpose
Black bean	Tuh	Big, black seed	Economic purpose
Peanut	Tuh neh	Big, long seed	Economic purpose
Watermelon	Biang Kai	Big, round fruit	Delicious, refreshing
Sesame	Ngu nga	Small, black seed	Good smell, eaten with sticky rice
Rubber	Cao su		Economic purpose
Avocado	Bo	Big, round fruit	Delicious
Durian	Sau rieng	Big fruit	Economic purpose
Mango	Xoai	Big fruit	Sour, delicious
Rambutan	Chom chom	Round fruit with soft thorns	Sweet, economic purpose

Table 2. The number of new crops in Nam Nung Commune

Crop	Yut Zu		Ja Ra		R'Kap	
	Indigenous crop	New crop	Indigenous crop	New crop	Indigenous crop	New crop
Upland rice	34	1	33	1	35	1
Lowland rice	0	0	0	2	0	0
Corn	5	2	5	2	8	2
Fruit tree	5	5	4	4	6	5
Cash crop	0	3	0	3	0	4

Some crops came to Nam Nung from the Daklak Center for Agricultural Extension and socioeconomic development programmes of the local Government. On the positive side, these crops have diversified the crop structure in Nam Nung. Five new fruit trees imported into Nam Nung by the Program for Reclaiming Intercropped Gardens of the Daklak Center for Agricultural Extension are mango, rambutan, custard apple, durian and jack fruit.

The 135 Program for Particularly Difficult Communes of the Government provides hybrid seeds of maize varieties (*LVN 10* and *DK88*) and high-yield beans (green bean, soyabean, peanut, black bean and red bean). Cash crops from new crop models of the Daklak Center for Agricultural Extension and other development programmes are coffee, pepper and cashew nut.

The abovementioned crops have played an important role in the socioeconomic development of villages in Nam Nung and increase the crop diversity in this locality. However, the trend of new crop importation should be properly considered from the point of view of *in situ* crop diversity conservation.

Approaches to crop diversity conservation in Nam Nung Commune

Community characters of M'Nong people

The M'Nong people are one of the highly communistic groups of people in the Central Highlands. Their communistic characters are presented in their material as well as spiritual life. In farming, the M'Nong people have been exchanging and sharing upland rice varieties and local crops for a long time, so their variety network is unofficial and sometimes not clearly seen. No household is a monopoly supplier of crop species to the community. All indigenous crop categories have been traditionally preserved for ages by farmers' households.

Variety conservation by traditions

There are eight different ethnic groups in Nam Nung Commune. Every group has its characteristics in traditional culture and religion with different ideological systems and traditional polytheism. Each of them has its own agricultural production practices.

Some crop categories do not have many positive characteristics but are still being conserved by matriarchy. It does not mean that these categories are unique but they have something related to cultural and spiritual aspects. It may be a symbol of family lineage preservation according to the M'Nong customs. A mother gives varieties to her daughter at the wedding as an admonition to take care of her family's food and offspring to conserve their family lineage. This helps to conserve the upland rice diversity because the daughter will never get rid of her mother's varieties.

Variety conservation by groups of households

Participatory grading matrix ranking method was used to classify households into poor, average and rich. The local people themselves selected criteria for grouping households based on the actual condition of the community. Three villages and 30 households in each village participated in the grouping process with criteria chosen by the community. The results obtained are shown in Table 3.

Table 3. Classification of 30 households in the three villages in Nam Nung Commune

Village	Rich		Average		Poor	
	No. of HHs	%	No. of HHs	%	No. of HHs	%
Yuk Yu	3	10.0	20	66.6	7	23.3
R'Kap	12	40.0	10	33.3	8	26.6
Ja Ra	0	0.0	9	30.0	21	70.0

The data in Table 3 indicate that there is a big economic difference among households in each village and among villages as well. For Yuk Yu Village, the rich account for 10%, the average for the largest percentage (66.6%), while in R'Kap, the difference is not high. This shows that the living standard and community development in this village are at a relatively high level. For Ja Ra Commune the difference is very distinct. There is no rich household but 70% are average households. This is the least-developed village in terms of economic development in the studied location. In general, however, the percentage of poor households is still high for the three villages.

Through interviews and independent discussions with groups about crop diversity and crop conservation, the main factors noted are as follows:

- There are similarities in terms of crop diversity conservation among the villages. The poor village has higher crop diversity than the rich and average villages, particularly in local upland rice.
- The groups of rich households often maintain less diverse categories of upland rice than the poor ones. The rich groups conserve 5–6 upland rice varieties with good quality and medium productivity. New crop diversification needs good care techniques. The rich groups have more resources (labour, equipment and budget) to invest in farming activities for high crop yield and so they rapidly acquire new kinds of industrial crops with high economic effectiveness such as coffee, hybrid maize, green bean and peanut. Consequently, these groups are speeding up the erosion of genetic resources in the region.
- The average and poor groups have less chance to apply advanced technologies, so they have to rely on traditional crop varieties. As a result, they are preserving more crop diversity in the region. Because of the shortage in resources, the investment in farming is quite low and their crop cultivation is mainly based on the natural resources. There is high crop diversity, especially upland rice with the lifecycle of 3–4.5 months. These groups also conserve many kinds of annual food crops to avoid harvest failure, consequently alleviating hunger. The analyzed results are presented in Table 4.

Variety seed harvest and preservation by the local people

Variety selection

The M'Nong people have an experience of cluster or individual variety selection according to each crop kind. In the whole upland rice plot, good clusters are harvested manually: women carry home-made baskets (*gui*[1]) on their backs, collecting rice seeds and putting them into the baskets. The rice seeds are dried and preserved separately. In the past, as was the custom, upland rice had to be collected by hand only because the M'Nong people thought that collecting rice by other instruments may "hurt" rice and god worship would not be blessed. For intercropped plants, good individuals are selected. They usually harvest whole fruit, drying them without separating seeds from the fruit, and preserve them for the next cropping season, for example whole ears of corn and whole fruit of chili, loofah, squash and other vegetables and beans.

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[1] Gui is a basket made of bamboo to contain or carry agricultural products and other commodities.

Table 4. Factors influencing crop diversity conservation among the three groups

	Rich HHs	Medium HHs	Poor HHs
Degree of diversity	Average	Average	High
Number of upland rice varieties	18	24	34
Crop care techniques	High, proactive	Average	Based on natural resources
New crop adoption	High	Relatively low	Low or none
Literacy standard	High	Average	Low
Labour resource	Fairly high	Average	Low
Financial resource	Fairly high	Average	Low
Erosion of local crops	High	Average	Low

Variety preservation

As is the custom, upland rice is cultivated far from peoples' houses and rice is dried and stored right in the fields. From time to time, women take some rice for their family food. When they use up all the previously taken rice, the women will go to the fields to take another new portion of rice home.

For variety preservation, in dry season (from April to November), food crops cannot be grown. The varieties' seeds for the next crops are preserved as dried seeds or dried fruits.

For rare or specialty upland rice cultivated in small plots of land, rice panicles are cut and hung in bunches above the kitchen. For normal rice cultivated in a large area, after harvesting, threshing and cleaning from mixed materials, seeds are dried and stored in specialized containers like *gui* or tanks made of bamboo or wood.

For maize varieties, whole corn ears are harvested and hung in bunches in the kitchens.

For vegetables and beans, depending on what kind, seeds may be separated or kept as whole and dried fruits.

Conclusions

The results of our study show that:

- The variety network and variety preservation methods in Nam Nung Commune have not been much affected by market and economic changes, especially in Ja Ra Village.
- The crop diversity is different among villages and among groups of households in a village. In general, groups of poor households conserve more crop diversity than the average and rich ones while the rich groups tend to accept new crops to replace the traditional ones. As they have more resources, they can invest in growing new crops to gain better economic efficiency,
- The adoption of new crops is the main cause of genetic erosion of local traditional germplasm. This is an important issue, which needs to be addressed in the *in situ* crop diversity conservation on-farm in Daklak.

Gender role in on-farm management of biodiversity: a case study in Nhon Nghia, Chau Thanh, Can Tho, Vietnam

Nguyen Ngoc De and Nguyen Hong Tin

Introduction

Nhon Nghia, a village of Chau Thanh District, Can Tho Province is located in a freshwater area of the Mekong Delta. The village is subdivided into six hamlets (Nhon Hung, Nhon Khanh, Nhon Phu, Nhon Thanh, Nhon Thuan, Nhon Thuan II) and the village town. The total village population is 16 414 people with 3325 households. The majority of the population are Vietnamese (99.7%), a few are Chinese and Khmer (0.26% and 0.04%, respectively). They settled in the area more than 300 years ago.

With total natural lowland area of 2018.3 ha, it is classified as an alluvial soil village with fresh water available year round. The maximum water depth is 0.5 m in the paddy field from September to October annually.

In Nhon Nghia Village, rice and fruit trees are the major crops that contribute a large part to family income. The total planted area of fruit trees is 881.2 ha, mainly citrus species (700 ha of orange, mandarin and pomelo). Three crops of rice are grown per year with short-duration varieties. The sown area of winter/spring rice was 761.1 ha with an average yield of 6 t/ha. The summer/autumn rice occupies 532.7 ha with average yield of 4.5 t/ha while autumn/winter rice occupied 362.2 ha with average yield of 4–4.5t/ha.

Upland crops—mainly cabbage, eggplant and tomato—cover 181.2 ha in the village. Vegetables are also rather important because Nhon Nghia Village is located close to the markets of Can Tho City.

Crop diversification in this village can be considered high in comparison with other villages in the region thanks to the availability of fresh water year round, good irrigation systems, market accessibility and experienced farmers.

In order to help farmers improve local diversity, as well as their income, the Home Garden *In situ* Conservation Project and many other extension activities and rural development programmes have tried to reach the area. It is important to understand the farm work arrangement and decision-making process within a farm household for more effective project implementation.

The study was conducted in 2001, aiming at understanding the gender role in on-farm management of biodiversity of major crops to direct the planning for on-farm conservation and technology transfer to production.

Nhon Nghia Village, Chau Thanh District of Can Tho Province has been selected for a case study in freshwater agriculture communities in the Mekong Delta of Vietnam.

Methodology

Location and time of survey

The study survey was conducted at Nhon Nghia Village in July 2001 by IPGRI Home Garden Project staff of Can Tho University.

Survey method

The participatory rural appraisal (PRA) techniques were used in the survey. Focus Group Discussions were conducted with male and female farmers.

Information collection

- Information was collected from key local informants and farmers.
- Key informants were local extension workers, farmer association staff and farmers.

- Focus group discussions were conducted with two separate groups of farmers (16 males and 16 females).

Content of the survey
In each group, farmers were asked to give their opinion and judgments on:
- Who does what? And who makes decisions in farming activities for major crops in the village?
- Target crops: rice, upland crops, vegetables, root crops, fruit trees, ornamental plants, medicinal plants and spices.

Data analysis
Descriptive analysis and Excel software were used for data analysis management.

Results and discussion

Gender role in farming activities

Gender importance by crop
Figure 1 shows the percentage of work contribution from males and females in the family to eight different main crops in the village. Judgements from male and female group were identical.

In the family, males play an important role in rice, fruit tree, ornamental and medicinal plant production, whereas females take care of upland crops, vegetables, root crops and especially spices. Table 1 summarizes this observation.

Gender importance by tasks
In general, men do most work that needs more strength and energy like land preparation, applying fertilizers, spraying pesticides, irrigation, assembling produce and transportation (mainly on their shoulders or by hand). Women work mainly in transplanting, replanting, weeding, removing off-type plants, cleaning, drying and selling farm products; these activities need more skills and patience (Table 2).

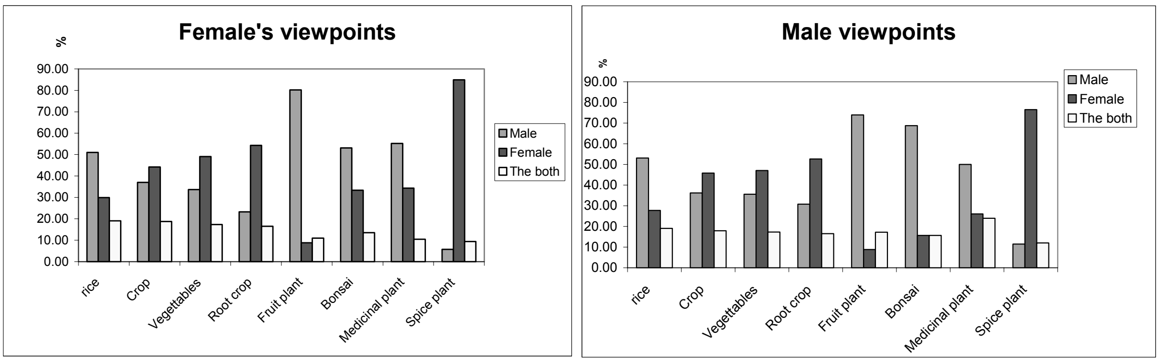

Figure 1. Gender importance in farming activities related to eight main crops.

Table 1. Gender importance by crop (Can Tho University, 2001)

Crop	Male	Female	Both
Rice	+++	++	+
Upland crops	++	+++	+
Vegetables	++	+++	+
Root crops	++	+++	+
Fruit trees	++++	+	+
Ornamental plants	++++	+	+
Medicinal plants	+++	++	+
Spices	+	++++	+

Table 2. Gender importance by activity (Can Tho University, 2001)

Activity	Male	Female	Both
Seed preparation	+++	++	+
Land preparation	++++	+	+
Seeding	++	+++	+
Replanting	+	++++	+
Weeding	+	++++	+
Fertilization	++++	+	+
Pesticide spraying	++++	+	+
Irrigation	++++	+	+
Removing off-type plants	+	++++	+
Harvesting	++	+++	+
Collecting harvested rice	+++++	–	+
Threshing	++	+++	+
Cleaning	–	+++++	+
Drying	+	++++	+
Transporting	++++	+	+
Storing	++	+++	+
Keeping seeds	++	+++	+
Selling	+	++++	+

However, the gender importance by tasks varies depending on what kinds of crops are grown by the farm households. These differences will be discussed for each crop in the following sections.

Gender role in rice production

Rice production is the main farming activity in the village in particular and in the Mekong Delta in general. Most fieldwork in rice production is done by male farmers (>52.1% of activities) compared with female farmers (28.9% of activities), especially land preparation, seeding, fertilization, pesticide spraying, irrigation, collecting panicles after harvesting, threshing, transportation and storing. Females play the main role in replanting of empty spaces after crop establishment, weeding, harvesting, cleaning and selling. Drying rice is a special task done by both male and female farmers (Table 3).

Table 3. Gender contribution (%) in rice production in Nhon Nghia Village (Can Tho University, 2001)

Activity	Contribution (%)		
	Male	Female	Both
Seed preparation	62.5	18.8	18.8
Land preparation	68.8	6.3	25.0
Seeding	87.5	0.0	12.5
Replanting	0.0	81.3	18.8
Weeding	12.5	75.0	12.5
Fertilization	87.5	6.3	6.3
Spraying	100.0	0.0	0.0
Irrigation	87.5	6.3	6.3
Removing off-type plants	50.0	31.3	18.7
Harvesting	12.5	62.5	25.0
Collecting harvested rice	87.5	0.0	12.5
Threshing	75.0	0.0	25.0
Cleaning	0.0	87.5	12.5
Drying	25.0	25.0	50.0
Transporting	87.5	0.0	12.5
Storing	68.8	6.3	25.0
Keeping seeds	12.5	43.8	43.7
Selling	12.5	68.8	18.8
Mean	52.1	28.9	19.1

Male and female viewpoints agree in judging the contribution of men and women to rice-production activities.

Gender role in upland crop production

Upland crop production is an additional source of family income in the village. The main upland crops are cabbages, eggplants, etc.

The study results show that female farmers play a more important role in upland crop production (45% compared with 36.7% of activities) than males. The women's activities include seeding, replanting, weeding, harvesting, threshing, drying, storing, keeping seeds for the next crops and selling products. Men take care of land preparation, fertilization, spraying pesticides, irrigation and transportation (Table 4).

Gender role in vegetable production

Similarly to upland crop production, women also play the key role in vegetable production. On average, women contribute 48.1% of the field work, while men do 34.6% of the work (Table 5). However, in general females do more complicated work, while males do most of the heavy physical work. As women take care of seed selection and storage, they contribute more to agrobiodiversity conservation on farm, including that of vegetables.

Table 4. Gender contribution (%) in upland crop production in Nhon Nghia Village (Can Tho University, 2001)

Activity	**Contribution (%)**		
	Male	**Female**	**Both**
Seed preparation	50.0	25.0	25.0
Land preparation	75.0	12.5	12.5
Seeding	18.7	50.0	31.3
Replanting	12.5	62.5	25.0
Weeding	12.5	68.7	18.8
Fertilization	56.3	18.8	25.0
Spraying	100.0	0.0	0.0
Irrigation	68.8	12.5	18.8
Harvesting	6.3	87.5	6.3
Threshing	18.8	43.7	37.5
Drying	6.3	75.0	18.8
Transporting	87.5	0.0	12.5
Storing	25.0	62.5	12.5
Keeping seeds	6.3	75.0	18.8
Selling products	6.3	81.3	12.5
Mean	36.7	45.0	18.3

Table 5. Gender contribution (%) in vegetable production in Nhon Nghia Village (Can Tho University, 2001)

Activity	**Contribution (%)**		
	Male	**Female**	**Both**
Seed preparation	25.0	62.5	12.5
Land preparation	87.5	0.0	12.5
Seeding	25.0	37.5	37.5
Replanting	25.0	37.5	37.5
Weeding	12.5	68.7	18.8
Fertilization	62.5	18.8	18.7
Spraying	93.8	0.0	6.3
Harvesting	31.3	31.2	37.5
Threshing	0.0	93.8	6.3
Drying	0.0	87.5	12.5
Transporting	81.3	12.5	6.3
Keeping seeds	6.3	75.0	18.8
Selling products	0.0	100.0	0.0
Mean	34.6	48.1	17.3

Table 6. Gender contribution (%) in root crop production in Nhon Nghia Village (Can Tho University, 2001)

Activity	Contribution (%)		
	Male	Female	Both
Seed preparation	62.5	25.0	12.5
Land preparation	34.4	43.8	21.9
Seeding	9.4	59.4	31.2
Replanting	9.4	75.0	15.7
Weeding	40.6	43.8	15.6
Fertilization	78.2	6.3	15.7
Spraying	50.0	43.8	6.3
Harvesting	6.3	71.9	21.9
Threshing	0.0	84.4	15.6
Drying	40.6	43.8	15.6
Transporting	40.7	37.5	21.9
Storing	0.0	68.8	31.3
Keeping seeds	6.3	87.5	6.3
Selling products	0.0	58.0	0.0
Mean	27.0	53.5	16.5

Gender role in root crop production

In root crop production, women's role is even more important. Men contribute only 27% of the work. As for vegetables, women work with most aspects of production, even contributing more to land preparation, generally done by men. Again, seed-related work is taken care of by women.

Gender role in fruit production

In contrast to upland and root crop production, fruit production is mostly the men's task, even in selling the products (77% of work). With an average planted area of 0.75 ha per farm household, fruit production in the village is mainly for sale. Orange, mandarin and pomelo are the major fruit crops in the village.

The study results reveal that men are not only active in work that requires more strength and energy but also pay more attention to things that could generate more income for their families. Women's contribution to fruit tree production is related mainly to weeding (Table 7).

Gender role in ornamental plant production

Ornamental planting is aimed at home decoration and entertainment. Some farmers grow flowers for sale and to serve festivals, holidays and indoor decoration. In this village, the ornamental plants including flowers are mainly grown by men (more than 60% of the work). Women participate mainly in weeding and selling products (Table 8).

Table 7. Gender contribution (%) in fruit production in Nhon Nghia Village (Can Tho University, 2001)

Activity	Contribution (%)		
	Male	Female	Both
Seedling preparation	93.7	0.0	6.3
Making beds	100.0	0.0	0.0
Making holes	100.0	0.0	0.0
Planting	100.0	0.0	0.0
Pruning	87.5	0.0	12.5
Weeding	0.0	87.5	12.5
Fertilization	87.5	0.0	12.5
Spraying pesticides	87.5	0.0	12.5
Harvesting	75.0	0.0	25.0
Transporting	81.2	0.0	18.8
Keeping seeds	75.0	6.3	18.7
Selling products	37.5	12.5	50.0
Mean	77.1	8.8	14.1

Table 8. Gender discrimination (%) in ornamental plant production in Nhon Nghia Village (Can Tho University, 2001)

Activity	Contribution (%)		
	Male	Female	Both
Seedling preparation	93.8	0.0	6.3
Making beds	87.5	0.0	12.5
Making holes	93.7	0.0	6.3
Planting	50.0	43.8	6.3
Pruning	43.8	25.0	31.2
Weeding	37.5	50.0	12.5
Fertilization	31.3	31.3	37.5
Spraying pesticides	75.0	0.0	25.0
Harvesting	75.0	18.8	6.3
Transporting	68.8	25.0	6.3
Keeping seeds	62.5	12.5	25.0
Selling products	12.5	87.5	0.0
Mean	60.9	24.5	14.6

Gender role in medicinal plant production

Medicinal plant production is mainly for family health security as some diseases can be cured by traditional treatment with different herbs. Men play an important role in planting medicinal plants (average of 52.6% of work). Women contribute to medicinal planting in pruning and weeding (Table 9). Even though it is rare, women do take care of selling medicinal products.

Gender role in spice plant production

Generally, women take care of food preparation in the family. Spices are essential for cooking. The study results reveal that spice plant production is mainly the task of women (Table 10).

Decision-making process

Decision-making on what to plant

In a family, the decision on what kind of crops and what varieties to be planted is made mostly by men (43% compared with 36% by women). Men play a more important role in fruit tree, ornamental, root crop and rice cultivation, while women's decisions are more important in vegetables, upland crops, medicinal and spice plant cultivation (Table 11).

Table 9. Gender contribution (%) in medicinal plant production in Nhon Nghia Village (Can Tho University, 2001)

Activity	Contribution (%)		
	Male	Female	Both
Seedling preparation	75.0	6.3	18.8
Making beds	68.8	12.5	18.8
Making holes	62.5	18.7	18.8
Planting	62.5	25.0	12.5
Pruning	37.5	50.0	12.5
Weeding	25.0	56.3	18.8
Fertilization	43.8	12.5	43.8
Spraying pesticides	81.3	6.3	12.5
Harvesting	37.5	37.5	25.0
Transporting	75.0	18.8	6.3
Keeping seeds	62.5	25.0	12.5
Selling	0.0	93.8	6.3
Mean	52.6	30.2	17.2

Table 10. Gender contribution (%) in spice plant production in Nhon Nghia Village (Can Tho University, 2001)

Activity	Contribution (%)		
	Male	**Female**	**Both**
Seedling preparation	12.5	75.0	12.5
Making beds	3.2	87.5	9.4
Making holes	6.3	75.0	18.8
Planting	0.0	87.5	12.5
Pruning	0.0	81.3	18.8
Weeding	0.0	87.5	12.5
Fertilization	0.0	93.8	6.3
Spraying pesticides	75.0	25.0	0.0
Harvesting	0.0	93.7	6.3
Transporting	0.0	87.5	12.5
Keeping seeds	6.3	81.3	12.5
Selling products	0.0	93.8	6.3
Mean	8.6	80.8	10.7

Table 11. Gender contribution (%) in decision-making on what to plant in Nhon Nghia Village (Can Tho University, 2001)

Crop	Level of decision (%)		
	Male	**Female**	**Both**
Rice	37.5	31.3	31.3
Vegetables	37.5	43.8	18.8
Upland crops	31.3	43.8	25.0
Root crops	43.8	31.3	25.0
Fruit trees	87.5	0.0	12.5
Ornamental plants	50.0	37.5	12.5
Medicinal plants	31.3	50.0	18.8
Spice plants	25.0	50.0	25.0
Mean	43.0	36.0	21.1

Decision-making about planting time

Men are more decisive in terms of seasonal planting calendars in most cases, except with ornamental, medicinal and spice plants (Table 12). Fruit trees and rice are mostly the responsibility of men.

Decision-making on how to plant

Similar to the decision-making on when to plant, the decision on what farming techniques to be used is mainly made by men (61.7% compared with 27.4% by women). However, ornamental, medicinal and spice plant cultivation practices are women's decisions (Table 13). In most studied families men seem be more skillful and knowledgeable in technical aspects of crop production.

Table 12. Gender contribution (%) in decision-making on when to plant in Nhon Nghia Village (Can Tho University, 2001)

Crop	Level of decision (%)		
	Male	**Female**	**Both**
Rice	75.0	0.0	25.0
Vegetables	68.8	18.8	12.5
Upland crops	62.5	12.5	25.0
Root crops	50.0	31.3	18.8
Fruit trees	93.8	0.0	6.3
Ornamental plants	37.5	43.8	18.8
Medicinal plants	31.3	43.8	25.0
Spice plants	25.0	50.0	25.0
Mean	55.5	25.0	19.6

Table 13. Gender contribution (%) in decision-making on how to plant in Nhon Nghia Village (Can Tho University, 2001)

Crop	Level of decision (%)		
	Male	Female	Both
Rice	87.5	0.0	12.5
Vegetables	75.0	18.8	6.3
Upland crops	62.5	25.0	12.5
Root crops	50.0	31.3	18.8
Fruit trees	93.8	0.0	6.3
Ornamental plants	43.8	50.0	6.3
Medicinal plants	37.5	50.0	12.5
Spice plants	43.8	43.8	12.5
Mean	61.7	27.4	11.0

Decision-making on marketing of farm produce

The decision on whether to sell or not to sell, where to sell and at what price of all farm produce is made by women (Tables 14 and 15). Women, as family accountant and cashier, are responsible for marketing farm produce. In most families in the village, women appear to be more skillful and knowledgeable in marketing aspects.

Table 16 summarizes the gender role in decision-making. It can be seen that men are very decisive in technical-related issues while women make market-related decisions.

Table 14. Gender contribution (%) in decision-making on whether to sell or not to sell agroproducts in Nhon Nghia Village (Can Tho University, 2001)

Crop	Level of decision (%)		
	Male	Female	Both
Rice	25.0	50.0	25.0
Vegetables	31.3	43.8	25.0
Upland crops	18.8	56.3	25.0
Root crops	25.0	43.8	31.3
Fruit trees	18.8	56.3	25.0
Ornamental plants	25.0	50.0	25.0
Medicinal plants	18.8	50.0	31.3
Spice plants	12.5	56.3	31.3
Mean	21.9	50.8	27.4

Table 15. Gender contribution (%) in decision-making on where to sell and at what price in Nhon Nghia Village (Can Tho University, 2001)

Crop	Level of decision (%)		
	Male	Female	Both
Rice	37.5	50.0	12.5
Vegetables	31.3	56.3	12.5
Upland crops	25.0	43.8	31.3
Root crops	18.8	56.3	25.0
Fruit trees	43.8	50.0	6.3
Ornamental plants	37.5	37.5	25.0
Medicinal plants	18.8	31.3	50.0
Spice plants	12.5	56.3	31.3
Mean	28.2	47.7	24.2

Table 16. Gender importance on decision-making (Can Tho University, 2001)

Issue	Male	Female	Both
What to plant?	+++	++	+
When to plant?	+++	++	+
How to plant?	++++	+	+
Sell or not sell?	+	+++	++
Where and what price?	++	+++	+

Concluding remarks

Gender role in farming activities

- Work arrangement within a family depends on capacity, knowledge, skill and time available of male and female members.
- Men usually take care of field crops such as rice, fruit trees and ornamental plants while women are responsible for vegetables, spice, root crops and upland crops.
- Men are active not only in work that requires more strength and energy but also in things aimed at generating income for their families. Land preparation, fertilizer application, pesticide spraying, irrigation and transportation are mostly men's responsibility.
- Work related to seed use such as seed preparation, threshing, drying and keeping seeds from season to season, and marketing are mostly done by women. Therefore, women are an important part of genetic diversity conservation, seed security and marketing of farm produce.

Decision-making

- In the studied families, men are very decisive in technical-related issues (e.g. selection of crops, varieties, planting season and cultural practices) while women make decisions related to the market.
- Understanding of the gender role in biodiversity management on-farm may help identify the contribution of men and women to local crop diversity conservation, appropriate approaches for enhancement of biodiversity and transfer of advanced technologies to improve farmers' practices toward crop diversification and sustainable agricultural production.

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Annexe

Table 1. Gender contribution (%) in rice production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seed preparation	87.5	0.0	12.5	37.5	37.5	25.0
Land preparation	81.3	6.3	12.5	56.3	6.3	37.5
Seeding	100.0	0.0	0.0	75.0	0.0	25.0
Replanting	0.0	75.0	25.0	0.0	87.5	12.5
Weeding	12.5	81.3	6.3	12.5	68.7	18.7
Fertilization	93.7	0.0	6.3	81.3	12.5	6.3
Spraying	100.0	0.0	0.0	100.0	0.0	0.0
Irrigation	87.5	0.0	12.5	87.5	12.5	0.0
Removing off-types	18.7	62.5	18.7	81.3	0.0	18.7
Harvesting	25.0	56.3	18.7	0.0	68.7	31.3
Collecting	75.0	0.0	25.0	100.0	0.0	0.0
Threshing	62.5	0.0	37.5	87.5	0.0	12.5
Cleaning	0.0	81.3	18.7	0.0	93.7	6.3
Drying	25.0	43.7	31.3	25.0	6.3	68.7
Transporting	75.0	0.0	25.0	100.0	0.0	0.0
Storing	75.0	12.5	12.5	62.5	0.0	37.5
Keeping seed	25.0	6.3	68.7	0.0	81.3	18.7
Selling	12.5	75.0	12.5	12.5	62.5	25.0
Mean	53.1	27.8	19.1	51.0	29.9	19.1

Table 2. Gender contribution (%) in upland crop production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seed preparation	37.5	43.7	18.7	62.5	6.3	31.3
Land preparation	75.0	12.5	12.5	75.0	12.5	12.5
Seeding	18.7	75.0	6.3	18.7	25.0	56.3
Replanting	18.7	68.7	12.5	6.3	56.3	37.5
Weeding	25.0	43.7	31.3	0.0	93.7	6.3
Fertilization	37.5	31.3	31.3	75.0	6.3	18.7
Spraying	100.0	0.0	0.0	100.0	0.0	0.0
Irrigation	56.3	12.5	31.2	81.3	12.5	6.3
Harvesting	12.5	75.0	12.5	0.0	100.0	0.0
Threshing	12.5	68.7	18.7	25.0	18.7	56.3
Drying	12.5	50.0	37.5	0.0	100.0	0.0
Transporting	93.7	0.0	6.3	81.3	0.0	18.7
Storing	25.0	50.0	25.0	25.0	75.0	0.0
Keeping seed	12.5	75.0	12.5	0.0	75.0	25.0
Selling	6.3	81.3	12.5	6.3	81.3	12.5
Mean	36.3	45.8	17.9	37.1	44.2	18.7

Table 3. Gender contribution (%) in vegetable production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seed preparation	25.0	56.3	18.7	25.0	68.7	6.3
Land preparation	93.7	0.0	6.3	81.3	0.0	18.7
Seeding	12.5	50.0	37.5	37.5	25.0	37.5
Replanting	12.5	56.3	31.3	37.5	18.7	43.7
Weeding	18.7	68.7	12.5	6.3	68.7	25.0
Fertilization	75.0	6.3	18.7	50.0	31.3	18.7

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Spraying	100.0	0.0	0.0	87.5	0.0	12.5
Harvesting	31.3	43.7	25.0	31.3	18.7	50.0
Threshing	0.0	87.5	12.5	0.0	100.0	0.0
Drying	0.0	75.0	25.0	0.0	100.0	0.0
Transporting	81.3	18.7	0.0	81.3	6.3	12.5
Keeping seed	12.5	50.0	37.5	0.0	100.0	0.0
Selling	0.0	100.0	0.0	0.0	100.0	0.0
Mean	35.6	47.1	17.3	33.6	49.0	17.3

Table 4. Gender contribution (%) in root crop production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seed preparation	43.7	43.7	12.5	81.3	6.3	12.5
Land preparation	68.7	6.3	25.0	0.0	81.3	18.7
Seeding	12.5	68.7	18.7	6.3	50.0	43.7
Replanting	18.7	75.0	6.3	0.0	75.0	25.0
Weeding	12.5	75.0	12.5	68.7	12.5	18.7
Fertilization	56.3	12.5	31.3	100.0	0.0	0.0
Spraying	100.0	0.0	0.0	0.0	87.5	12.5
Harvesting	12.5	50.0	37.5	0.0	93.7	6.3
Threshing	0.0	81.3	18.7	0.0	87.5	12.5
Drying	12.5	75.0	12.5	68.7	12.5	18.7
Transporting	81.3	0.0	18.7	0.0	75.0	25.0
Storing	0.0	75.0	25.0	0.0	62.5	37.5
Keeping seed	12.5	75.0	12.5	0.0	100.0	0.0
Selling	0.0	100.0	0.0	0.0	16.0	0.0
Mean	30.8	52.7	16.5	23.2	54.3	16.5

Table 5. Gender contribution (%) in fruit production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seedling preparation	93.7	0.0	6.3	93.7	0.0	6.3
Making beds	100.0	0.0	0.0	100.0	0.0	0.0
Making holes	100.0	0.0	0.0	100.0	0.0	0.0
Planting	100.0	0.0	0.0	100.0	0.0	0.0
Pruning	81.3	0.0	18.7	93.7	0.0	6.3
Weeding	0.0	81.3	18.7	0.0	93.7	6.3
Fertilization	81.3	0.0	18.7	93.7	0.0	6.3
Spraying	100.0	0.0	0.0	75.0	0.0	25.0
Harvesting	75.0	0.0	25.0	75.0	0.0	25.0
Transporting	68.7	0.0	31.3	93.7	0.0	6.3
Keeping seed	75.0	6.3	18.7	75.0	6.3	18.7
Selling	12.5	18.7	68.7	62.5	6.3	31.3
Mean	74.0	8.8	17.2	80.2	8.8	10.9

Table 6. Gender contribution (%) in ornamental plant production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seedling preparation	87.5	0.0	12.5	100.0	0.0	0.0
Making beds	87.5	0.0	12.5	87.5	0.0	12.5
Making holes	93.7	0.0	6.3	93.7	0.0	6.3
Planting	75.0	12.5	12.5	25.0	75.0	0.0

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Pruning	62.5	18.7	18.7	25.0	31.3	43.7
Weeding	25.0	56.3	18.7	50.0	43.7	6.3
Fertilization	56.3	12.5	31.3	6.3	50.0	43.7
Spraying	75.0	0.0	25.0	75.0	0.0	25.0
Harvesting	87.5	0.0	12.5	62.5	37.5	0.0
Transporting	87.5	0.0	12.5	50.0	50.0	0.0
Keeping seed	75.0	0.0	25.0	50.0	25.0	25.0
Selling	12.5	87.5	0.0	12.5	87.5	0.0
Mean	68.7	15.6	15.6	53.1	33.3	13.5

Table 7. Gender contribution (%) in medicinal plant production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seedling preparation	50.0	12.5	37.5	100.0	0.0	0.0
Making beds	56.3	6.3	37.5	81.3	18.7	0.0
Making holes	50.0	18.7	31.3	75.0	18.7	6.3
Planting	68.7	12.5	18.7	56.3	37.5	6.3
Pruning	43.7	31.3	25.0	31.3	68.7	0.0
Weeding	12.5	50.0	37.5	37.5	62.5	0.0
Fertilization	62.5	12.5	25.0	25.0	12.5	62.5
Spraying	87.5	0.0	12.5	75.0	12.5	12.5
Harvesting	75.0	6.3	18.7	0.0	68.7	31.3
Transporting	62.5	31.3	6.3	87.5	6.3	6.3
Keeping seed	31.3	43.7	25.0	93.7	6.3	0.0
Selling	0.0	87.5	12.5	0.0	100.0	0.0
Mean	50.0	26.0	24.0	55.2	34.4	10.4

Table 8. Gender contribution (%) in spice plant production from the viewpoint of male and female farmers (Can Tho University, 2001)

Activity	Male viewpoint			Female viewpoint		
	Male	Female	Both	Male	Female	Both
Seedling preparation	18.7	56.3	25.0	6.3	93.7	0.0
Making beds	6.3	93.7	0.0	0.0	81.3	18.7
Making holes	6.3	93.7	0.0	6.3	56.3	37.5
Planting	0.0	87.5	12.5	0.0	87.5	12.5
Pruning	0.0	75.0	25.0	0.0	87.5	12.5
Weeding	0.0	81.3	18.7	0.0	93.7	6.3
Fertilization	0.0	87.5	12.5	0.0	100.0	0.0
Spraying	93.7	6.3	0.0	56.3	43.7	0.0
Harvesting	0.0	93.7	6.3	0.0	93.7	6.3
Transporting	0.0	75.0	25.0	0.0	100.0	0.0
Keeping seed	12.5	81.3	6.3	0.0	81.3	18.7
Selling	0.0	87.5	12.5	0.0	100.0	0.0
Mean	11.5	76.6	12.0	5.7	84.9	9.4

Table 9. Gender contribution (%) in decision-making in what to plant from the viewpoint of male and female farmers (Can Tho University, 2001)

Crop	Male viewpoint (%)			Female viewpoint (%)		
	Male	Female	Both	Male	Female	Both
Rice	43.75	31.25	25	31.25	31.25	37.5
Vegetables	50	50	0	25	37.5	37.5
Upland crops	43.75	37.5	18.75	18.75	50	31.25
Root crops	37.5	31.25	31.25	50	31.25	18.75
Fruit trees	75	0	25	100	0	0
Ornamental plants	50	31.25	18.75	50	43.75	6.25
Medicinal plants	31.25	43.75	25	31.25	56.25	12.5
Spice plants	18.75	37.5	43.75	31.25	62.5	6.25

Table 10. Gender contribution (%) in decision-making in when to plant from the viewpoint of male and female farmers (Can Tho University, 2001)

Crop	Male viewpoint (%)			Female viewpoint (%)		
	Male	Female	Both	Male	Female	Both
Rice	68.75	0	31.25	81.25	0	18.75
Vegetables	62.5	12.5	25	75	25	0
Upland crops	75	18.75	6.25	50	6.25	43.75
Root crops	56.25	25	18.75	43.75	37.5	18.75
Fruit trees	87.5	0	12.5	100	0	0
Ornamental plants	31.25	50	18.75	43.75	37.5	18.75
Medicinal plants	37.5	37.5	25	25	50	25
Spice plants	25	56.25	18.75	25	43.75	31.25

Table 11. Gender contribution (%) in decision-making in how to plant from the viewpoint of male and female farmers (Can Tho University, 2001)

Crop	Male viewpoint (%)			Female viewpoint (%)		
	Male	Female	Both	Male	Female	Both
Rice	81.25	0	18.75	93.75	0	6.25
Vegetables	68.75	25	6.25	81.25	12.5	6.25
Upland crops	68.75	31.25	0	56.25	18.75	25
Root crops	56.25	18.75	25	43.75	43.75	12.5
Fruit trees	87.5	0	12.5	100	0	0
Ornamental plants	37.5	50	12.5	50	50	0
Medicinal plants	50	43.75	6.25	25	56.25	18.75
Spice plants	43.75	50	6.25	43.75	37.5	18.75

Table 12. Gender contribution (%) in decision-making in whether to sell or not from the viewpoint of male and female farmers (Can Tho University, 2001)

Crop	Male viewpoint (%)			Female viewpoint (%)		
	Male	Female	Both	Male	Female	Both
Rice	31.25	43.75	25	18.75	56.25	25
Vegetables	25	50	25	37.5	37.5	25
Upland crops	18.75	50	31.25	18.75	62.5	18.75
Root crops	18.75	50	31.25	31.25	37.5	31.25
Fruit trees	25	50	25	12.5	62.5	25
Ornamental plants	18.75	43.75	37.5	31.25	56.25	12.5
Medicinal plants	18.75	56.25	25	18.75	43.75	37.5
Spice plants	18.75	50	31.25	6.25	62.5	31.25

Table 13. Gender contribution (%) in decision-making in where to sell and at what price to sell from the viewpoint of male and female farmers (Can Tho University, 2001)

Crop	Male viewpoint (%)			Female viewpoint (%)		
	Male	Female	Both	Male	Female	Both
Rice	37.5	43.75	18.75	37.5	56.25	6.25
Vegetables	37.5	43.75	18.75	25	68.75	6.25
Upland crops	31.25	43.75	25	18.75	43.75	37.5
Root crops	18.75	43.75	37.5	18.75	68.75	12.5
Fruit trees	50	50	0	37.5	50	12.5
Ornamental plants	37.5	37.5	25	37.5	37.5	25
Medicinal plants	18.75	25	56.25	18.75	37.5	43.75
Spice plants	18.75	62.5	18.75	6.25	50	43.75

Chapter 5. Factors affecting local crop diversity

Effects of farming practices on crop yield and economic efficiency in specialty rice production in Nghia Hung District, Nam Dinh Province

Le Quang Khoi and Luu Ngoc Trinh

Introduction

Since 1995, the rice yield and production in Vietnam have increased rapidly to meet the domestic consumption and exportation demands. However, irrigated rice production still meets a lot of difficulties. The application of new rice varieties with high yield in the large areas leads to monoculture of a few varieties and decreases the diversity of local traditional varieties. The pest and disease incidence has also increased because of the lack of horizontal resistance of many modern varieties. In addition, farmers have to use many pesticides and chemical fertilizers that can affect not only the producer's but also the consumer's health and cause environmental pollution, especially in water sources and soils.

As farmers can now supply sufficient food to meet their consumption demand, they started to think about producing rice with high quality to sell and get more income. Before, this idea was not practical owing to the chronic lack of food, and the high-yielding varieties were more preferred. Now, it is quite feasible because of the increased market demand. As a result, some special rice-growing areas have been established to produce a few high cash value varieties. *Tam Thom* varieties in the north of Vietnam are specialty rices with nice smell and high quality. The cultivation of *Tam Thom* varieties provides higher economic efficiency for farmers in its natural habitat than planting improved varieties. This will create favourable conditions for strengthening *in situ* conservation of local traditional rice diversity as a precious asset for sustainable agricultural and rural development in the long term. This report deals with the results of our study on these aspects.

Materials and methods

- Participatory surveys were conducted and rice samples were collected from 59 farmers' households in Dong Lac Village, Nghia Lac Commune and 30 farmers' households in Kien Thanh Village, Nghia Loi Commune in 1999.
- Surveys were also conducted to record farmers' practices in rice production, effects of fertilizers on rice yield and economic efficiency of traditional and local rice production.
- Also applied were the biodiversity investigation forms designed by Plant Genetic Resources Center (PGRC) of VASI.
- Interviews and discussions were conducted to collect data of socioeconomic conditions, farming culture, seed storage and agrobiological characteristics serving as the baseline survey of the Project "Strengthening the scientific basis of *in situ* conservation of agrobiological diversity on-farm: Vietnam Component" jointly implemented by VASI and International Plant Genetic Resources Institute (IPGRI).
- IRRISTAT, MSSTAT and EXCEL were used for data analysis.

Results and discussion

Evaluation of rice diversity index at Kien Thanh and Dong Lac Villages

- Rice collection in 1999 decreased rapidly in both Kien Thanh and Dong Lac. The total of rice varieties was 15–16 and their diversity indices were around 0.752.

- Kien Thanh Village has introduced a lot of improved rice varieties to plant in the wet season.
- Rice diversity index in the wet season in Dong Lac Village is 0.385, lower than at Kien Thanh because Dong Lac has larger areas of *Tam Xoan* and *Nep Thai Binh* (70% of compared total rice areas) (Table 1).

In the wet season, Dong Lac cultivates 96% of areas with *Tam Thom*, so that the non-glutinous rice diversity index is very low (0.122), but still high (0.701) in Kien Thanh. These results showed that specialty rice production has developed rapidly to meet the market demand; consequently rice diversity decreased rapidly. Dong Lac serves as a good example for this.

***Farmers' opinion on rice selection for production*:** Through our surveys in Kien Thanh, we found 14 rice varieties. Farmers with good knowledge have selected modern varieties like *Luong Quang, Q5, Khang Dan* and *Tap giao 1* to get higher yield but they still grow *Tam Xoan*, a high-value local non-glutinous and aromatic rice variety.

In Dong Lac Village, farmers' selection of rice varieties is based on economic efficiency and available techniques. *Luong Quang, Tap giao 1* and *Q5* have been selected for the dry season owing to available technical skills, while *Tam Xoan* and *Nep Thai Binh* are being produced in the wet season because of their high economic efficiency.

The market-oriented rice production in large monoculture inevitably leads to decrease in the number of rice varieties, hence narrowing the rice genetic diversity base.

Seed supply systems

Seed supply systems of local rice

Local rices like *Tam Xoan*, *Tam Nghe* (non-glutinous), *Nep Thai Binh*, *Nep Ba Lao* and *Nep cai Hoa Vang* (glutinous) are popular varieties in production at Kien Thanh and Dong Lac Villages. In Dong Lac 95.4% of farmers' households are self-suppliers of seed (Table 2).

Seed supply system of improved rice varieties

Hybrid rice: Almost all seeds of hybrid rice were bought from the State seed supply company.

Table 1. Rice diversity index at Kien Thanh and Dong Lac Villages

Index	Dong Lac	Kien Thanh
Yearly index		
Rice diversity index	0.751	0.754
Glutinous rice diversity index	0.465	0.446
None-glutinous rice diversity index	0.707	0.732
Improved rice diversity index	0.610	0.703
Local rice diversity index	0.340	0.505
Local glutinous rice diversity index	0.398	0.257
Improved rice diversity index	0.418	†
Seasonal index		
Rice diversity index in the wet season	0.385	0.723
Improved rice diversity index in the wet season	0.335	0.661
Non-glutinous diversity index in the wet season	0.122	0.701
Rice diversity index in the dry season	0.590	0.691
Non-glutinous rice diversity index in the dry season	0.597	0.686

† Only improved glutinous rice varieties remain.

Table 2. Seed supply system of rice production (% of surveyed farmers' household)

Seed source	Dong Lac	Kien Thanh
Local rice	100	100
Self-supply	95.4	80.0
State seed supply company	0.0	0.0
Market and free exchange	4.0	16.5
Others	0.6	3.5
Improved rice	100	100
Self-supply	48.8	62.0
State seed supply company	25.5	14.5
Market and free exchange	20.5	21.0
Others	5.2	2.5
Hybrid rice	100	100
State seed company	95.0	82.0
Exchange in the local market	5.0	15.0
Others	0.0	3.0

Basic rice varieties: almost all basic rice varieties are being kept by farmers (43.8% of farmers' household in Dong Lac and 62% in Kien Thanh). The percentage of seeds bought from the State company is very low (14.5% in Kien Thanh and 25.5% in Dong Lac). As it is very easy to maintain seeds of local rice varieties, farmers tend to keep seeds themselves from season to season. In the meantime, the seeds bought from State companies can be used only 3 to 4 years, after which they need to be replaced.

Farmer's seed storage in Dong Lac and Kien Thanh Villages

Both local and major rice varieties have been selected by farmers based on their experiences in cultivation, combined with the guidance of extensionists and technical officers, as well as on the experience shared among farmers. The seed selection and storage procedures are illustrated in Figure 1.

Selection of rice field: Rice fields where rice grows well with no pest and disease damage are chosen for seed collection. It is better if the selected fields are isolated or far from other varieties.
Selection of rice plants: Good rice plants in the middle of the field of selected varieties are chosen and harvested; the border plants are not taken. Then they are dried and stored separately in isolated places.
Selection of panicles: After collection of rice plant, good panicles are chosen (about 50-60%) for seeds.
Selection of seeds: After panicle selection, farmers thresh only 50–70% of grains per panicle for seeds.
Cleaning and drying: Farmers clean and dry selected grains for storage. When drying seeds they try to avoid rainy or too hot and sunny days.
Seed storage: After seed drying, farmers put seeds into glazed jars with caps. Many farmers also use nylon bags to store rice seeds.

Fertilizer utilization for rice production in Kien Thanh and Dong Lac

The surveyed results of farmer's practices in both dry and wet seasons show that procedures of rice cultivation are not different and consist of land preparation, seedling, transplanting, weeding, fertilizer use, irrigation, plant protection and harvest (Table 3). Table 3 shows that the level of nitrogen fertilizer used for improved and hybrid rices is very high, but very low for local and traditional rice varieties.

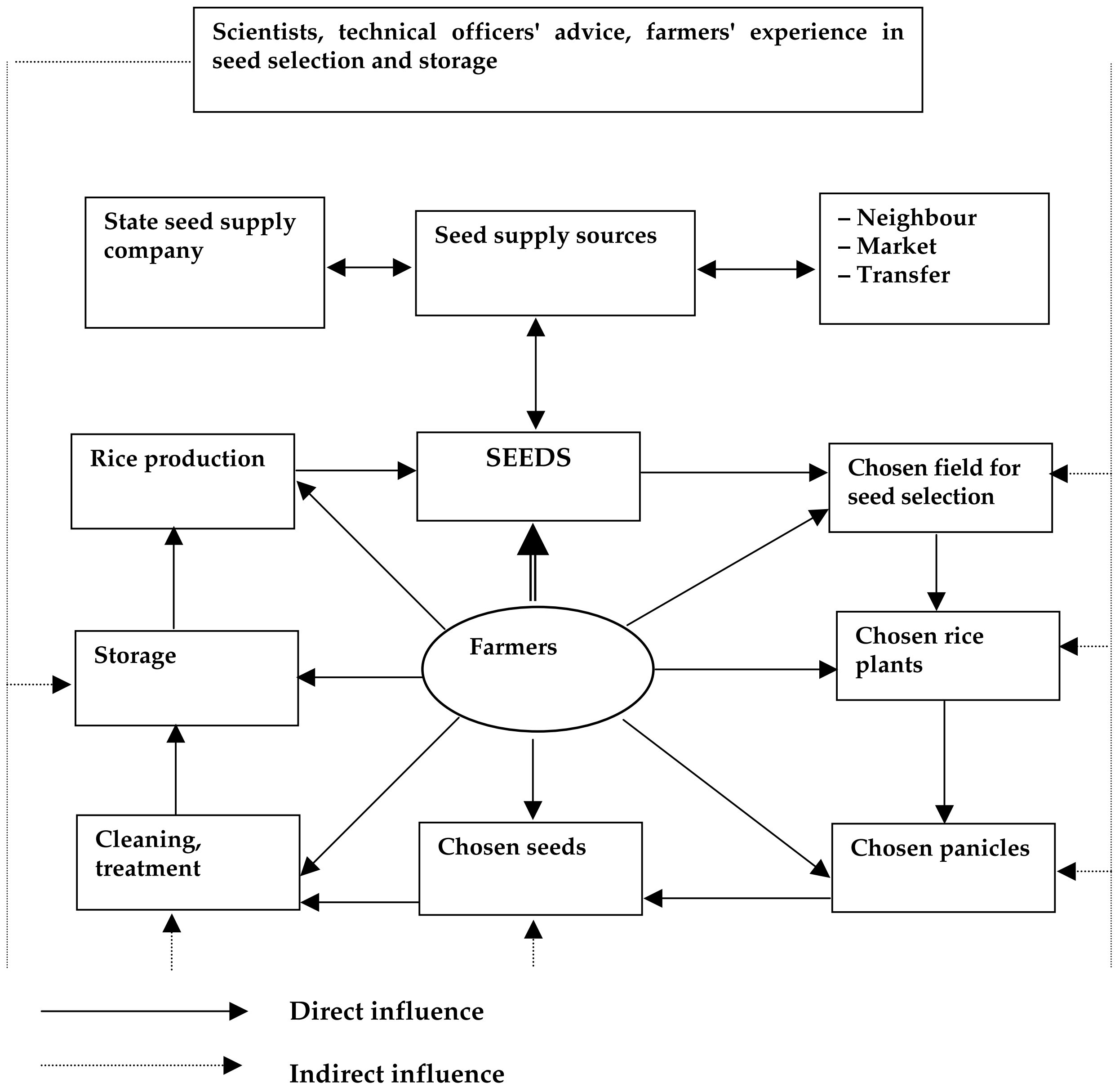

Figure 1. Procedure of seed selection and storage from season to season (six steps) in Kien Thanh and Dong Lac Villages.

Table 3. Fertilizer utilization and yield of popular rice varieties in Kien Thanh and Dong Lac in 1999 (kg/360 m^2)

Rice varieties	Fertilizer				Yield
	Organic	Nitrogen	Phosphate	Potassium	
Kien Thanh Village					
Local rice in the wet season	185.6 ± 21.6	10.1 ± 0.15	12.7 ± 0.36	3.1±0.10	125.6 ± 2.7
Improved rice in the wet season	217.0 ± 23.3	11.5 ± 0.20	14.1 ± 0.40	3.1 ± 0.10	208.9 ± 3.6
Improved rice in the dry season	258.0 ± 12.8	11.7 ± 0.30	13.8 ± 0.40	2.9 ± 0.10	255.2 ± 2.1
Dong Lac Village					
Local rice in the wet season	137.0 ± 13.2	9.7 ± 0.20	10.3 ± 0.10	2.5 ± 0.20	127.1 ± 1.98
Improved rice in the wet season	159.4 ± 17.5	12.3 ± 0.30	14.0 ± 0.50	2.9 ± 0.20	195.1 ± 3.8
Improved rice in the dry season	262.0 ± 8.2	12.8 ± 0.28	16.6 ± 0.30	2.7 ± 0.15	257.8 ± 2.3

Relationship of fertilizer amount and rice yield

Mathematical functions were used to analyze the relations between fertilizers and crop yield in Kien Thanh and Dong Lac (Table 4).

Table 4. Relationship of fertilizer amount and rice yield in Kien Thanh and Dong Lac Village in 1999

Village/ Season	Organic (x1)		Nitrogen (x2)		Phosphate (x3)		Potassium (x4)	
	R	Equation	R	Equation	R	Equation	R	Equation
Kien Thanh Village								
Local rice in wet season	0.813***	$y = 0.1x1 + 107.0$	-0.004ns	$y = -0.07x2 + 126.2$	0.632 * *	$y = 5.47x3 + 56.4$	0.345 *	$y = 10.06x4 + 98.3$
Improved rice in wet season	0.865***	$y = 0.15x1 + 177.3$	0.509**	$y = 8.86x2 + 102.2$	0.643**	$y = 4.87x3 + 140.2$	0.315*	$y = 12.2x4 + 171.5$
Improved rice in dry season	0.757***	$y = 0.13x1 + 219.1$	0.852***	$y = 7.12x2 + 170.3$	0.876***	$y = 4.41x3 + 194.2$	0.397*	$y = 10.2x4 + 226.7$
Dong Lac Village								
Local rice in wet season	0.773***	$y = 0.12x1 + 111.3$	0.156 ns	$y = 1.97x2 + 107.5$	0.591**	$y = 2.06x3 + 105.9$	0.40*	$y = 4.16x4 + 116.7$
Improved rice in wet season	0.729***	$y = 0.157x + 170.1$	0.547**	$y = 10.16x2 + 70.9$	0.416*	$y = 4.72x3 + 123.7$	0.394*	$y = 12.14x4 + 164.1$
Improved rice in dry season	0.687**	$y = 0.19x1 + 207.2$	0.672**	$y = 7.96x2 + 156.9$	0.594**	$y = 4.69x3 + 179.8$	0.482*	$y = 7.45x4 + 237.9$

*** $P < 0.001$; * $P < 0.05$; ** $P < 0.01$; ns: nonsignificant.

Local rice yield has interacted deeply with organic fertilizers both in Kien Thanh and Dong Lac (R=0.8128***in Kien Thanh and R=0.773*** in Dong Lac). Nitrogen fertilizers interacted deeply with improved rice varieties in both wet and dry seasons.

Comparison of economic efficiency between local and improved rice in Kien Thanh and Dong Lac in the wet season, 1999

Farmers selected seeds from season to season following two key purposes: (1) technical feasibility, and (2) economic efficiency. In this study, the economic efficiency of local rices *Tam Thom* and *Nep* was compared with that of improved rice varieties in 1999.

Kien Thanh Village, Nghia Loi Commune

The results of an economic efficiency study in Kien Thanh concerning local traditional and improved varieties are shown in Table 5. The data show that the local rice varieties *Tam Thom* and *Nep* have much higher efficiency than improved rice varieties (2.06 and 1.86 times, respectively).

Table 5. Comparison of economic efficiency between local and improved rice in Kien Thanh in the wet season, 1999

Parameter	Improved rice (a)	Tam Thom (local rice) (b)	Glutinous rice (c)	(b)/(a)	(c)/(a)
Yield (kg/sao)	206	118	129.0	0.57	0.62
Price (1000VND/kg)	1.74	3.60	3.40	2.12	1.96
Total income (1000VND/sao)	357.41	435.60	439.20	1.22	1.23
Cost for material (1000VND/sao)	97.37	73.40	82.50	0.75	0.85
Cost for labour (1000VND/sao)	79.20	71.20	73.90	0.90	0.93
Tax-free income (labour included) (1000VND/sao)	260.04	362.10	356.60	1.39	1.37

Parameter	Improved rice (a)	Tam Thom (local rice) (b)	Glutinous rice (c)	(b)/(a)	(c)/(a)
Income after tax deduction (1000VND/sao)	227.74	329.80	324.30	1.45	1.42
Net income (1000VND/sao)	148.52	258.6	250.40	1.74	1.69
Investment result/1 VND for material cost (VND)	3.67	5.93	5.30	1.62	1.45
Investment result/1 VND for production cost (VND)	1.71	2.46	2.30	1.44	1.36
Net income/1 VND of production cost	0.71	1.46	1.30	2.06	1.86

Dong Lac Village, Nghia Lac Commune

The results of an economic efficiency study in Dong Lac concerning local traditional and improved varieties are shown in Table 6. In Dong Lac, both absolute income and relative economic efficiency of traditional rice varieties production are still higher than in Kien Thanh.

Conclusions and suggestions

Conclusions

In order to get more income, farmers in the studied communes select local traditional and specialty rice varieties rather than the improved varieties. This kind of market-oriented production may lead to a decrease in the number of rice varieties, causing erosion of diverse rice genetic resources in the two villages. However, this is also a good opportunity to launch a nationwide campaign for on-farm conservation of local traditional genetic resources that have numerous precious traits and will be the basis of survival for future generations.

Cost of labour and seed of local and specialty rices is lower and their economic efficiency is higher than that of improved rice varieties. At present, the amount of nitrogen fertilizer used for *Tam Thom* production is quite high, leading to a decrease in its yield and economic efficiency. So, for traditional varieties, nitrogen fertilizers may not be the best choice. Instead, organic fertilizers should be used to produce clean products that can be sold for a higher price; their market is more available.

Table 6. Comparison of economic efficiency between local and improved rice varieties in Dong Lac in the wet season, 1999

Parameter	Improved rice (a)	Tam Thom (local rice) (b)	Glutinous rice (c)	(b)/(a)	(c)/(a)
Yield (kg/sao)	191	119	131	0.62	0.69
Price (1000VND/kg)	1.76	3.70	3.42	2.10	1.94
Total income (1000VND/sao)	336.16	440.30	448.02	1.31	1.33
Cost for material (1000VND/sao)	93.13	52.60	64.30	0.57	0.69
Cost for labour (1000VND/sao)	86.00	66.00	76.00	0.77	0.88
Tax-free income (labour included) (1000VND/sao)	243.03	387.70	383.72	1.50	1.58
Income after taxes (1000VND/sao)	210.73	355.40	351.42	1.69	1.67
Net income (1000VND/sao)	124.73	289.40	275.42	2.32	2.21
Investment result/1 VND for material cost (VND)	3.61	8.37	6.96	2.32	1.93
Investment result/1 VND for production cost (VND)	1.59	2.91	2.59	1.84	1.63
Net- ncome/1 VND of production cost	0.59	1.91	1.59	3.25	2.71

Suggestions

To facilitate agrobiodiversity conservation on farm, it is necessary to:

1. Identify suitable rice collections and appropriate cropping patterns. This will help not only to maintain diversity of rice varieties but also to increase economic efficiency for farmers.
2. Strengthen research and extension activities concerning the use of indigenous knowledge, traditional techniques and genetic resources. This will help to cope with the environmental changes and to protect the rural environment from pollution.
3. Carry out research to identify the best fertilizer level and production techniques for each outstanding local traditional variety like *Tam Thom, Nep Hoa Vang, Nep Thai Binh*, etc. in order to reduce the production cost, hence increasing their economic efficiency and stimulating farmers to conserve the agrobiodiversity on-farm.

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Effects of traditional farming systems on upland rice diversity in Da Bac site

Luu Ngoc Trinh, Nguyen Thi Ngoc Hue, Dang Van Nien and Nguyen Phung Ha

Introduction

The Tay people are the second largest ethnic group in Vietnam, following the Kinh (the most numerous ethnic group). They have a comparatively high education level, good farming knowledge and their distribution covers all areas of the north, northeast and northwest mountainous regions of Vietnam.

Each ethnic group has its own customs, practices and ways of living. The relationships between cultural customs and cultivation practices are close. Many different cultivation practices are typical for many ethnic minorities of Vietnam. In addition, they have their own varieties suitable for specific micro-ecosystems. This means that there is species diversity or biodiversity of their various crops.

The Tay in Da Bac District, Hoa Binh Province are part of the Tay ethnic group in Vietnam. They have their own cultivation systems and select seed to adapt to local conditions. This has created not only high diversity of crop species but also intravarietal diversity. Upland rice is an excellent example of this diversity.

Conducting studies on the effects of traditional farming systems on rice diversity and establishing suitable models for *in situ* conservation are very important research issues.

This paper reports a study of the Tay people at Da Bac site. The study objectives were to:

- study the effects of management methods and household storage on the diversity of local rice varieties
- analyze the effects of farming management on maintenance of rice genetic diversity.

Study methodology

PRA and RRA were applied to collect information about the local rice varieties, their growth duration, soil fertility requirements and uses.

Results and discussion

Upland rice diversity by growth duration

The Da Bac farmer can not use new cultivation technologies, so lengthening harvesting time is one suitable practice to avoid no or poor harvests. In both villages, rice varieties have various growth durations: long term, medium term and short term. This is because the cultivation season depends on the rainy season, beginning from April to late May, and harvest season begins from September to late November in mountainous areas. The distance

Table 1. Classification of upland rice varieties by growth duration at two microsites, Da Bac District, Hoa Binh Province

	Growth duration	
Short	**Medium**	**Long**
Khau mon tram	Khau khinh	Khau dam ca
Khau mac buom	Khau mon nieu	Khau lech luong
Khau tram pom	Khau hang ngua	Khau cam pi
Khau nam ma	Khau hang mu	Khau yen the
Khau tram sai	Khau tram khao	Khau mac cai
Khau thuong hai	Khau cao su	Khau mac co
Khau lao	Khau toi	Khau luong cong
Khau hang don	Khau tram hom	
Ke de tram	Tang san nieu	
Khau tram nanh	Ca lan danh	
	Ca lan khao	

from house to field, and also from one field to another is very far. If all varieties have the same growth duration, it will be difficult to grow as well as harvest all crops in a short time, and to avoid a harvest failure when conditions are not favourable.

Using many varieties with different growth durations is a suitable aspect of the farming systems of mountain farmers. This practice is one reason for upland rice diversity in mountainous areas.

Upland rice diversity by soil fertility requirement

In mountainous regions, most farmers do not use any kind of fertilizer in shifting cultivation; they grow rice only on the natural fertility of the soil. The rice varieties in the two villages have adapted to special niches. In fact, the upland rice in Da Bac district is of three separate types. There are varieties such as *Khau Khinh, Khau Toi* and *Khau Tram Khao* which have good growth and high yield only in highly fertile soils. Growing them in poor soil may result in a very bad and uneven harvest. However, there are varieties that have good growth ability and stable yield in poor soils, such as *Khau Mon, Khau Thuong Hai* and *Khau Cao Su*. This explains why *Khau* is still grown in a large area by many households in Cang Village, in spite of its low quality.

Upland rice diversity by use value in Da Bac site

Table 3 shows that the farmers keep local rice varieties as a traditional food crop granted by the gods for holidays and festivals, and also as medicinal materials. Some typical rice landraces are maintained for good taste and cooking quality; others for processing purposes. This applies to Vietnam in general, and to mountainous areas in particular.

Conclusion

Traditional practices have significantly affected the rice genetic diversity in the two study villages. During the production process, the farmers have selected and conserved an appropriate number of rice varieties to cope with the specific conditions, soil fertility, utilization demands, preferences, and cultural traditions and customs.

Table 2. Classification of upland rice varieties by fertility requirement at two microsites in Da Bac District, Hoa Binh Province

Soil fertility		
High	**Medium**	**Low**
Khau mac buom	Khau tram sai	Khau mon tram
Khau nam ma	Khau lao	Khau tram pom
Khau khinh	Khau tram nanh	Khau thuong hai
Khau toi	Khau hang ngua	Ke de nieu
Khau tram khao	Khau tram hom	Ke de tram
Khau dam ca	Ca lan danh	Khau mon nieu
Khau luong cong	Ca lan khao	Khau hang mu
Khau cam pi	Khau lech luong	Tang san nieu
	Khau mac co	Khau cao su
	Khau mac cai	
	Khau hang don	
	Khau yen the	

Table 3. Classification of upland rice diversity by use value in Da Bac site

Use	Variety
Food (rice, gleam)	Khau mon, Khau mac cai, Khau ca lan, Khau tram khao, Khau tram nanh, Khau tram pom, Tang san nieu, Khau cao su, etc.
Gleam, sweet gleam, cakes	Khau khinh, Khau lao, Khau do, Khau mac cai, Khau hang mu, etc.
Medicine	Khau cam pi
Traditional festivals	Khau tram hom, Khau khinh, Khau lech luong, Khau toi, Khau Lao, etc.

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Study of the effect of socioeconomic factors on crop diversity in some studied ecosites

Dinh Van Dao, Luu Ngoc Trinh, Tran van The and Nguyen Ngoc Hue

Introduction

The attention to high-yielding new varieties and the neglect of local low-yielding varieties have been being the main factors leading to the loss of balance in agrobiodiversity. Agricultural development has been and is being affected by this imbalance. Crop diversity is highly dependent on socioeconomic factors such as household (HH) knowledge, food supply status, traditional practices, etc., as well as on agroecological conditions in rural areas. The study of the effects of these factors can help develop a balanced production in terms of economic efficiency and conservation of agrobiodiversity for sustainable development.

Objectives of the study

- To analyze the relationship between socioeconomic factors such as the age of HH head, food self-sufficiency, number of HH members, total income, agricultural portion from total income and total farming lands as well as crop diversity at HH level by using quantitative analysis.
- To find out the useful and unuseful factors valuable for *in situ* conservation.

Materials and methods

Site and household selection

The sites and households for the study chosen from three selected sites of an IPGRI *in situ* conservation project differ from each other in ecosystems and socioeconomic conditions. The rules for selection and selected sites are shown in Table 1.

Data collection and analysis

Data collection: Rapid Rural Appraisal (RRA) and participatory rural appraisal (PRA) methods were used for data collecting.

Data analysis methods: Excel program was used for calculation of statistical parameters. A multiple variable model combined with hypothetic variable were used to show relationships between observed factors and existing crop diversity at HH level. The following is an equation of the model:

$$Y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + bz$$

where:

Y= Dependent variable (Number of varieties in HH)

$a_1 - a_5$ = Coefficients of independent variables

b = Coefficient of logic variable

x_1 = Age of HH head (year)

x_2 = Total of people in HH (persons)

x_3 = Income per year (Mil. VND)

x_4 = Agricultural portion from the total income (%)

x_5 = Area of field land (m^2)

z = Food self-sufficiency: This is a dummy hypothetic variable that aims to replace qualitative with quantitative variable expressed like logic variable, the value of which was scored as 1 and 0, representing food self-sufficient and non-sufficient farmer HHs, respectively.

Table 1. Rules for selection, selected sites and the number of selected households

Ecosystem	Selected sites		Total HHs in village	Investigated HHs	
				No.	%
Mountainous	Da Bac District, Hoa Binh Province	Cang Village, Doan Ket Commune	83	62	75
		Tat Village, Tan Minh Commune	68	62	91
Midland	Nho Quan District, Ninh Binh Province	Quang Mao Village, Thach Binh Province	39	38	98
		Yen Minh Village, Yen Quang Commune	105	73	70
Red River Delta	Nghia Hung District, Nam Dinh Province	Group 3 and Group 10, Dong Lac Village, Nghia Lac Commune	345	121	35
		Kien Thanh Village, Nghia Loi Commune	435	73	17

The model was analyzed as follows:

If x_i increases once, then Y would be $a_i x_i$ times more and vice versa.

$b <= 1$, and if b is closer to 1 then Y is more influenced by hypothetic variable (z) and vice versa. In this case, therefore, the age of HH head, farming land and agricultural portion from the total income are not changing within a defined period of time. The results show neither increased nor decreased factors affecting crop diversity.

Some valuable conclusions on different levels of observed factors influencing crop diversity will be made based on the analyzed results and the factors that need to be paid more attention to for PGR *in situ* conservation activities will be pointed out.

Results and discussion

Main features at six studied sites

The socioeconomic parameters studied at the six sites are shown in Table 2. Tat and Cang Villages are situated in mountainous ecosites 30–80 km from the district centre. As the transportation is very difficult, exchange of agroproducts is limited. Moreover, the Tay minority constitutes about 99% of the total population and their agricultural production is still backward. Regardless of this, the diversity of upland rice is high in this area.

Yen Minh and Quang Mao belong to a midland ecosite, so the exchange of agroproducts is easier than at the abovementioned two villages, but agroproduction is still self-sufficient. The diversity level of crop varieties is lower than that of Tat and Cang Villages in the mountainous ecosite. Besides rice, some taro varieties with high quality are used in this area.

Dong Lac and Kien Thanh Villages are representative of the Red River Delta area where modern techniques of cultivation have been applied and farmers' knowledge on agricultural production is very high. Traditional rice varieties such as *Tam Xoan* and *Tam Ap Be* with high commercial value are diverse in this area. This feature is recognized as a good condition for selection of *in situ* conservation sites of *Tam* varieties.

3.2. Factors chosen for study

The reasons for choosing six effective factors and an independent factor are as follows:

The average age of HH heads

This factor is related to education level, knowledge level and decision-making ability to select crop varieties. The older HH heads often have a low education level so that their old ideas and limited knowledge make it difficult for them to choose crop varieties and agricultural practices. The average age of HH heads is clearly different in three ecosites (Table 3).

Table 2. Selected socioeconomic parameters by site

Criteria	Tat Village		Cang Village		Yen Minh Village		Quang Mao Village		Dong Lac Village		Kien Thanh Village	
	quantity	%	quantity	%	quantity	%	quantity	%	quantity	%	quantity	%
Total land (*ha*)	158.1	100	150.2	100	57.72	100	80	100	90.6	100	45.8	100.0
Total agricultural land (*ha*)	42.8	27.1	41.1	27.36	48	83.2	10	12.5	72.7	70.3	37.4	75.9
Total of HH (*HH*)	83	10.0	68	100.0	105	100	42	100	1140	100.0	435	100.0
Rich HH (*HH*)	8	10.2	8	11.0	24	22.8	6	14	114	10.0	87	20.0
High–medium HH (*HH*)	12	13.6	3	4.0	16	15.23	21	50	570	50.0	174	40.0
Medium HH (*HH*)	38	45.5	41	60.3	49	46.67	9	21	331	30.0	152	35.0
Poor HH (*HH*)	25	30.0	16	23.7	16	15.24	6	15	115	10.1	22	5.0
Investigated HH (*HH*)	62	47.7	62	92.5	73	68.57	38	90.4	121	12.0	73	16.7
Total of population (*persons*)	406	–	378	–	465	–	250	–	4900	–	1750	–
Average no. of people per HH	4.89	–	5.55	–	4.42	–	5.95	–	4.3	–	4.0	–
Altitude (*masl*)	675	–	675	–	90	–	60	–	1.4	–	1.4	–
Mean annual rainfall (*mm*)	1750	–	1750	–	1900	–	1900	–	1600	–	1600	–
Average yearly temperature (*°C*)	23.5	–	23.5	–	27.5	–	27.5	–	32 – 35	–	32 –35	–
No. of crop species	66	–	87	–	107	–	95	–	123	–	70	

Table 3. Quantification of factors affecting crop diversity

Criteria	Tat ($X \pm m_x$)	Cang ($X \pm m_x$)	Yen Minh ($X \pm m_x$)	Quang Mao ($X \pm m_x$)	Dong Lac ($X \pm m_x$)	Kien Thanh ($X \pm m_x$)
Age of HH head (*year*)	38 ± 1.43	43.3 ± 1.11	47.22 ± 1.27	42.6 ± 1.69	51.58 ± 1.13	44 ± 1.18
Food self-sufficiency	0.5 ± 0.09	0.34 ± 0.12	0.7 ± 0.051	0.50 ± 0.08	0.9 ± 0.03	0.85 ± 0.04
No. of HH members (*persons*)	5.5 ± 0.16	5.22 ± 0.05	4.87 ± 0.17	6 ± 0.27	4.53 ± 0.14	4.67 ± 0.15
Total income/year (*million VND*)	4.92 ± 0.55	5.28 ± 0.45	15.65 ± 0.79	11.73 ± 0.69	22.95 ± 1.64	15.88 ± 1.05
Agricultural portion from total income (%)	65.9 ± 1.17	73.75 ± 1.08	84.54 ± 2.0	81 ± 2.67	76.81 ± 1.83	79.22 ± 2.25
Total farming land (m^2)	34284 ± 156.3	32051 ± 164.5	6183.02 ± 239.2	23353 ± 264.7	5812.01 ± 453.82	4817.04 ± 503.9
No. of crop varieties/ HH (*varieties*)	4.9 ± 0.18	5.7 ± 0.19	4.24 ± 0.141	3.87 ± 0.23	5.28 ± 0.16	4.48 ± 0.21

Number of people

In rural areas, the number of people is an important factor for farmer HH economy. The labour force for agriculture is not much dependent on age, so that the number of people per HH has been selected.

Food self-sufficiency

Food self-sufficiency is 0.5 for Tat and 0.35 for Cang Village. The data in Table 3 show that many farmer HHs do not have enough food and their crop varieties are limited. The two villages in the Red River Delta ecosite have a high coefficient of food self-sufficiency (0.9 in Dong Lac and 0.85 in Kien Thanh). This is a good condition for choosing suitable crop varieties. The difference in food self-sufficiency coefficients in various areas helps in creating different solutions for *in situ* conservation activities.

Total income, agricultural portion from total income and farming land

The averages of total income of investigated farmers differs and increases from mountainous areas down to the Red River Delta area. In contrast, the average farming land of each HH is highest in mountainous areas. The agricultural portion from the total income is also different among the selected ecosites (Table 3). The average number of crop varieties is different in each farmer HH. Obviously, each ecosite has its own specific varieties. For example, upland rice varieties are grown in mountainous areas, local taro varieties in midland areas and aromatic rice varieties in the Red River Delta.

The selected factors are suitable for the particular conditions of each site. The observed (independent) factors do not change much (m_x is very low). Owing to the large number of samples, the representativeness is high and will make the result statistically significant in the model analyzing process.

Results of model analysis

All the observed samples (100%) are closely related within all ecosites. Multiple R at three ecosites is a positive value and decreases from mountainous to the Red River Delta through the midland ecosite. It is clear that selected socioeconomic factors positively affect the number of crop varieties in farmer HHs, the level being different at all ecosites. Multiple R is low in Kien Thanh Village (0.18) and in Dong Lac Village (0.29). This means that the relationship between observed variables and the number of crop varieties in farmer HHs is not close. In contrast, multiple R in the mountainous ecosites is rather high (0.76 in Cang and 0.77 in Tat Villages). It means the dependent and independent factors are highly related.

Table 4. Relative coefficients of independent variables concerning crop diversity at HH level

TT	Criteria	Tat	Cang	Yen Minh	Quang Mao	Dong Lac	Kien Thanh
I	Observed variable	62	62	80	38	121	73
II	Regression variable	62	62	79	38	121	73
III	Multiple (R)	0.77**	0.76**	0.43**	0.47**	0.29*	0.18**
IV	R Square	0.59	0.58	0.18	0.22	0.08	0.10
V	Coefficient of independent variable						
1	Age of HH head (X_1)	–0.027**	–0.03	0.02	0.01	0.001	0.06
2	Food self=sufficiency (Z)	–0.28**	–0.30**	0.13	0.99**	0.83**	–0.076
3	Number of people per HH (X_2)	–0.53**	0.21**	0.16**	0.1	0.09	0.3
4	Total income (X_3)	–0.16**	0.20*	0.02*	0.11*	–0.09	–0.003
5	Agricultural portion from total income (X_4)	0.12**	0.26 **	0.01	0.01	0.015*	0.005*
6	Farming land (X_5)	0.16 **	0.62**	0.0001	0.00001	0.00004	0.00006

** Significance level P= 99%; * significance level P= 95%.

The statistical significance of multiple R in three ecosites is shown at confidence level *P*=99%. The result shows that selected factors relate in linearity with the number of crop varieties in farmers' HH (by comparison of R, Fisher's test).

The level of dependence of the number of crop varieties on socioeconomic factors is different among ecosites; 58% of the change in the number of crop varieties depends on the socioeconomic factors in mountainous ecosites. The R square is low at Dong Lac and Kien Thanh. This reflects the conditions of each ecosite; the number of crop varieties depends very much on selected factors in mountainous areas. Furthermore, farmers are using a lot of upland rice varieties which makes the area conditions more diverse while in the Red River Delta areas, the diversity of crop varieties depends more on varietal factors such as high yield and short growth duration.

The analysis of the obtained results shows that the number of crop varieties is affected by all the observed factors (number of people in HHs, agricultural portion from total income and farming land area) in all three ecosites.

The coefficient of the number of people per HH was positive in all three ecosites. The highest was observed in Tat Village (0.53 at *P*=99%) and the lowest at Dong Lac Village. Because of slash-and-burn cultivation in mountainous areas, application of comprehensive measures of cultivation is difficult. Therefore, farmer HHs need a lot of labour to work on a farm. In contrast, modern techniques of cultivation are easily applied in the Red River Delta area, so the agricultural production is less affected by the number of people in HHs.

Agricultural portion from total income

Like the number of people per HH, the coefficient of agricultural portion factor is positive and decreases regularly from mountainous to the Red River Delta areas. Among the study sites, this coefficient is highest in Cang Village (0.26 at *P*=99%) and lowest in Kien Thanh Village. The actual total income of HH is low, but its agricultural portion is high in mountainous areas. In order to increase the total income, farmers have to extend their agricultural production using different crop varieties.

The number of crop varieties is clearly affected by the agricultural area. The coefficient of farming factor is high at Tat and Cang Villages (0.26 and 0.62 at *P*=99%). Otherwise, this factor is affected very little in the Red River Delta area. This result shows that diversity of crop varieties is high in mountainous areas where the upland rice area is very large and upland rice varieties enjoy the highest diversity.

Food self-sufficiency

The coefficient of this factor is negative in all mountainous ecosites (–0.28 at *P*=95% in Tat and –0.3 at *P*=95% in Cang Village). This result could be explained as follows: the farmers are used to intergrowing different crop varieties in one field during one growing season to reduce the risk of bad weather conditions. This is the reason for high diversity of crop varieties. The diversity of crop varieties is clearly affected by food self-sufficiency in Quang Mao Village (0.99 at *P*=99%). The result clearly indicates that the application of suitable crop structure in different soil types could increase the agricultural production. In Dong Lac and Kien Thanh, the food self-sufficiency is mainly based on production of aromatic rice with high market value.

Conclusions and suggestions

- The crop diversity among varieties is affected by different factors in all ecosites.
- The number of varieties is more clearly influenced by the independent variables in mountainous ecosites than at other ecosites and the multiple R is also highest in mountainous ecosites (R = 0.76 and 0.77).
- The variability coefficients of factors representing farming land, agricultural portion from total income and number of HHs varies highly. The coefficients of total income

and farming land are highest in mountainous ecosites and lowest in the Red River Delta ecosites.

- The diversity of crop variety factor is not affected by food self-sufficiency at the two villages in mountainous areas but is clearly affected in the midland ecosites.
- It is important to focus on the factors such as number of people per HH, agricultural portion from total income and area of farming land in selecting HHs for *in situ* conservation at different sites.

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