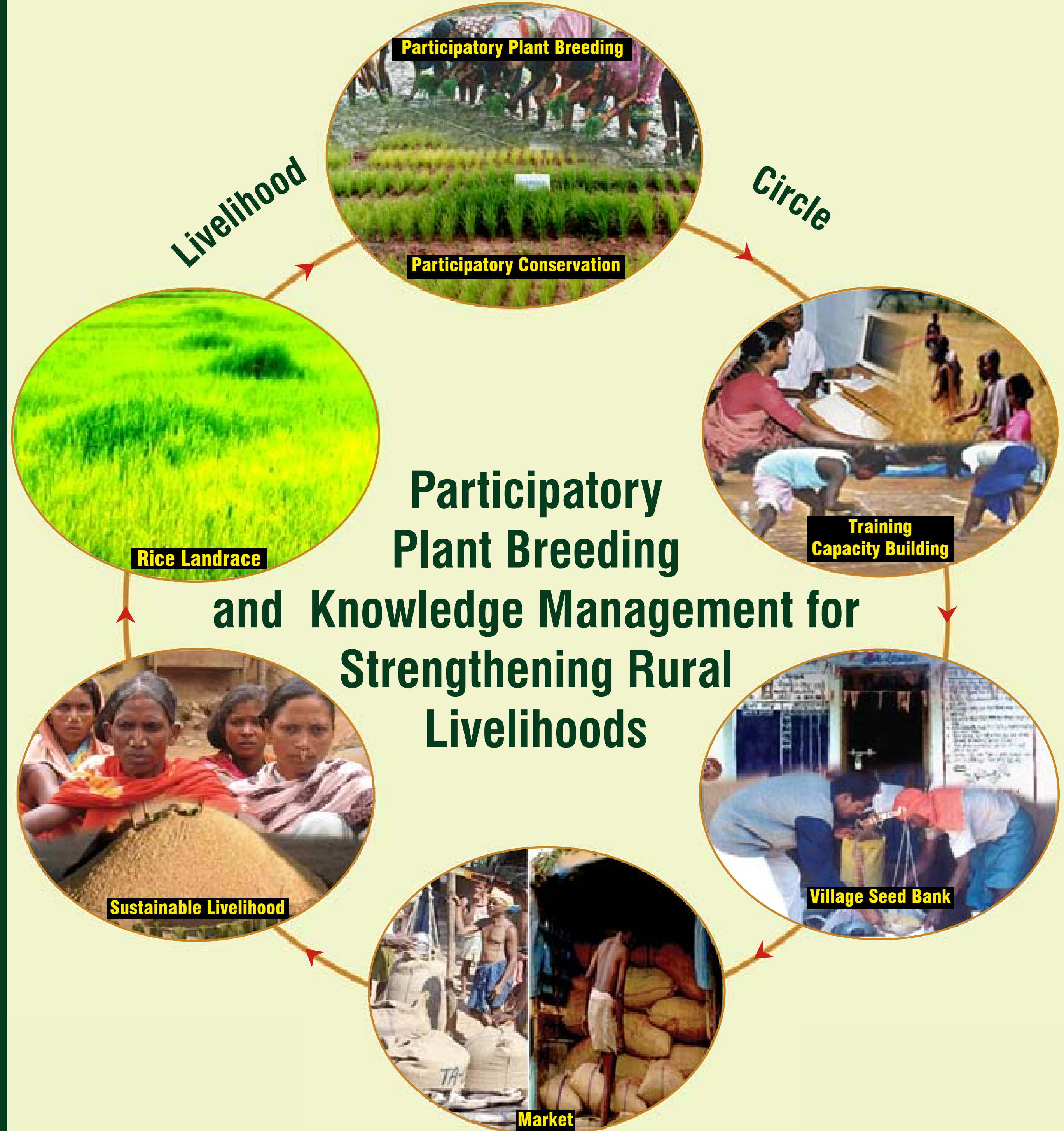
M S Swaminathan Research Foundation
3rd Cross Street, Institutional Area
Taramani, Chennai 600 113, INDIA
Tel: +91-44-2254 1229, 2254 1698
Fax: +91-44-2254 1319
Email: executivedirector@mssrf.res.in
www.mssrf.org

Participatory Plant Breeding and Knowledge Management for Strengthening Rural Livelihoods

Participatory Plant Breeding and Knowledge Management for Strengthening Rural Livelihoods



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Agency for Development and Cooperation SDC

Edited by
V. Arunachalam

MSSRF

Participatory Plant Breeding and Knowledge Management for Strengthening Rural Livelihoods

Papers Presented in an International Symposium held at
M. S. Swaminathan Research Foundation
Chennai

Edited by
V. Arunachalam
Technical Programme Advisor
M. S. Swaminathan Research Foundation
Chennai

MSSRF/PR/07/66

M S Swaminathan Research Foundation
3rd Cross Street, Institutional Area
Taramani, Chennai 600 113, INDIA
Tel: +91-44-2254 1229, 2254 1698
Fax: +91-44-2254 1319
Email: executivedirector@mssrf.res.in
www.mssrf.org

Foreword

The concept of Evergreen Revolution involves enhancement of productivity in perpetuity without associated ecological and/ or social harm. To achieve such a revolution in farm productivity, there is need to mainstream sustainability parameters in research and development. In the area of plant breeding, this implies the conservation of genetic diversity and its use for breeding varieties which are adapted to the local agro-climatic and agro-economic conditions as well as culinary preference. Varietal homogeneity enhances genetic vulnerability to pests and diseases and hence genetic heterogeneity is vital for sustainable agriculture.

Participatory plant breeding is an effective pathway to develop strains of crop varieties adapted to local conditions and to maintain genetic diversity among the varieties cultivated. Wherever participatory methods of breeding and knowledge management have been effectively used, the result has been the development of varieties which are adapted to local agro-climatic condition, efficient in the use of the available water and nutrient resources, and amenable to agronomic practices like integrated nutrient supply and integrated pest management. The NERICA Rices developed by the West African Rice Development Association (WARDA) provide a good example of the effectiveness of participatory plant breeding in achieving yield and production breakthrough.

MSSRF, with generous financial support from the Swiss Agency for Development and Corporation, has been engaged in Participatory Plant Breeding (PPB) work with the tribal families of the Koraput region in Orissa. During the last ten years, this work has yielded very valuable results and has resulted in an improved strain of the local variety Kalajeera. Encouraged by the power of PPB to promote and sustain an evergreen revolution, MSSRF organized an International Symposium on Participatory Plant Breeding and Knowledge Management for Strengthening Rural Livelihoods in July 2006. The present publication contains the papers presented at this symposium as well as the text of the Chennai Statement on PPB. I hope the publication which summarizes the available international experience in PPB will be widely read and used by scientists and scholars working in the area of sustainable agriculture.

I am grateful to the donors, International Rice Research Institute, Philippines; Bioversity International, Italy; XV International Genetics Congress Trust, New Delhi; and Swiss Agency for Development and Cooperation, New Delhi whose financial support enabled us to organize this symposium. I am also indebted to my colleague Prof. V. Arunachalam, who shouldered along with Dr V. Arivudai Nambi, Project Coordinator the main responsibility for organizing this symposium and for compiling and editing this publication.

M. S. Swaminathan
Chairman
M. S. Swaminathan Research Foundation

Foreword

The escalating rate of erosion of biodiversity in India and the world is a grave concern. Erosion of biodiversity not only represents an irretrievable loss for humanity, it also deprives millions of rural people, especially tribal, of their livelihoods. The real challenge is to find ways and means of reconciling the needs of the rural poor with the necessity of conserving and enhancing the natural resource base. This is the area in which the MS Swaminathan Research Foundation (MSSRF) has built up its expertise through its Biodiversity Programme in partnership with Swiss Agency for Development and Cooperation a department of the Foreign Affairs Ministry of Switzerland.

The overall goal of the partnership is to promote biodiversity conservation and enhancement as an effective instrument for natural resource management and poverty alleviation. During the partnership the objectives of developing innovative approaches and their wider dissemination, enhancing capacities of stakeholders at various levels and contributing to conducive policy, legal and institutional conditions at national and state levels have been achieved to a great extent. In particular, some noteworthy achievements have been the revitalization of in situ on-farm conservation traditions through quality seed production, the establishment of community seed banks, participatory genetic enhancement of land-races of rice varieties, establishment of community biodiversity registers, linking up of communities with markets and identification of value addition processes.

Participatory Plant Breeding (PPB) techniques and procedures, a path way to revive participatory conservation activities, as practiced by the poor tribal farming community, in Jeypore tract of Orissa, claimed to be the secondary centre of origin of rice, helped tribal community in Orissa for improving their livelihoods. It is a matter of great satisfaction that not only landraces that were disappearing were revived, through PPB but they were used effectively and efficiently to meet tribals' food security requirements and also helped create economic incentives to conserve the eroding biodiversity in this part of the country. This would not have been possible but for the two-pronged strategy adopted by MSSRF at community and policy level.

We wish to sincerely thank Professor MS Swaminathan for guiding the project on "Biodiversity Conservation, Integrated Natural Resource Management and Poverty Reduction" to its success. We also wish to congratulate his dedicated team for bringing out this publication of the papers presented during the three day International Symposium on "Participatory Plant Breeding and Knowledge Management for strengthening Rural Livelihoods" from 17-19 July 2006 held at MSSRF, Chennai, at a time when knowledge on PPB is of strategic importance. Government needs information for informed policy dialogue and decision making on PPB, civil society needs information on PPB to participate in policy formulation and to guide -implementation of biodiversity conservation initiatives and development agencies need information on PPB to support implementation of the convention for biological diversity.

However, challenges remain in effectively integrating judicious biodiversity management in agriculture notably through building strong institutions and developing appropriate regulatory mechanisms. Unless additional efforts are made the 2010 biodiversity targets declared by the UN Biodiversity Convention in 2002 of "achieving a significant reduction in the rate of biodiversity loss at all levels" will hardly be met.

Francois Binder
Country Director
Swiss Agency for Development and Co-operation, India

Contents

Abstracts Only

Preface

Participatory Plant Breeding (PPB) has evolved into a popular discipline providing a bridge between classical Mendelian breeding and modern molecular breeding. It is acknowledged that high yielding varieties (HYVs) developed in many crops through years of sustained plant breeding research have been primarily responsible to elevate nations suffering from chronic food deficit to food self-sufficiency and surplus. At the same time, poor farmers with small and marginal holdings who could not afford the input requirements of HYVs were left out of the HYV opportunities.

Further, HYVs aimed at increasing productivity and hence production. On the other hand, poor farming communities desire varieties that cater to their desirable taste and cooking preferences. But HYVs were not bred for such desired traits; hence tribal/rural communities who grow HYVs to gain economic benefit through buy-back arrangements, do also grow small areas with traditional varieties they prefer.

In the context of improving their lot and non-HYV farmers, in general, PPB has been recognized as a possible option. In the process, opportunities for conserving peoples' local varieties and ancient landraces can open up addressing the important area of biodiversity conservation. In such a process, the traditional knowledge of tribal women, particularly seed selection, could come to profitable use thus emphasizing the role of women in farming. Conservation, cultivation, consumption and economic gains through marketing excess production when enabled could lead to sustainable pathways of poverty reduction.

A number of global organizations have been working with less-privileged farming communities using PPB as a desired option. In particular, they employ participatory varietal selection to breed and introduce varieties carrying farmer-desired traits.

M S Swaminathan Research Foundation has been working for more than 8 years in the area of biodiversity conservation and poverty reduction with a pro-poor, pro-woman, pro-nature and pro-livelihood orientation. The pathway of Participatory Plant Breeding has benefited considerably the poor tribal farming community in Jeypore tract of Orissa, a secondary center of origin of rice. Not only landraces that were going out of cultivation were revived but used efficiently to meet the food needs of tribals and to earn economic gain. This has resulted in an over all improvement in the lives of poor tribal communities[1].

To gain further from diverse attempts across countries on such objectives and to share experiences, MSSRF organized a three day International Symposium on "Participatory Plant Breeding and Knowledge Management for strengthening Rural

Livelihoods" from 17-19 July 2006 at M.S. Swaminathan Research Foundation, Chennai. The symposium had the following sessions:

1. Participatory Research for Livelihood Security. I. Participatory Plant Breeding and Improvement
2. Participatory Research for Livelihood Security. II. Livelihood Options
3. Integrating Traditional knowledge with improvement options for enhanced Livelihood Security of the poor
4. Social Benefits from Participatory Improvement and Gender Issues
5. Case histories that demonstrate enhanced livelihood security of the poor
6. Capacity building, Training institutions and Farmers' Rights

Around 80 scientists including representation from six countries, international organizations in India, Agricultural Universities, Government organizations and NGOs participated in the symposium. The symposium provided ample time for discussion after formal presentations. After the symposium, the participants converged on a Chennai statement on Participatory Plant Breeding that is appended at the end of 'Preface'. This book presents edited version of presentations approved by contributors.

Salient points emerged from the symposium on the theory and practice of PPB and related livelihood options.

Participatory Plant Breeding (PPB) is seen as a way to overcome the limitations of conventional breeding by offering farmers the choice to decide which varieties suit better their needs and conditions without exposing the household to any change entailing risk. While professional breeders generate genetic variability on the varieties known to farmers, testing and selection are done on-farm jointly by farmers and breeders in a number of targeted environments. By this process varieties reach 'release phase' much earlier[2]. The impact of PPB on rice farmers in West Africa, particularly, Burkina Faso, underlined the need for careful choice of research goals, target environments and user communities. Involvement of women improved adoption of accepted varieties, like six NERICA[†] rice selections. PPB thus improved on-farm research efficiency and adoption of more farmer-acceptable varieties[3].

[†] NERICA, acronym for 'New Rice for Africa', was derived from a cross between oryza glaberrima, most common species in Africa, with the Asian *Oryza sativa;* the sterility of progeny was overcome with embryo rescue technique using a culture containing coconut milk, a learning from China. NERICA is resistant to weeds, drought and pests and thrives in poor soils.

Some unique natural resources have a great potential to ensure livelihood security. For example, the medicinal rice, Njavara, unique to Kerala, believed to have been cultivated for about 2500 years has the potential to provide huge benefits; but the essential process of characterization, purification and genetic improvement, followed by clinical validation and legal protection remain to be addressed[4].

At times, nutritionally important local varieties remain to be utilized in enabling livelihood security since they need yield and nutrition improvement. Sweet potato (*Ipomoea batatas* (L.) Lam.) with orange-flesh is such an important root crop rich in vitamin A and beta-carotene. Through new practices of cultivation and on-farm participatory selection, two lines with good yield meeting consumer preference were developed[5]. Likewise through the approach of Participatory Varietal Selection (PVS) two rice and two maize varieties preferred by farmers could be developed[6].

Landraces with unique genetic properties are important in PPB. For example, highly productive site-adapted rice variety was developed from landrace X high yielding variety crosses in Palakkad district of Kerala. Using participatory farmers as seed producers, and Kerala local journals to publicize the performance, commendable spread of the new varieties was achieved[14]. In another case, seed purification and selection in aromatic wild landraces of Kalanamak, particularly for salt tolerance, led to black-husked, non-basmati aromatic paddy with high yields and were found to suffer less from different diseases and pests in its native area of cultivation[15].

Crop improvement driven by Indigenous Technical Knowledge was found to be an effective pathway of PPB. ITK holders proved to be of great help in purifying finger millet and rice landraces and increase their productivity and production[8]. In addition, traditional management of diversity was found to be an amplifier of intra-specific diversity of a clonal crop, cassava in Brazil. A strong relationship between itinerant agricultural cycles of traditional people's farming system (swidden cultivation) and amplified diversity of cassava was illustrated[7].

Social and gender concerns are important areas to be addressed in participatory improvement. Traits for improvement must take into account cultural factors such as different user needs, markets, social status, economic and gender-specific tasks like post harvest work and value addition. Participatory programmes must have concern for marginalized groups of the society including women from poor farming households and the challenges they face to overcome social and gender problems[9]. Discussing gendered knowledge and women's changing status in two agrobiodiversity-rich locations, Kolli Hills in Tamilnadu and Jeypore in Orissa, answer to the question, 'When is knowledge power?' was sought and it was shown that, knowledge is power only when it is valued by the entire community[10].

Capacity building of tribal women farmers is an important area. One paper[11] has described efforts in that direction and another[12] focused on indigenous knowledge and gender differentiated participation as important components of participatory breeding and improvement.

Strengthening livelihoods was found feasible through procuring local resources of medicinal plants and traditional food crops, processing and marketing using community enterprises[13].

In capacity building of farmers in relation to farmers' rights, knowledge of plant breeding (both scientific and local) and farmers' needs in their own farming systems, access to genetic material (both farmers' varieties and formal sector material), and capability to generate conducive policies that allow PPB spread of its results, notably in the form of seed laws and regulations to protect farmers' rights and avoid misappropriation were emphasized as important requisites[16].

This symposium on PPB would not have been possible without the benevolent advice and help of Dr. M.S. Swaminathan, Chairman, MSSRF at all stages of the Symposium. A large number of colleagues from MSSRF have willingly assisted in various activities of the symposium to whom I owe a deep sense of gratitude. In particular, my sincere thanks to Dr. V. Arivudai Nambi for ensuring all the logistics and to Ms. Shanthi and Ms. Sathya for their hard work in a variety of telling tasks and effort in getting written papers from authors, and collating edited version to the present shape.

The generous financial support from International Rice Research Institute, Philippines; Bioversity International, Italy; XV International Genetics Congress Trust, New Delhi; and Swiss Agency for Development and Cooperation, New Delhi has been an empowering source in organizing this Symposium. I also record the good and patient work done by A.M.M. Printers in bringing the book to this shape.

Chennai
July 2007

V. Arunachalam

Chennai Statement on Participatory Plant Breeding

Participatory Plant Breeding is an approach to address critical issues in agriculture, to demystify Science and to bring key stakeholders together to address present and future concerns.

It provides a bridge between Mendelian and Molecular Breeding and results in synergy between scientific knowledge and farmer's wisdom.

It is an option to create economic and social stake in the conservation of landraces and is, in general, a win-win situation for the farmer, the scientist and the environment.

It provides gendered voice to the farming community, particularly; the traditionally marginalized, like tribals and elevates local knowledge to the level of science.

It has been shown to be efficient in accelerating adoption of acceptable varieties.

Efficient PPB

- takes a broad approach to solve critical problems arising out of modern agriculture such as economic viability of crop production, food and nutritional insecurity, degradation of land, destruction of biodiversity and unsustainable agricultural practices,
- emphasizes downstream, people-doable and cost-effective technologies,
- aims at prioritization of problems, symmetrical relationships among partners, and constant evaluation and monitoring of success,
- recognizes and values the knowledge and important role of women in conservation of biodiversity and agriculture and addresses gender imbalances in participation, decision-making and benefit sharing,
- takes into account Farmers' gendered priorities and practices, Farmers' gendered ITK and wisdom, and strives for social and gender equity,
- deals not only with improving yield of farmers' varieties, but also provides a strategic frame for saving grains and seeds and gainful marketing,
- helps with necessary information for gaining legal rights to farmers' varieties under *sui generis* laws, such as the Protection of Plant Varieties and Farmers' Rights Act, 2001 of the Government of India,

- provides options to program novel genetic combinations, through pre-breeding, such as those incorporating drought and salinity resistance taking care to assign proper weightage to phenotypic expression, and
- opens desired space for sustainable livelihood using indigenous varieties with special traits like Njavara, Kalajeera and Kalanamak, when characterized for biomolecules relevant to their special traits.

Keynote Address

1

Participatory Plant Breeding: Precept and Practice

V. Arunachalam

Agrobiodiversity is the substrate of plant improvement. Methods of improvement using agro-diversity are founded on the well-known fundamental laws of Mendel. Mendel's classic experiments with garden pea did also anchor classic elements of Genetics and Plant breeding. Multitude of breeding hypotheses and methods developed on the strength of Mendel's Laws constitute, in principle, the subject that deserves to be described as Mendelian Breeding.

Over the century, Mendelian Breeding has come a long way. It has set several milestones in its stride. Green revolution that salvaged India from poverty to plenty in food remains the most striking of the lot. Mendelian breeding is essentially an iterative technology where each generation is evaluated and the next generation evolved from selections made in the earlier generation. Naturally therefore, it takes a few years. But if characterization, evaluation and identification methodologies are efficient, the time period can be reduced considerably.

One of its salient advantages is the sieving of genetic material under improvement, through the environment where it is bred every generation. Hence to a great extent, the genotype X environment (G X E) interaction is taken into account. High yielding varieties (HYVs) were bred this way.

Very soon it was realized that the technology works in environments endowed with desirably high inputs. While it provides for high yields, it did not necessarily cater to individual taste requirements. But rural and tribal population residing in deep interior regions, do not particularly prefer HYVs. Consumers and their habitats vary equally widely. A large spectrum of people, particularly tribals, prefers crop varieties that are highly adapted to their native habitats; highly tradition bound, their age-old consumption pattern and taste match only such local varieties. However the local varieties are eco- and site-specific; the tribals possess high indigenous technical knowledge (ITK) on them. Though their yield levels do not match those of HYVs, they score over HYVs when considering the fact that their areas of cultivation are exposed to hostile weather. The local varieties, in fact, are genetically resilient and give sustained yields even under uncertain weather conditions.

Thus in order to integrate farmer expertise, their ITK, and ecology and growing environment of the local varieties synergistically with appropriate scientific skill and knowledge, a new paradigm involving equal participation of farmers has been successfully put into practice in the recent past giving rise to a new area, now popularly known as Participatory Plant Breeding (PPB); it is increasingly ranked as an effective and efficient tool in generating gainful goods through prudent utilization of biodiversity and natural resources.

Table 1.1 **The distinguishing features of Formal (PB) and Participatory (PPB) Breeding**

	PB	PPB
1.	Favourable robust environment	Heterogeneous fragile environment
2.	Assured inputs	Low / inadequate inputs
3.	Can be cost-intensive	Has to be cost-effective
4.	Aims at widely applicable impact [Wide horizon]	Has to focus on site-specific methods [Narrow horizon]
5.	Can work on high-tech mode	Learn to scale-up downstream technology
6.	Can invest high technical skill	Constrained to farmer preference
7.	Unrestrained options	Has to be practical with popular acceptance
8.	Can rest on an innovative theoretical base [Narrow genetic base]	Wide options to utilise site diversity both intra- and inter-specific [Broad genetic base]
9.	High productivity is the usual target	Sustainability of production (though moderate) and local preference are targets
10.	Generates new varieties and identifies growing targets [Exploiting G X E]	Site-specific varieties imperative [Utilizing G X E]

Mendelian and Participatory breeding complement and supplement each other providing a strong sustainable frame to crop improvement and hence to economic benefit and secure livelihood.

They, however, should be dynamic and constantly reoriented to demanding field realities. More than high-end options, they should be cost-effective and doable on a participatory mode. Instead of the popular 'lab' to 'land' transition, it should be the reverse 'land' to 'lab' option. Site-specific problems needing an optimal solution should be the subject of 'lab' studies. Such salient differences (Table1.1) highlight the reach and restrictions of formal and participatory plant breeding.

Simultaneous to the development of Mendelian and Partcipatory Breeding,rapid advances in molecular biology (particularly identification of molecular markers) set a new shape to plant breeding. In fact the discovery that molecular markers mimic Mendelian genes and hence are inherited as simple (single) Mendelian genes gave a new impetus. Soon a concept that molecular markers associated with Quantitative Traits (QTs) and QT loci (QTLs) can be identified gained ground.

A subject utilizing marker-aided selection and breeding, now popularly called as 'Molecular Breeding' was developed. The three types of breeding described above constitute the modern triangle of breeding (Figure 1.1).

Crops are many and varied, food, feed, ornamental, plantation, fruit and vegetable crops to name a few. Though a number of crops may naturally grow in a site, a few crops would preferentially grow in abundance. They are, in other words, highly adapted to the site. Human selection, the crop diversity, the soil and climatic environment in the growing site are some inter-linked factors influencing adaptation.

Tribal communities and tribal lands

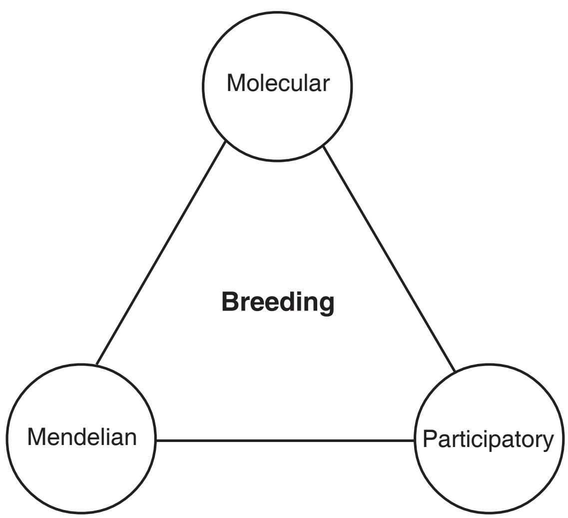


Figure 1.1. **The modern triangle of breeding**

Tribal tracts in Orissa state, particularly the undivided Koraput district, are known home to a rich diversity of rice. In fact, this vast diversity has earned Orissa the recognition as a secondary centre of origin of rice. In addition, the undivided Koraput region including the present Jeypore district has a vast tribal and cultural diversity. Out of the 62 scheduled tribes, 29 are found in this region. *Kandha, Saora, Bhattada, Bonda, Koya and Paroja* are predominant among them. The tribal population forms 22.4% of the total population of Orissa state, and about 8% of the total population of India.

Land types and the landraces

Land is highly uneven and undulating with varying slopes. Broadly the lands are classified as upland (UL, *donger*), medium land (ML, *sariabeda*) and lowland (LL, *khalbeda*) and *jhola* land. While the latter two are grown mostly to rice, medium and uplands are grown to millets, pulses and oilseeds. Broadly, uplands are situated above 200m, medium land between 100 and 200m and lowland less than 100m. However, the criteria for land classification are not rigid. Traditional knowledge of tribal families received from their elders, both on the classification of land and landraces (LRs) [the native varieties that were cultivated in their habitats for a very long time and hence were completely adapted to their sites] finally prevail in their practice.

Natural conservation of landraces

Rice is grown mostly in the rainy season (*Kharif*) though, in principle, two more crops, winter and summer are feasible in identified stretches. During the monsoon, starting in May or early June, nurseries are raised in some lowland area and transplanted later. By and large however, broadcasting traditional varieties and landraces is usual. Based on the traditions followed in the households, specific landraces are cultivated. One of the main objectives remains to be saving of seeds of preferred traditional landraces for use in household functions, ceremonies or festivals. A few popular landraces that are maintained this way is given in Table 1.2 with other characteristics associated with them.

We note that the landraces had different maturity duration. They would then be harvested at different months thus making rice available throughout the year to meet their consumption needs. This was a natural in-built mechanism for conservation of a diverse range of rice landraces.

Erosion of rice diversity

Over time, the weather pattern became unpredictable. For instance, during the

Table 1.2 **Some valuable rice landraces preserved by Orissa tribal farmers for religious functions**

Rice variety	Predominant quality	Festivals	Time of maturity (Month)
Kalakrishna	Scented	All festivals	January
Tulsi	Scented	Chaitra Parva	April
Machhakanta	White slender short grains, good taste	Manabasa and Lakshmi Puja	November
Mer	Black grains with medicinal properties	Annual ceremony of forefathers	November
Kalajeera	Scented	Temple deities	November
Haladichudi	White slender long grains, good taste	Shakti Puja	December
Deulabhoga	Bold and short grains, reddish tinge on cooking with mild scent preferred during worship at temples	Temple deities	December

years, 1998 to 2002, rainfall recorded high month-wise variation. The precipitation during the most-rainy months, June to September showed also excessive variation. When the crop neared maturity, erratic receding rain during October – November affected either maturity or the harvested produce. In 1998 for example, the crop at harvest suffered heavy losses due to excessive rain. The distribution of rainfall within a month remained also erratic. Further, the methods of cultivation practised by tribals were those based on traditional knowledge handed over from generation to generation was practical long earlier. Presently, climatic aberration interspersed with drought and flooding was unfavourable for realising stable yields under traditional practices of cultivation. Consequently the tribals were unable to get food even for a few months. This led them to take to alternative means like non-farm labour. Sufficient seeds of their landraces could not be saved. In turn, they had to seek help from private moneylenders for purchasing seeds every crop season landing them in perpetual debt trap. Over time, rice lands and rice crop failed to receive needed attention. Landraces that were conserved by tribal families started declining. It is estimated that more than 3000 landraces reported in the early nineties fell to as low as about 300 around 1998. This erosion of rice diversity needed immediate measures for revival and revitalization.

The advent of HYVs

To save the situation, high yielding varieties (HYVs) technology came to be extended. Seeds of HYVs and other inputs were provided mostly by the Government agencies with a buy-back arrangement of the produce. Those economic amenities made the farmers attempt growing HYVs. But they continued cultivating in addition their preferred LRs in small areas, reserving them for their consumption. Further HYV technology was not entirely consonant with the traditional practices. In particular, chemical fertilization and pest / disease prevention measures conflicted with their preference for pure organic farming. In addition, HYV technology extension could not replace the traditional practices of cultivation (developed for long duration LRs). Thus expected dividends of HYVs were hardly realized.

Participatory initiatives of MSSRF

In this backdrop, M.S. Swaminathan Research Foundation (MSSRF) conceived a project with the major objectives of restoration and revitalization of rice diversity, its conservation and sustainable use with gender equity and equitable benefit sharing under a pro-nature, pro-women and pro-poor framework. Funded by Swiss Agency for Development and Cooperation, it was initiated in 1998. Participatory Plant Breeding (PPB) was selected as a tool to meet the objectives efficiently. This tool sought to associate, in its every effort, tribal community and farmers as equal co-partners. Thus every initiative and activity step was placed before people and discussed in a free and friendly critical mode. Only those steps that met with a consensus were put into action.

The main mode of implementation is through Participatory Rural Appraisal (PRA). PRAs were conducted as often as needed and in every PRA, gender equity was maintained and women participation in the decision processes ensured. Every PRA either included a concerned member of Panchayat Samiti or the proceedings were put before the samiti immediately after PRA and necessary approval obtained. Such a procedure enabled smooth participation by stakeholders. Field experiments were safeguarded from natural or animal damage. Thus PPB pathway was arranged to be more or less smooth.

The Methodology

Year 1 (1998)

An extensive survey of the rice crop consisting of 26 LRs was made across 18 villages covering three districts and seven blocks. Scientists interacted with concerned farmers in their fields and underlined the following problems:

a. Ill-prepared and uneven land with a high density of clods

b. Broadcasting of seeds resulting usually in

   i. plants growing on clods disconnected from soil,

   ii. patchy germination because of seeds that are mixed and impure, often of suboptimal quality,

   iii. extraordinarily high density of plants in some patches and few plants in yet others,

   iv. generally high population leading to early yellowing of the crop with high susceptibility to pests / diseases,

   v. crowded haphazard crop growth allowing no space for weeding, draining of water and similar necessary field interventions and even harvest, and

   vi. uneconomical use of irrigation water.

The options open for improving performance of their preferred LRs was placed before farmers in a PRA. Farmers underlined poverty of scientific information on optimal agriculture and aberrant weather as major difficulties. On a consensus, it was decided to use PPB as the next step of participatory improvement of rice LRs. But the harvest of 1998 suffered heavily on account of excessive rain. It was not possible to evaluate the yield performance of the 26 LRs, though yields of a small sample of plants were obtained in some cases.

Year 2 (1999)

The data and details that were collected on some LRs were discussed with participating farmers who helped to evaluate those LRs sharing their traditional knowledge on them. Of the 26 LRs, farmers retained nine only and added 13 more to make 22 LRs for further experimentation.

As the first step of PPB, scientific remedy was sought to the farmer-cultivation maladies. High-end PPB tools could be of little use at that point of time. People needed to understand why their traditional methods did not provide good yield and how they can refine their methods with a critical scientific input. This refinement process must produce economic benefit but with no increase in input or cost of cultivation, if it has to become a viable pathway. This became particularly important because PPB did not plan either to compensate for the innovative failure or to offer incentives for the effort. After an extensive evaluation of the ground situation, it was decided, with the consent of the participating farmers, to put into practice a set of modified agronomic practices (Table 1.3).

Table 1.3. **Rice Cultivation: the maladies of traditional practices and remedies based on scientific logic**

MALADY	REMEDY
Bad (or no) land preparation	Optimal land preparation
FYM application while ploughing	FYM application in residual moisture
Poor seed	Seed selection by pre-soaking in water
	Raising nursery in optimal land, under row planting and moisture
Haphazard broadcasting of seeds	Line sowing with optimal plant to plant distance (20cm between and 10cm within rows)
	Compulsory transplanting in lowlands and medium lands
	Broadcasting in lines in uplands
	North-south row for maximum sunlight interception
High seed rate often » 80 kg/ha	Seed rate as low as 20 kg/ha under nursery
Uneven plant stand, early yellowing, dense weeds, disease-prone, improper seed fill, poor yield	Healthy and good plant stand, good tillering, almost nil disease, minimal weeds, good seed fill and yield

Since water was not an easy source, farmers were advised optimal water usage throughout the crop season. In particular, water saving was advised at puddling, transplanting, and tillering stages where traditionally very high quantities of water were used.

Any method, if it has to be practiced voluntarily, has to demonstrate its efficiency over an existing method. Therefore the superiority of the modified cultivation method

<table>
<tr><td>R I</td><td>V5</td><td>V3</td><td>V2</td><td>V4</td><td>V1</td><td>V6</td><td rowspan="3">V1</td><td rowspan="3">V2</td><td rowspan="3">V3</td><td rowspan="3">V4</td><td rowspan="3">V5</td><td rowspan="3">V6</td></tr>
<tr><td>R II</td><td>V1</td><td>V6</td><td>V4</td><td>V5</td><td>V3</td><td>V2</td></tr>
<tr><td>R III</td><td>V3</td><td>V4</td><td>V2</td><td>V6</td><td>V5</td><td>V1</td></tr>
<tr><td></td><td colspan="6">Modified cultivation
3 Replications
Plot: 30 sq.m</td><td colspan="6">Traditional Cultivation
No Replication
Plot: 90 sq.m</td></tr>
</table>

Figure 1.2 **Design of PPB experiment – Jeypore, Kharif, 1999**

over the traditional method was sought to be demonstrated in all types of cultivated land. For this purpose, a field experimental design was devised (Figure 1.2).

MSSRF scientists helped the farmers to prepare land, layout fields, and plant the crop in the field design. In one block, 3 replications were laid with plots of 30 sq.m each. In those plots, farmers used the refined methods of cultivation under the guidance of scientists. In an adjacent block, farmers laid out single replication plots of 90 sq.m, each, equivalent to the area allotted to an LR under refined cultivation. Those plots were cultivated using farmers' own individual traditional practices. The experiment was simultaneously conducted during 1999 in 5 villages, Barangput, Patraput, Pujariput, Tolla and Mohuli from Jeypore and Boipariguda blocks.

Scientists with the help of farmers took representative sample of plants and recorded observations on 7 morphological traits. With 2 more traits computed using some of them, data on 9 traits on plant samples in replications, land types and farmers became available. Multivariate statistical analysis using methods developed earlier, helped to characterize each landrace on the 9 traits and provide overall performance score. It was found that the ranking on overall performance score differed from the numerical ranking based on grain yield alone (Table 1.4). The results were critically evaluated with farmers' own knowledge in a large PRA. It was interesting that the top two LRs selected on scientific analysis concurred with the ones selected by farmers on their traditional insight under each land type (Table1.4).

This experience helped to draw two inferences of value in PPB:

(1) Farmers' traditional knowledge is relevant and must be recognized in any technology development (2) a designed experimental evaluation of varietal

Table 1.4 **Top-performing varieties selected on farmer consensus for large-scale demonstration in Jeypore tract – Kharif 2000**

Land type	Varieties*	Y	R
Upland	Paradhan	1173	1
Medium Land	Sapuri	3515	1
	Limbachudi	2915	3
Lowland	Barapanka	3438	3
	Kalajeera	2459	6

** Selected out of 22 varieties tested in Kharif 1999 on refined and farmer practices; Y: Yield (kg/ha); R: Ranking on Y* performance is crucial and (3) selection on a set of diagnostic traits would be proper and closer to the true performance of varieties in contrast to yield alone.

In the PRA, lingering questions on the cost of cultivation using the refined module were discussed. Even scientists had reservations on the feasibility of line sowing by farmers in view of the added cost of labour. Therefore data were collected on benefit: cost ratio of cultivation in the traditional and refined methods from 3 farmers each for upland, medium land and lowland separately. The cost of cultivation was divided into 5 major components: (1) ploughing, (2) FYM application, (3) sowing, (4) weeding, (5) harvest and post-harvest. An analysis of componental costs showed that the cost of transplanting in rows in lowland was significantly higher in 1999 than traditional method. This was possibly due to the reason that farmers have just begun to learn row planting for the first time in 1999. Hence they needed to use rope with positions of plants at 10cm interval marked with beads. In the beginning this process took time. Soon farmers learnt row planting on their own judgement without any aids. Thus in the year 2000, the cost of labour to use refined method was not significant from that for farmers' method. Even the nominal increase in the cost of transplantation, if any, was offset by lower intensity of weeds, less taxing and less expensive weeding and easier harvest of plants (in rows). In addition, the 20cm spacing between rows proved to be ideal for harvested bundles from adjacent rows to be stacked in standing position, the bundles of one row resting on those of the other. This arrangement helped easy drying of the harvested material in the field. Thus total cost of cultivation remained essentially the same though the distribution of cost across major components varied.

The perceptible advantage is in the benefit (Table 1.5); for as high as 70% improved yield with well-filled grains and good seeds were harvested that could increase economic returns substantially.

During 1999, farmers were also given practical training of selecting well-filled seeds from type plants for next season crop. Thus good seeds were collected from each of the 22 LRs.

Participatory Conservation System (PCS)

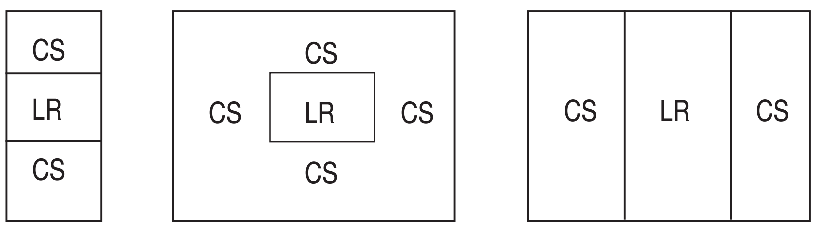
Scientists raised a pertinent question after the PPB experiments of 1999. They argued that the program started with 26 LRs in 1998, worked with 22 LRs in 1999 and decided to scale up cultivation of 6 LRs in large-scale in 2000. Thus the progressive reduction in LRs that are upscaled works counter to conserving all LRs thus not addressing agro biodiversity issues adequately.

Table 1.5 **Benefits of Modified over Farmer cultivation**

Land Type	Variety	Yield (kg/ha) 1998	Yield (kg/ha)1999		MO / FR
			MO	FR	
Lowland	Bayagunda	1755	3679	2321	1.6
	Gadakuta	1352	1524	961	1.6
	Barapanka	1643	3438	2533	1.4
	Kalachudi	1309	2562	2007	1.3
Medium Land	Bodikaburi	1261	2838	1736	1.6
Upland	Paradhan	562	1028	622	1.7

MO – Modified FR - Farmer

This problem was posed in a PRA and farmers' reaction was gathered. Farmers expressed that they would continue conserving only LRs of their traditional choice. It was felt useful to optimize that willingness for conservation. Therefore a participatory mode was devised to conserve available LRs in farmers' fields. A design was developed to grow the LRs each farmer likes to conserve along with the LR they cultivate in large plots (Figure 1.3).



LR: landrace cultivated in large plots; CS: LRs under onservation

Figure 1.3 **Participatory conservation scheme while cultivating desired LRs**

Farmers were given the choice to grow conservation lines according to their choice, the number and their identity varying across farmers. However, even with such choices, it is possible that all the germplasm lines could be conserved / regenerated across a set of 10 or more farmers. For instance, in Kharif 1999 the PPB program regenerated 70 LRs across 7 farmer's fields, each farmer growing, on an average, about 10 different lines. Training was given to the farmers on assessing conservation lines carefully and saving seeds only from type plants.

The feasibility of Participatory Conservation System (PCS), though has thus been demonstrated, it would sustain only if participating scientists and farmers monitor the activity with care and caution. A checklist of guiding principles is given here for illustration.

1. Decide about the number of germplasm lines to be conserved during a particular season.
2. Allot them across farmers after discussion in a PRA before every crop season.
3. Keep carefully seeds of the concerned germplasm preferably sealed in aluminium foil envelopes in one of the nearby field gene-seed-grain banks,that people desired to call by the name, Village seed banks (VSBs). In successive cycles, only those seeds need to be distributed and used for regeneration.
4. Monitor proper planting (including direct seeding or transplanting) and examine the lines for mixtures and rogue plants during the optimal crop growth.
5. Tag type plants and ensure collection of seeds from them only.
6. After leaving a portion with the concerned farmer, store the rest of them carefully in VSB.

The concepts of participatory crop improvement and participatory conservation-cum-cultivation shall need further scaling up and institutionalization.

Another question that naturally arose was why a farmer has to conserve some LRs along with desired LRs in large plots without any extra income. The following facts studied carefully provide the answer:

(1) Farmers know the need for conservation, at least of those LRs which are used in their household functions and festivals (see table 1.2)

(2) The PPB program has educated the farmers how genetic enhancement and LR diversity are inter-related. In fact, the program initiated the following participatory breeding options with people taking a full role:

   a. Hybridisation between selected LRs for which a few young men and women were taught the process of emasculation and pollination. In a PRA, the basic concepts of varietal breeding using hybridisation as an initiating step were taught to the community. Three crosses were made with the community help. As the first attempt, there were setbacks due to deficient understanding, operational and other problems. Despite them, four populations in F6 generation, one of which showd early maturity by 10 days compared to the parents, are now in large scale testing in farmers' fields.

   b. The utility of exchanging varieties across UL, ML and LL was tested. Farmers reported early flowering by about 10 days of Sapuri, an ML variety when grown in LL.

c. A local variety, *Veliyan* from Wayanad, Kerala when planted in Jeypore grew to a profuse height of 7 feet and above and yielded about 6 tons of fodder per ha. Farmers say that cattle liked the fodder very much.

The above three breeding options tried on an experimental basis helped people to understand the value and utility of germplasm and hence their conservation. It remains still to intensify knowledge transfer more effectively and intensively, and to institutionalise conservation as a habit along with cultivation. A well-defined program is now in operation at a few test villages.

Year 3 (2000)

Since large-scale experimentation was not possible with all the 22 LRs, a set of 38 demonstrations with the 6 selected LRs was planned across 4 blocks and 11 villages.

An analysis of the yield data showed variable performance across farmers' plots despite the fact that the year was almost normal in rainfall and distribution. The analysis results were discussed in a PRA and farmers' reasons for such a variable performance were elicited. Farmers were unanimous that the refined method of cultivation was really profitable but for various reasons of their own, farmers either did not adopt refined cultivation practices or adopted them only partially. This suggested that in any scaling up of a technology transfer, especially with poor tribal farmers, more scientific supervision and persuasion would play a positive role. This would need a number of scientists to be associated with PPB technology evaluation and transfer. Yet farmers who adopted the technology have realized high yields (Table 1.6).

Table 1.6 **Yield advantage realised by some farmers by refined cultivation of LR in large areas (Jeypore, Kharif 2000)**

LR	Farmer	Land type (sq.m)	Area sown	Yield (kg/ha)
Sapuri	Sunadhar Katia	ML	1633	5883
Limbachudi	Trilochan Ghiuria	ML	1321	4466
Kalajeera	Dhanurjoy Pujari	LL	570	5700
	Trilochan Ghiuria	LL	1178	4149
Barapanka	Jagannath Patnaik	LL	2400	5766

LR - Land Race; ML - Medium Land; LL - Low Land

The demonstrations helped to move forward the path to progress with willing, voluntary and committed participation of a large number of farmers. They discovered in the year that the LR, Kalajeera performed well not only in grain yield (of about 4 tons on an average) but in the quality of grains (favourable for their consumption). In a fair organised by the Government of Orissa, people observed that Kalajeera rice (scented non-basmati type) was sold at Rs. 22 a kilogram. They desired and decided on its large-scale production and marketing.

At this stage, MSSRF felt that people should need to know the differences between seed, grain and gene, and how to produce and store them. They were given back-up information on those concepts in a mode they could understand. The concepts, being highly technical to the farmers, need to be exhorted often and more intensively. But they understood that (i) properly produced seeds would have a good market than grains, (ii) refined cultivation module would guarantee high yields and (iii) such yield gains would leave, after their consumption needs, surplus grains to dispose off. At this point, MSSRF introduced the concept of Field gene-seed-grain banks at village level (Village Seed Bank, for short, as desired by farmers) and provided the necessary knowledge backup. People understood the utility of VSB and constructed such banks on their own, with some infrastructure help, in 5 villages – Patraput, Tolla, Nuaguda, Baluguda and Pujariput. The VSB is just a room partitioned into two chambers. In one of them, seeds of high purity (genetic homogeneity) would be stored in watertight aluminium envelopes and kept neatly sealed and labelled in slotted angle racks. In the remaining space, seeds of popular LRs of commercial purity would be stored in large quantity in traditional containers and kept proofed with cow dung paste as is the wont of tribal people. In the other chamber, grains of the popular LRs spared for disposal would be kept. Just as a bank which records the accumulated money in a passbook so that the customer can withdraw it when needed, so also the VSBs would record the seed and grain contributed by each farmer in a passbook and give to them for use or withdrawal any time. Seed and grain contributed thus by farmers would be stored with adequate precautions in VSBs. They would be disposed at the best time and rate in the market and the money realized would be proportionately shared among the contributing community. A special management committee would monitor the bank's activities. Selected female and male farmers, the Panchayat Samiti and an MSSRF scientist as facilitator would constitute the committee. The committee can decide the mode of sale of seeds, grains and/or loaning to deserving people and recovering them after a season according to their own convention. We hope a sustainable shape to these ideas would be firmed up.

The rise of Kalajeera at Jeypore

The pattern of growth of Kalajeera at Jeypore during 2000-2006 is quite striking (Figure 1.4). The number of farm families, area and production were found to be steadily increasing, particularly from 2004 when marketing channels were facilitated. However, unpredictable and harsh weather of Orissa contribute to inevitable fluctuations. Yet income and benefit: cost ratio remained high and almost stable. More directed help to the tribal farming community and monitoring quality production of Kalajeera is logically expected to give rich dividends.

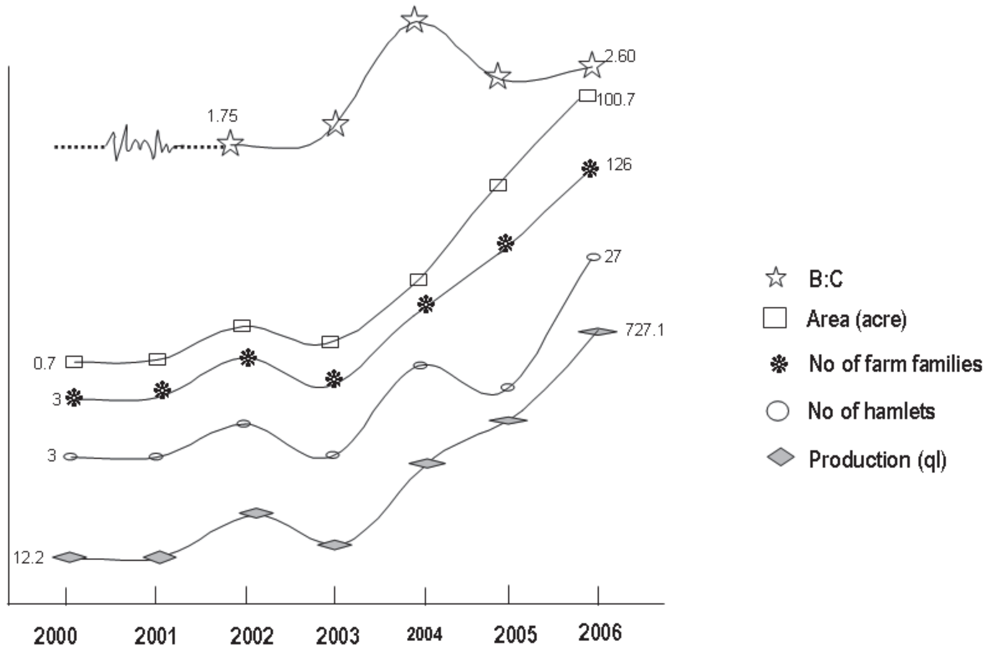


Figure 1.4 **Status of Kalajeera during 2000 – 2006**

Evaluation of quality and distinctness of Kalajeera for export

M/S Tilda Riceland Pvt. Ltd who has considerable experience in exporting non-basmai traditional varieties came forward to discuss a working plan for evaluating the quality of Kalajeera for export. A draft Memorandum of Understanding prepared by MSSRF in consultation with Tilda Rice land was approved by the Government of Orissa, and under this tripartite MOU between MSSRF, Tilda Riceland and Government of Orissa, the quality of Kalajeera was evaluated for export.

40 samples of Jeypore Kalajeera collected from plots of various farmers in the hamlets, Baliguda, Tolla, Pujariput, Patraput, Kasiguda, Nuaguda, Taliaguda,

Jhalaguda, Kundura and Kasiguda were evaluated for quality traits by Tilda Riceland Ltd.. The material was generated either from MSSRF supplied pure seeds or from the seeds saved by farmers in the earlier season. The quality traits of Jeypore Kalajeera were compared with those of an exported Basmati variety, Abhijit (Haryana Basmati Collection 19). Kalajeera scored better than Abhijit in amylose, and alkali score indicating comparative low stickiness, and low time of cooking and softness respectively that are desirable for export. Further, DNA test on the 40 samples testified the purity and homogeneity of Jeypore Kalajeera.

An important result is that there is no variation in any trait between material generated from pure seeds kept by MSSRF and farmer-saved seeds suggesting seed/grain production can safely be done in all villages by farmers using seeds saved by them. Therefore large scale production of Jeypore Kalajeera can safely be programmed in a number of hamlets across Koraput region. It is however essential to test verify the quality of seeds before concluding that the site-specific landrace, Kalajeera can be produced in all areas of Koraput District.

PPB experience over the years 1998 – 2003 has provided a number of leads to follow-up. Some of them are (a) an interactive, synergistic networking with the Government, (b) a replication of successful PPB initiatives across other districts of Orissa state, (c) attempting genetic enhancement generating life saving irrigation facilities using cropping system approach, and (d) drawing benefit from integrating conservation – cultivation with the social forestry. When these options are pursued with participation by the people, it seems certain that the dividends from PPB as a tool in improving sustainable livelihood of tribal poor leading to poverty reduction would be substantial.

The participatory breeding and improvement advocated in this paper have the following salient features:

1. Farmers were directly involved in PPB including varietal purification and selection. So they gained confidence to do such activities independently.
2. Farmers did the LR X LR crosses themselves and their further segregating populations grown in their fields for selection. They would now test the advanced F6 populations in their fields'
3. Such activities differ from the usual format of making crosses and growing further generations in experimental fields before giving advanced generation material to farmers for selection in their fields.

The ten lessons we learnt doing PPB were

1. Establishing rapport with people in target area and involving Panchayat Raj institutions right from the beginning,
2. Listening to learn and practicing before precept
3. Giving voice to women; recognizing and incorporating gendered ITK in scientific options
4. Confining breeding options to those understandable and doable by people in contrast to text book or high-tech breeding
5. Demystifying science and making understanding simpler; concurrently using science to analyze, interpret and infer in participation with people
6. Remembering that the first step is slippery and hence setting a firm foot not to falter
7. Realising that completing the full livelihood cycle is more important than just increasing productivity and production
8. Facilitating changes to evolve through knowledge empowerment and never forcing change
9. Avoiding use of monetary or other incentives to effect change as they are unsustainable, but enabling know-how and do-how to achieve the same ends

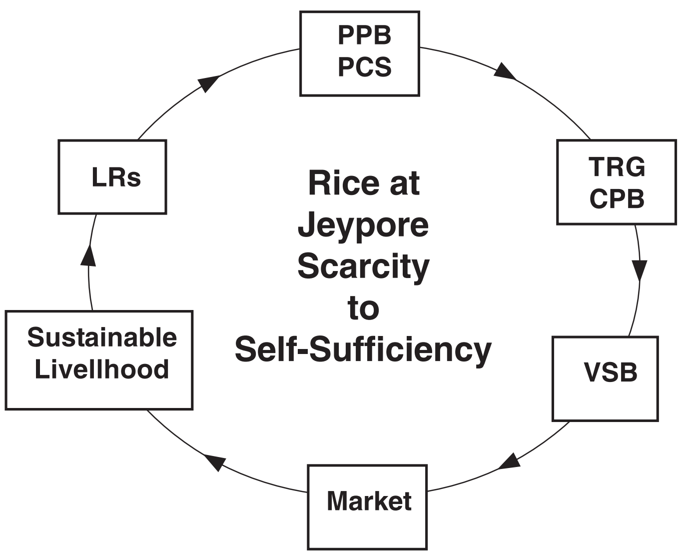


Figure 1.5 **The Livelihood Circle**

10. Recognizing marketing is tricky and risky, appraising authorities and enlisting Government cooperation to manage marketing and make Biodiversity Conservation a purposeful exercise.

Thus PPB, as a tool, has formulated a pathway (Figure 1.5), identified activities in a chronological sequence, and executed them with the consensus of people introducing mid-course corrections whenever needed. The major activities have come a full circle, that could be called a Livelihood Circle, from rich unrefined generated by participatory breeding natural resources in Jeypore through identifying operational tools, employing them judiciously to pilot the resources to perceptible gains in the economic and food fronts.

2

A Model of Decentralized-Participatory Plant Breeding

S. Ceccarelli and S. Grando

It is widely recognized that conventional plant breeding has been more beneficial to farmers in high potential environments or those who could profitably modify their environment to suit new cultivars, than to the poorest farmers who could not afford to modify their environment through the application of additional inputs and could not risk the replacement of their traditional, well known and reliable varieties. As a consequence, low yields, crop failures, malnutrition, famine, and eventually poverty still affect a large proportion of humanity.

Participatory plant breeding is seen by several scientists as a way to overcome the limitations of conventional breeding by offering farmers the possibility to decide which varieties suit better their needs and conditions without exposing the household to any risk during the selection progress. Participatory plant breeding exploits the potential gains of breeding for specific adaptation through decentralized selection, defined as selection in the target environment, and is the ultimate conceptual consequence of a positive interpretation of genotype x environment interactions.

The paper describes a model of participatory plant breeding in which genetic variability is generated by breeders, selection is conducted jointly by breeders, farmers and extension specialists in a number of target environments, and the best selections are used in further cycles of recombination and selection. Therefore, from a scientific viewpoint, the process is similar to a conventional breeding program with three main differences, namely a) testing and selection take place on-farm rather than on-station, b) key decisions are taken jointly by farmers and breeder, and c) the process can be independently implemented in a large number of locations.

Farmers handle the first phases of seed multiplication of promising breeding material in village based seed production systems. The model has the following advantages: the

varieties reach the release phase earlier than in conventional breeding, the release and seed multiplication concentrate on varieties known to be acceptable by farmers, an increase in biodiversity because different varieties are selected in different locations, the varieties fit the agronomic management that farmers are familiar with and can afford, and therefore the varieties can be beneficial to poor farmers. These advantages are particularly relevant to developing countries where large investments in plant breeding have not resulted in production increases, especially in marginal environments.

In addition to the economical benefits, participatory research has a number of psychological, moral ethical benefits, which are the consequence of a progressive empowerment of the farmers' communities; these benefits affect sectors of their life beyond the agricultural aspects.

In conclusion, participatory plant breeding, as a case of demand driven research, gives voice to farmers, including those who have been traditionally the most marginalized such as the women, and elevates local knowledge to the role of science.

Keywords: Participatory plant breeding, genetic variability, conventional breeding, farmer's selection, local knowledge

In recent years there has been an increasing interest towards participatory research in general, and towards participatory plant breeding (PPB) in particular. Scientists have become increasingly aware that users' participation in technology development may in fact increase the probability of success for the technology [1].

The interest is partly associated with the perception that the impact of agricultural research, including plant breeding, particularly in developing countries and for marginal environments and poor farmers has been below the expectations, and in fact about 2 billion people still lack reliable access to safe, nutritious food, and 800 million of them are chronically malnourished [2].

Three common characteristics of most agricultural research which might help explaining its limited impact in marginal areas are:

1. The research agenda is usually decided unilaterally by the scientists and is not discussed with the users; Agricultural research is typically organized in compartments, i.e. disciplines and/or commodities, and seldom uses an integrated approach
2. As a consequence there is a continuous emphasis on "interdisciplinary research"; this contrasts with the integration existing at farm level;

3. There is a disproportion between the large amount of technologies generated by agricultural scientists and the relatively small number of them actually adopted and used by the farmers.

When one looks at these characteristics as applied to plant breeding programs, most scientists would agree that

1. Plant breeding has not been very successful in marginal environments and for poor farmers,
2. It still takes a long time (about 15 years) to release a new variety,
3. Many varieties are officially released, but few are adopted by farmers; by contrast farmers often grow varieties which were not officially released,
4. Even when new varieties are acceptable to farmers, their seed is either not available or too expensive, and
5. There is a widespread perception of a decrease of biodiversity associated with conventional plant breeding.

Participatory research in general, defined as that type of research in which users are involved in the design % and not merely in the final testing % of a new technology, is now seen by many as a way to address these problems. PPB in particular, defined as that type of plant breeding in which farmers, as well as other partners, such as extension staff, seed producers, traders, NGOs etc., participate in the development of a new variety, is expected to produce varieties which are adapted not only to the physical but also to the socio-economic environment in which they are utilized.

The objective of this paper is to illustrate some of the characteristics of PPB using examples from projects implemented by the International Center for Agricultural Research in the Dry Areas (ICARDA) in a number of countries.

Genotype x Environment Interactions and Breeding Strategies

Plant breeding is a complex process and in the majority of cases (the only notable exception being the breeding programs in Australia), only a small fraction of it takes place in farmers' fields: most of the process takes place in one, or more often in a number of research stations, and all the decisions are taken by the breeders and collaborating scientists (pathologist, entomologist, quality specialists, etc.).One of the main consequences is that a large amount of breeding material is discarded before knowing whether it could have been useful in the real conditions of farmers' fields, and the one which is selected is likely to perform well in environments similar to the research stations, but not in environments which are very different.This is because of Genotype x Environment (GE) interactions that, when they cause a change of ranking between genotypes in different environments (crossover interaction), are one of the major factors limiting the efficiency of breeding programs. An example of crossover GE interactions between research stations and farmers fields is given in Figure 2.1. In both cases there was much more similarity between research stations than between farmers fields, and low or negative correlations between research stations and farmers fields.

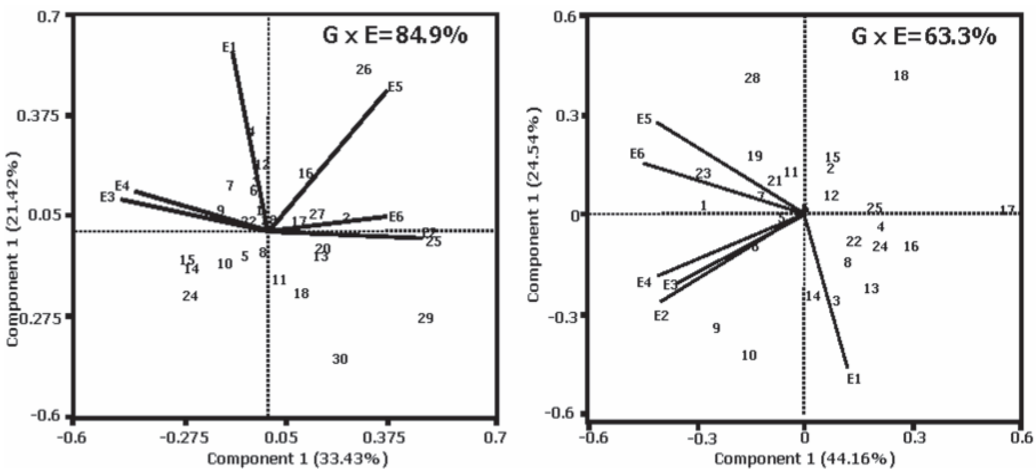


Figure 2.1 **Biplots of thirty barley genotypes grown in six locations in Morocco**

(left) including two research stations (E3 and E4) and four farmers' fields (E1, E2, E5 and E6) and of 25 barley genotypes in six locations in Tunisia (right) including two research stations (E5 and E6) and four farmers' fields (E1, E2, E3 and E4).

In general, when different lines or cultivars of a given crop are evaluated in a sufficiently wide range of environments, GE interactions of crossover type seem to be very common [3]and we have argued [4]that for crops grown in environments poorly represented by the research stations, this often results in discarding useful breeding materials. An example of the danger of discarding useful breeding material on station is shown in Figure 2.2 where the five highest yielding barley lines in a farmer field in Senafe (Eritrea), with yield advantages over the local check of between 27 and 30%, when tested on station showed a yield disadvantage of between 15 and 87% except entry 95 which had a yield advantage of only 4%.

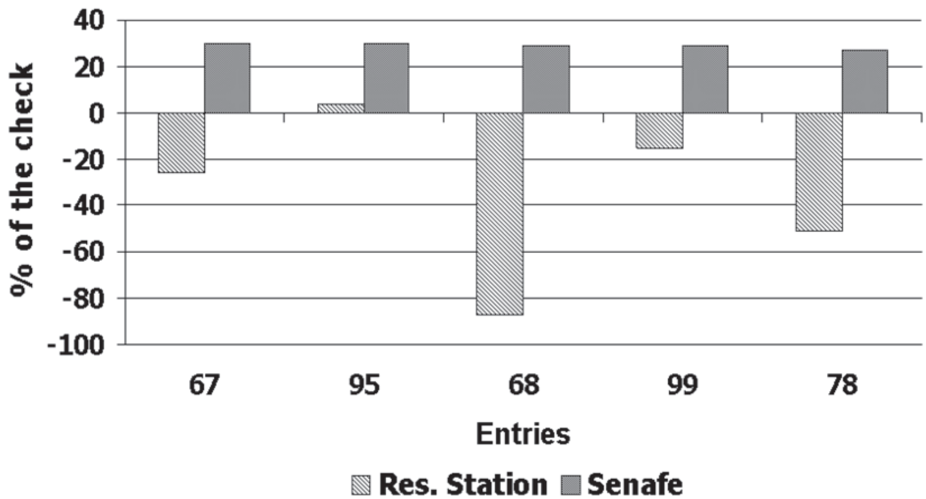


Figure 2.2 **Yield (in percent of the local check) of five barley lines in a farmer's field in Senafe (Eritrea) and in the research station at Halale (40 Km south of Asmara).**

When GE interactions are present the plant breeder can ignore them, avoid them or exploit them [5]. When GE interactions are significantly large, it is not possible to ignore them and the two remaining strategies are (1) to avoid them by selecting material that is broadly adapted to the entire range of target environments, or (2) to exploit them by selecting a range of material, each adapted to a specific environment [4]. The choice is based on a separate analysis of the two components of GE interactions, namely Genotype x Years (GY) and Genotype x Locations (GL), the first of which is largely unpredictable, while the second, if repeatable over time, identifies distinct target environments [6,7].

Selection for specific adaptation to each of the target environments is particularly important in breeding crops predominantly grown in unfavorable conditions, because unfavorable environments tend to be more different from each other than favorable environments [8]. An example is shown in Figure 2.3 where the total GE in the case of the two dry locations (left) was nearly 90%, while in the case of the two high rainfall locations was less than 50%.

Selecting for specific adaptation has the advantage of adapting cultivars to the physical environment where they are meant to be cultivated, and hence is more sustainable than other strategies which rely on modifying the environment to fit new cultivars adapted to more favorable conditions[9]. Selection theory shows that

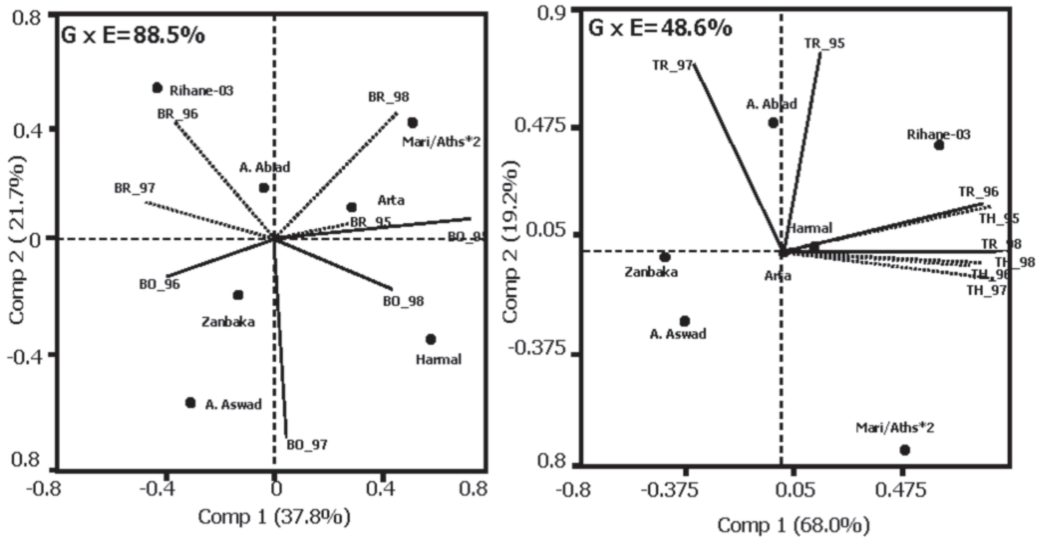


Figure 2.3 **Biplots of grain yield of seven barley cultivars grown for four years (1995 to 1998)**

in two dry locations, Bouider (BO) and Breda (BR) with a grand mean of 1.3 t/ha (left) and in two locations, Tel Hadya (TH) and Terbol (TR) with a grand mean of 3.5 t/ha (right).

selection for specific adaptation is more efficient because it exploits the larger heritabilities within each specific target environment.

The similarity between research stations observed in Figure 2.1 and between high rainfall locations and years observed in Figure 2.3 are likely to be also associated with the larger use of inputs (fertilizers, weed control, etc.) common to both research stations and high rainfall areas, which tend to smooth differences between locations and years. Selection for specific adaptation is based on direct selection in the target environment, which has been also defined decentralized selection [10,11,12].

The most serious limitation to decentralized selection for unfavorable environments is the large number of potential target environments. Moreover, the number of target environments is often increased by different uses of the crop (cash vs. local consumption), different access to inputs, different market opportunities, etc. Clearly, selection for specific adaptation to unfavorable conditions targets a larger sample of environments than selection for favorable environments. Consequently the number of selection sites will need to be larger. The participation of farmers in the very early stages of selection offers a solution to the problem of fitting the crop to a multitude of both target environments and users' preferences [13].

Defining Decentralized-Participatory Plant Breeding

Although plant breeding programs differ from each other depending on the crop, on the facilities and on the breeder, they all have in common some major stages that Schnell (1982)[14] has defined as "generation of variability", "selection", and "testing of experimental cultivars" (Figure 2.4). To illustrate the process we will use as an example a self-pollinated crop and the more common breeding practices. The generation of variability is the shortest stage, consisting of the process of making crosses (or, less frequently, inducing mutations) and producing segregating populations, and takes place in research stations. The second stage is longer, and consists firstly of the evaluation of the breeding value of the different segregating populations (by "cross-evaluation" or "selection between crosses"), and then in the selection of the best plants within the superior populations, or in various combinations of the two while reducing heterozygosity. The second stage, like the first, usually takes place in research stations (although there are exceptions), and in some crops it can be shortened by the use of techniques such as Single Seed Descent (SSD) and Doubled Haploids (DH). During the second stage, the breeding material is exposed to relevant biotic and abiotic stresses, often in more than one research stations. The end product of the second stage is usually a population of several thousand pure lines even in those situations where uniformity is not a farmer's necessity.

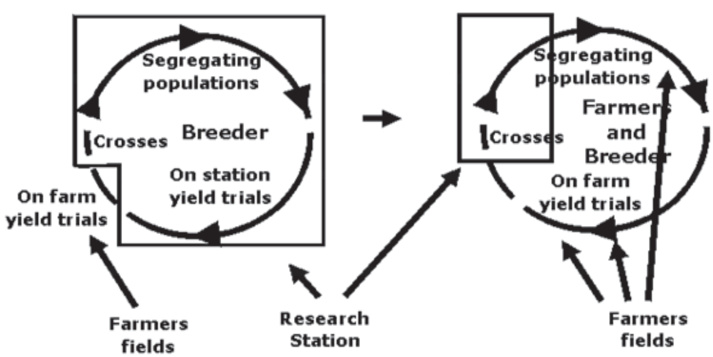


Figure 2.4 **Conventional plant breeding is a cyclic process that takes place largely within one or more research stations**

(left) with the breeder taking all decisions; decentralized-participatory plant breeding is the same process, but takes place mostly in farmers' fields (right) and the decisions are taken jointly by farmers and breeders.

The third stage is also long, consisting in the comparison of yield (usually of grain in those crops where the grain is the main commercial product) between the breeding lines produced during the second stage. This phase is usually subdivided in two sub-stages. The first takes place in one or more research stations and the trials are referred to as Multi Environment Trials (MET). The second, when the breeding lines have been reduced to between 10 and 20, takes place in farmers' fields and the trials are referred to as on-farm trials even though they also are typically MET. In some exceptional cases, such as in most of the breeding programs in Australia, also the all the yield testing takes place entirely in farmers' fields, and therefore is fully decentralized.

Plant breeding is a cyclic process (Figure 2.4): each year (or cropping season) a new cycle begins with new crosses, which are being made using largely as parents material derived from previous cycles. Therefore, each year, breeding materials belonging to the three stages described earlier, and to different steps within each stage, are grown simultaneously. This implies not only a considerable investment in land to grow the parental material, the various generations of segregating populations, and the various levels of yield testing, each representing a different breeding cycle (amounting at several tens of thousand plots), but also in people, and in facilities to handle the considerable amount of seed and of data that the process generates.

A decentralized-participatory plant breeding program (Figure 2.4, right) is exactly the same process with three differences: 1) most of the process takes place in farmers' fields; 2) the decisions are taken jointly by the farmers and the breeder, and 3) the process can be implemented in a number of locations involving a large number of farmers with different breeding materials.

In the following sections we describe a model of PPB that can be applied to self-pollinated crops. From a breeding point of view, this is only one of the several methods which can be used, but it is based on three main concepts, which can be generalized to any PPB program:

The trials are grown in farmers' fields using farmer's agronomic practices (to avoid GE interactions between research stations and farmers' fields) Selection is conducted jointly by breeders and farmers in farmers' fields, so that farmers participate in all key decisions.

The traditional linear sequence Scientist → Extension → Farmers is replaced by a team approach with Scientists, Extension Staff and Farmers participating in all major steps of variety development. The breeding method that the model assumes is a bulk-pedigree method which consists of three cycles of selection between populations (cross evaluation) followed, but not necessarily, by selection within superior cross[15].

A Model of Decentralized-Participatory Plant Breeding

The Model

The method of plant breeding we use in a number of countries has been described in detail by Ceccarelli and Grando (2005)[15] and by Mangione *et al.*[16] (in press): the crosses are done on station, where we also grow the F1 and the F2, while in the farmers' fields the bulks are yield tested over a period of four years (Figure 2.5).

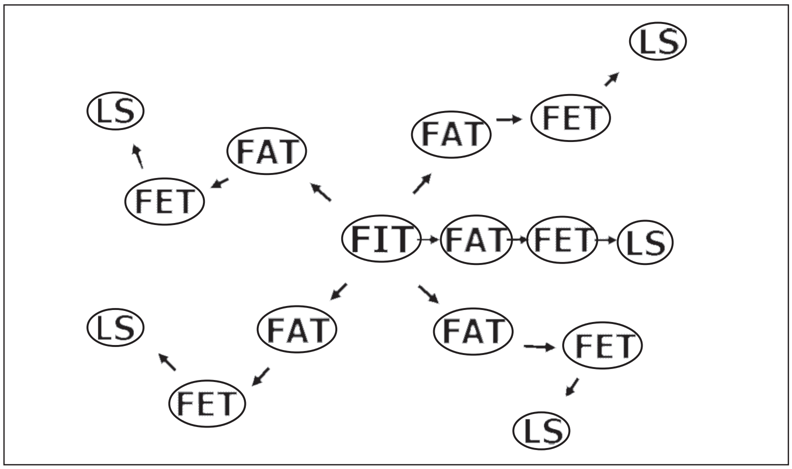


Figure 2.5 **A model of participatory plant breeding in one village**

from the farmer initial yield trial (FIT), grown by one farmer, participatory selection identifies the lines grown in the farmers advanced yield trials (FAT) by more farmers (5 in the figure). The process is repeated to identify lines grown in farmer elite trials (FET) and in the initial adoption stage (LS or large scale trials). The model takes four years for the full implementation.

The activities in farmers' fields begin with the yield testing of early segregating populations in trials called Farmers Initial Trials (FIT), which are unreplicated trials with systematic checks. The number of entries varies from about 50 in Egypt, to 75 in Eritrea and Algeria, to 170 in Jordan and Syria, and the total number of plots varies from 60 in Egypt, to 100 in Eritrea, Iran and Algeria and 200 in Jordan and Syria. Plot size varies from 2 m^2 to 12 m^2.

The breeding materials selected from the FIT with the process described in the next section, are yield tested for a second year in the Farmer Advanced Trials

(FAT) with a number of entries and checks that varies from village to village and from year to year. The plot size in the FAT is larger (10 to 45 m^2 depending on the country) and the number of FAT in each village depends on how many farmers are willing to grow this type of trial. In each village, the FAT contain the same entries. Each farmer decides the rotation, the seed rate, the soil type, the amount and the time of application of fertilizer. Therefore, the FAT are planted in a variety of soil types and of agronomic managements. During selection farmers exchange information about the agronomic management of the trials, and rely greatly on this information before deciding which entries to select. Therefore, the breeding materials start to be characterized for their responses to environmental or agronomic factors at an early stage of the selection process.

The entries selected from the FAT are tested in the Farmer Elite Trials (FET), with a plot size twice as large as the FAT, and, after one more cycle of selection, a number of lines (usually less than five) are planted by the farmers on large scale (LS) in unreplicated plots (few thousand m^2) as a first step in the adoption process.

The PPB trials (FIT, FAT and FET) are in all respect like the MET in a conventional breeding program as described earlier. Even when the MET are conducted in farmers' fields, like in the breeding programs in Australia, there are still at least two major differences between the MET and the PPB trials. The first is that MET are established with the primary objective of sampling target physical environments, while the PPB trials are meant to sample both physical and socio-economic environments including different types of users. The second is that MET data are usually analyzed to estimate or predict the genotypic value of each line across all locations, while in PPB trials the emphasis is on estimating or predicting the genotypic value of each line over time in a given location.

Farmers' selection and data collection

At the time of selection, farmers are provided with field books to register both qualitative and quantitative observations. Farmers' preferences are usually recorded from 0 (discarded) to 4 (most preferred plots) by between 10 and 30 farmers including (in some countries) women, eventually assisted by scientists (or literate farmers) for recording their scores. Breeders collect quantitative data on a number of traits indicated by farmers as important selection criteria (such as growth vigor, plant height, spike length, grain size, tillering, grain yield, biomass yield, harvest index, resistance to lodging and to diseases and pests, cold damage etc), as usually done in the yield trials in a conventional breeding program.

The data are processed (see under statistical analysis) and the final decision of which lines to retain for the following season is taken jointly by breeders and farmers in a special meeting and is based on both quantitative data and visual scores.

In parallel to the model shown in Figure 2.5, and in those countries where varieties of self-pollinated crops can be released only if genetically uniform, pure line selection within selected bulks is conducted on station. The head rows will be promoted to a screening nursery only if farmers select the corresponding bulks. The process is repeated until there is enough seed to include the lines (as F_7) in the yield-testing phase [15]. Therefore when the model is fully implemented, the breeding material which is yield tested includes new bulks as well as pure lines extracted from the best bulks of the previous cycle. If in a given country the requirements for the genetic uniformity of the varieties to be released are very strict, only the pure lines will be considered as candidates for release.

Experimental designs and Statistical analysis

An experimental design proved to be suitable in the first stage, and in the case of one host farmer in each location, is the unreplicated design with systematic checks every ten or every five entries arranged in rows and columns.

In the second and third level, the trials can be designed as á-lattices with two replications or as randomized complete blocks with farmers as replicates, or as standard replicated trials.

The data are subjected to different types of analysis, some of which developed at ICARDA such as the spatial analysis of un-replicated or replicated trials [17]. The environmentally standardized Best Lineal Unbiased Predictors (BLUPs) obtained from the analysis are then used to analyze Genotype x Environment Interactions (GE) using the GGEbiplot software [18].

Therefore, the PPB trials generate the same amount and quality of data generated by the MET in a conventional breeding program with the additional information on farmers' preferences usually not available in the MET. As a consequence, varieties produced by PPB are eligible to be submitted to the process of officially variety release that in several countries, including many in the developing world, is the legal prerequisite for the commercial seed production.

Time to variety release

In a typical breeding program, for example of a self-pollinated crop and following a classical pedigree method, it takes normally about 15 years to release a variety. With the method described in the previous section the time is reduced by half.

However, the comparison is biased because of the difference in the genetic structure of the material being released, i.e. pure lines in one case and populations in the second.

If populations are not acceptable by the variety release authorities, and the model includes pure line selection within the superior bulks, it can be shown that the time to variety release in the PPB program is still 3-4 years shorter than the conventional program based on the pedigree method, and again the comparison is biased because the conventional breeding program does not generate the information on farmers' preferences.

The method is therefore very flexible because it can generate populations, pure lines and eventually mixtures of pure lines. Similarly, when applied to cross pollinated crops, PPB can be used to produce hybrids, populations and synthetics.

Effect on biodiversity

One of the main benefits expected from PPB is an increase in crop biodiversity as a consequence of the joint effect of decentralized selection and of the farmers' participation. The effect on biodiversity is illustrated using the data of the 2001-2004 breeding cycle in Syria (Table 2.1). As indicated earlier, in each village the starting point of the breeding cycle in farmers' field are the initial yield trials with 165 genetically different entries: the number of entries tested in the subsequent trials decreases to about 17 in the FAT, to 7 in the FET and to 3 in the LS. The number of trials per village varies from 1 in the case of the FIT, to about 3 in the case of the other trials. The number of lines selected by between 8 to 10 farmers per village was on average 17, 8, 3.5, and between 1 and 2.

Table 2.1 **Flow of germplasm, Selection pressure, number of farmers participating in the selection and number of lines in initial adoption in one cycle of participatory plant breeding on barley in Syria.**

	FIT	FAT	FET	LS
Entries tested per village	165	17.3	7	3
Trials per village	1	3.2	3.4	2.8
Entries selected per village	17	8	3.5	1-2
Farmer selecting	9-10	8-9	8-9	8-9
Nr of different entries per village	412	238	51	19

FIT = Farmer Initial Trials, FAT = Farmer Advanced Trials, FET = Farmer Elite Trials; LS = Large Scale Trials

Because different germplasm is tested in different villages, the total number of genetically different entries tested in the various trials was 412 in the FIT, 238 in the FAT, 51 in the FET and 19 in LS. In the case of Syria, the number of different entries at the end of a breeding cycle in farmers fields is higher than the number of lines the Syrian National Program tests at the beginning of its on-farm testing which usually ends with one or two recommended varieties across the country.

Variety release and seed production

The potential advantages of PPB, such as the speed with which new varieties reach the farmers, the increased adoption rate and the increased biodiversity within the crop due to the selection of different varieties in different areas, will not be achieved if the seed of the new varieties does not become available in sufficient amounts to all the farmer community. In many countries this is associated with, and depends from, the official recognition of the new varieties. This process called variety release, is usually the responsibility of a committee (the variety release committee) nominated by the Minister of Agriculture, which decides based on a scientific report on the performance, agronomic characteristics, reaction to pests and disease and quality characteristics of the new variety. The farmers' opinion is not requested, and therefore there are several cases of varieties released which have never been grown by any farmer and of varieties grown by farmers without being released. In these cases, the considerable investment made in developing the new variety and in producing its seed has no benefits.

One of the most important advantages of PPB is associated with turning upside down the delivery phase of a plant breeding program (Figure 2.6). In a conventional breeding program, the most promising lines are released as varieties, their seed is produced under controlled conditions (certified seed) and only then farmers decide whether to adopt them or not; therefore the entire process is supply-driven. As a consequence, in many developing countries the process results in many varieties being releases and only a small fraction being adopted. With PPB, it is the initial farmers' adoption which drives the decision of which variety to release, and therefore the process is demand-driven. Adoption rates are expected to be higher, and risks are minimized, as an intimate knowledge of varietal performance is gained by farmers as part of the selection process. Last but not least, the institutional investment in seed production is nearly always paid off by farmers' adoption.

The implementation of a PPB program implies not only a change in the process of variety release but assumes also changes in the seed sector Conventional plant breeding and formal seed sector have been successful in providing seeds

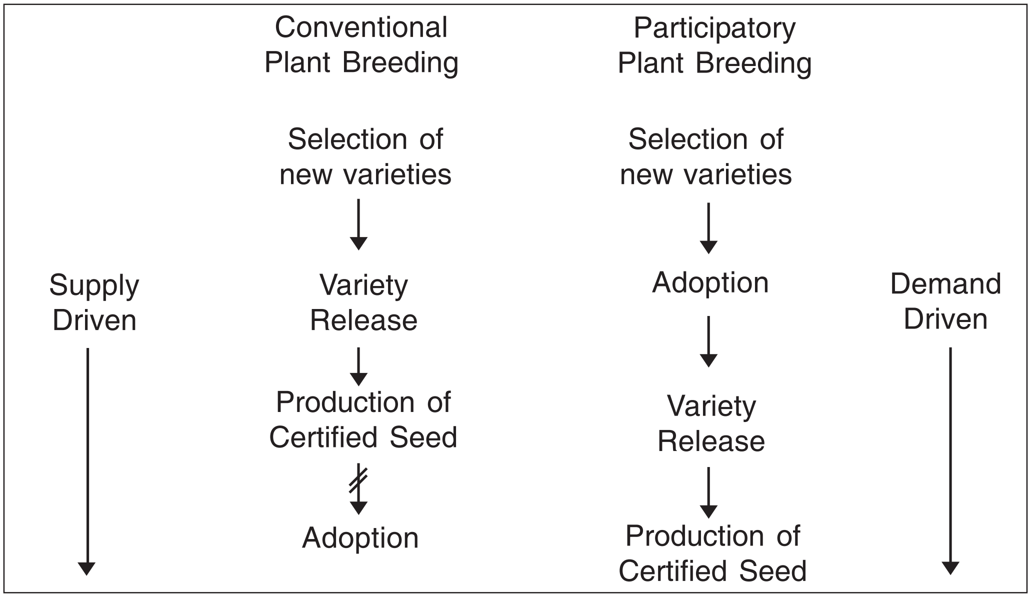


Figure 2.6 In Conventional Plant Breeding new varieties are released before knowing whether the farmers like them or not and the process is typically supply-driven. In Participatory Plant breeding the delivery phase is turned upside down because the process is driven by the initial adoption by farmers at the end of a full cycle of selection and is therefore demand-driven

of improved varieties of some important staple or cash crops to farmers in favorable areas of developing countries. However, the policy, regulatory, technical and institutional environment under which these institutions operate limits their ability to serve the diverse needs of the small-scale farmers in marginal environments and remote regions.

The model we are implementing (Figure 2.7) is based on the integration between the informal and the formal seed systems. During the selection and testing phase (the PPB trials described in Figure 2.5) the seed required, which varies from 50-100 kg for each variety while the number of varieties in each village varies between 15 and 30, is produced in the village and is cleaned and treated with locally manufactured equipment. These are small seed cleaners, which are able to process about 400 kg of seed per hour. After the Farmer Elite Trials, the first initial adoption usually takes place, seed requirement goes up to few tons/farmer and the number of varieties is reduced to 2-3 in each village. At this stage seed production is still handled at village level, using locally manufactured larger equipment capable of cleaning and treating 1 t/hour of seed.

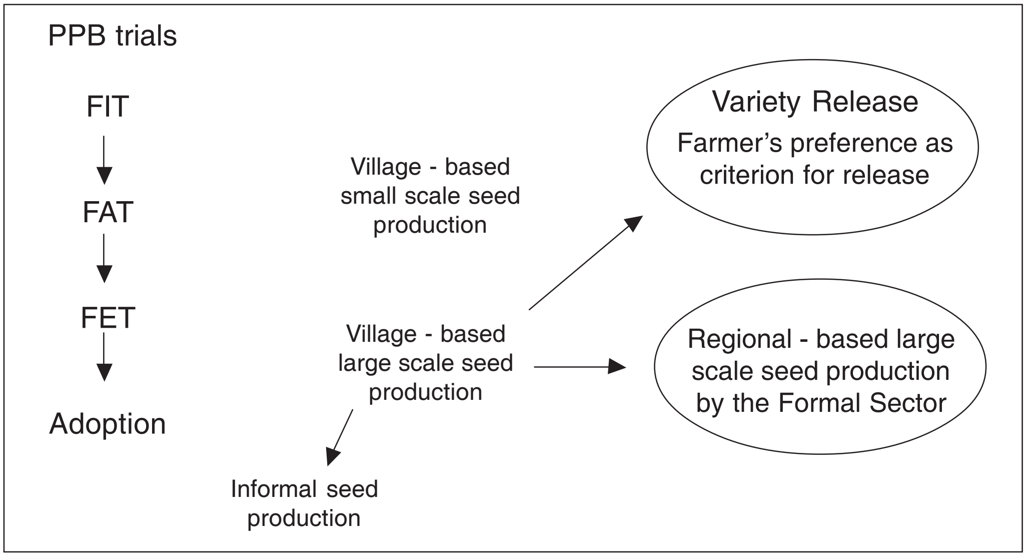


Figure 2.7 **Linking Participatory Plant Breeding, and Variety Release, with Informal and Formal Seed production**

In this phase the staff of the Seed Organization starts supervising the large scale village base seed production. At the same time, the procedure for variety release can be initiated, and if the initial adoption if followed by a wider demand for seed, the variety is released, and the formal seed system can initiate large scale regional seed production using as a starting point the few tons of seeds produced in the villages.In those countries where most of the seed used is produced by the informal seed system, the model can provide the informal system with quality seed of improved varieties.

Impact of Participatory Plant Breeding

By the end of 2006 the model shown in Figure 2.5 was fully implemented in Syria, Jordan, Egypt and Eritrea, and started in Algeria and in Iran (Table 2.2). PPB programs based on the methodology described above have been also implemented in Tunisia and Morocco [3] and Yemen. Table 2.2 shows one of the major advantages of PPB over conventional plant breeding and that is the possibility of working on more crops at the same time in a system context.

These PPB projects had four main types of impact:

Variety development: a number of varieties have been already adopted by farmers even though the program is relatively young in breeding terms (Table 2.3).

Table 2.2 **Countries where the participatory breeding program is implemented and program details.**

Country	Crop (s)	Locations	Trials	Plots
Syria	Barley	24	176	10,020
	Wheat	6	42	710
Jordan	Barley, Wheat, Chickpea	9	21	2,798
Egypt	Barley	6	20	460
Eritrea	Barley, Wheat, Hanfetse, Chickpea, Lentil, Faba bean	7	36	1,475
Algeria	Barley	5	5	500
	Durum Wheat	2	2	200
Iran	Barley	2	7	700
	Bread Wheat	2	2	200

Institutional: in several countries, the interest of policy makers and scientists in PPB as an approach which is expected to generate quicker and more relevant results has considerably increased.

Farmers' skills and empowerment: the cyclic nature of the PPB programs has considerably enriched farmers' knowledge, improved their negotiation capability, and enhanced their dignity [19].

Enhancement of biodiversity: different varieties have been selected in different areas within the same country, in response to different environmental constraints and users' needs. In Syria, where this type of impact has been measured more carefully, the number of varieties selected after three cycles of selection is 4-5 time higher than the number of varieties entering the on-farm trials in the conventional breeding program.

An economic analysis of the PPB barley breeding program in Syria is consistent with the opinion that PPB increases the benefits to resource poor farmers. The total estimated discounted research induced benefits to Syrian agriculture were estimated at US $21.9 million for conventional breeding and US $ 42.7 million to US $113.9 million for three different PPB approaches [20].

Using case studies on different crops, Ashby and Lilja (2004) [21] have shown that:

1. The use of participatory approaches improves the acceptability of varieties to disadvantaged farmers by including their preferences as criteria for developing,

testing and releasing new varieties. A survey conducted on over 150 PPB projects showed that a) PPB improved program's effectiveness in targeting the poor, b) by consulting women and involving them in varietal evaluation, there was a better acceptability and faster adoption of the varieties, and c) involvement of women farmers in the development of maize seed systems in China resulted in a broadened national maize genetic base, in improved maize yields and in strengthened womens' organizations.

2. PPB improves research efficiency. A case study conducted using the PPB program in Syria [22,23] found that farmers' selections are as high yielding as breeders' selections. Another study found that by introducing farmer participation at the design stage, a three years reduction was achieved in the time taken from initial crosses to release. In another example, breeders concluded that it was faster, less expensive and more reliable to involve farmers directly in the identification of promising accessions for use in the breeding program. Efficiency gains depend also on the extent to which farmer involvement enables the breeding program to minimize its investment in the development of varieties which, only after release, turn out to be of little if any interest to farmers.

3. PPB accelerates adoption. The incorporation of participatory approaches consistently enables breeding programs to "break through" adoption bottlenecks caused by low levels of acceptability of new varieties by poor farmers. In addition to the examples given in Table 2.3, other examples are Ethiopia, where out of over 122 varieties of cereals, legumes, and vegetables which had been released, only 12 were adopted by farmers, Brazil, where after years of non-adoption, the implementation of PPB lead to the adoption of several clones of cassava

Table 2.3 **Number of varieties selected and adopted by farmers in the PPB programs in 5 countries.**

Country	Crop (s)	Varieties
Syria	Barley	19
Jordan	Barley	1 (submitted)
Egypt	Barley	5
Eritrea	Barley	3
Yemen	Barley	2
	Lentil	2

which were both resistant to root rot and highly acceptable to farmers, and Ghana, where maize breeders had released several modern varieties(MVs) which had poor acceptability and poor adoption, while with farmers' participation the overall adoption of MVs increased to over two-thirds.

Eventually, there is increasing evidence that one of the most widespread impacts of participatory plant breeding, and possibly of participatory research in general, is of psychological and ethical nature: when farmers are asked which benefits they believe they receive from PPB, they refer that their quality of life has improved, that they feel happier as a consequence of changing their role from passive receivers to active protagonists, that their opinion is valued, and that, as an Eritrean farmer said, that they have taken back science in their hands.

Conclusions

The results presented in this paper indicate that is possible to organize a plant breeding program in a way that addresses not only those plant characteristics that maximize yield and stability over time in a given physical environment, but also the preferences of the users, by developing varieties which are specifically adapted to the different physical and socio-economic environments. Such an objective can be achieved by using a decentralized participatory approach, which needs to be extended also to the seed production aspects. A breeding program organized according to these principles will have the advantages of producing environmentally friendly varieties and of maintaining or even enhancing biodiversity.

The main objections to participatory plant breeding are usually that: 1) plant breeding is "plant breeder business", and if plant breeders do their job properly there should not be the need for participatory plant breeding, 2) is not possible for seed companies to cope with the multitude of varieties generated by participatory plant breeding, and 3) varieties bred through participatory plant breeding do not meet the requirements for official variety release.

With regards to the first objection, circumstantial evidence suggests that while plant breeding has been a success story in climatically, agronomically and economically favorable areas, and in areas where the agronomic environment could be modified to create near-optimum growing conditions, it has been much less successful in less-favorable areas. In those areas where it has been successful, plant breeding has raised both environmental concerns due to high levels of chemical inputs required by modern varieties, and biodiversity concern because of the narrowing of the genetic basis of agricultural crops. More recently, there is a widespread concern about the use of the improperly called Genetically

Modified Organisms (GMOs) which, regardless from other consideration, represent yet another type of top-down technology. For these reasons, it may be useful to explore alternative avenues of plant breeding where the same science can be used in a different way.

The objection that seed companies have difficulties in coping with several varieties assumes implicitly the need to breed taking into account the requirements of the seed companies rather that the interest of the farmers and the consumers at large. It also ignores that in the case of the major food crops and in developing countries, farmers and not seed companies are the main suppliers of seed with over 90% of the seed which is currently planted: participatory plant breeding can introduce new varieties directly into the most efficient seed system currently operating.

Against the third objection, the paper has shown that it is possible to organize a participatory breeding program in such a way that it generates the same quantity of information of the same (or even better) quality than a conventional breeding program. In addition to the usual data set on agronomic characteristics, a participatory breeding program also generates information on farmers preferences (which is missing in the data set generated in a conventional breeding program), and therefore it makes the process of variety release more efficient and effective.

The third objection usually addresses also the genetic structure of the varieties produced by PPB. It assumes that varieties produced by PPB are inevitably genetically heterogeneous, unstable and not distinct and therefore not suited for release. On this issue there are three points to make. Firstly, the majority of cultivars still grown in marginal environments are genetically heterogeneous, and in several cases their seed is multiplied officially by the same authorities which deny the right of populations to be released; secondly, it is disputable how wise it is to replace them with genetically uniform material; thirdly, we have shown that PPB, like conventional plant breeding, is flexible and can be used to produce varieties with different genetic structure including pure lines and hybrids.

Therefore many of the most frequent objections to PPB are unfounded; they ignore that farmers have domesticated the crops that feed the world, and that they have continued to modify the crops for millennia. In this process they have planted, harvested, exchanged seed, introduced new crops and new varieties, and in so doing they have accumulated a wealth of knowledge that modern science tends to ignore. Participatory plant breeding is one way of recognizing farmers' science and to merge it with modern science.

References

1. Rhoades, R., and Booth, R., 1982, Farmer-Back-To-Farmer: a model for generating acceptable agricultural technology. *Agricultural administration* **11**, 127-137.

2. Reynolds, M.P., and Borlaug, N. E., 2006, Applying innovations and new technologies for international collaborative wheat improvement. *J. Agricultural. Science*. **144**, 95-110

3. Ceccarelli, S., Grando, S., Amri, A., Asaad, F. A., Benbelkacem, A., Harrabi, M., Maatougui ,M., Mekni, M. S., Mimoun, H., El Einen, R. A., Felah ,M. El, El Sayed, A. F., Shreidi, A. S. and Yahyaoui, A., 2001, Decentralized and Participatory Plant Breeding for Marginal Environments. In *Broadening the Genetic Base of Crop Production* (eds. D. Cooper, T. Hodgink and C. Spillane), pp 115-135.CAB International.

4. Ceccarelli, S., 1989, Wide adaptation. How wide? *Euphytica* 40, 197-205.

5. Eisemann, R.L., Cooper, M. and Woodruff, D. R., 1990, Beyond the analytical methodology: better interpretation and exploitation of GenotypebyEnvironment interaction in breeding. In *Genotypebyenvironment interaction and plant breeding* (Ed. M.S. Kang), pp. 108117. Dept. of Agron. Louisiana State Agric. Experiment Stn., Baton Rouge, USA.

6. Annicchiarico, P., Bellah, F. and Chiari, T., 2005, Defining Subregions and Estimating Benefits for a Specific-Adaptation Strategy by Breeding Programs: A Case Study. *Crop Science* **45**, 1741-1749.

7. Annicchiarico, P., Bellah, F. and Chiari, T., 2006, Repeatable genotype x location interaction and its exploitation by conventional and GIS-based cultivar recommendation for durum wheat in Algeria. *European. J. Agronomy* **24**,70–81.

8. Ceccarelli, S. and Grando, S., 1997, Increasing the Efficiency of Breeding through Farmer Participation. In Ethics and Equity in conservation and use of genetic resources for sustainable food security, pp 116-121. *Proceeding of a workshop to develop guidelines for the CGIAR*, 2125 April 1997, Foz de Iguacu, Brazil. IPGRI, Rome, Italy. IPGRI.

9. Ceccarelli, S. and Grando, S., 2002, Plant breeding with farmers requires testing the assumptions of conventional plant breeding: Lessons from the ICARDA barley program. In *Farmers, scientists and plant breeding: Integrating Knowledge and Practice* (eds D.A. Cleveland David and D. Soleri, pp. 297- 332. Wallingford, Oxon, UK: CAB I Publishing International.

10. Falconer, D.S., 1981, Introduction to quantitative genetics. 2nd Ed. Longmann Group Ltd., London.

11. Simmonds, N.W., 1984, Decentralized selection. *Sugar Cane* **6**: 8 10.

12. Simmonds, N.W., 1991, Selection for local adaptation in a plant breeding programme. *Theoretical and Applied Genetics* **82**: 363 367

13. Ceccarelli, S., 1996, Positive interpretation of genotype by environment interactions in relation to sustainability and biodiversity. In *Plant Adaptation and Crop Improvement* (eds.M. Cooper and G.L. Hammers), pp.467-486. CAB International, Wallingford. U.K., ICRISAT, Andra Pradesh, India, IRRI, Manila, Philippines.

14. Schnell, F.W., 1982, A synoptic study of the methods and categories of plant breeding. *Zeitshrift für Pflanzenzüchtung* **89**, 1-18.

15. Ceccarelli, S. and Grando, S., 2005, Decentralized-Participatory Plant Breeding pg 145-156 In *In the Wake of the Double Helix: From the Green Revolution to the Gene Revolution* (eds R. Tuberosa, R.L. Phillips and M. Gale, pp. 145-156. ©2005 Avenue media, Bologna, Italy.

16. Mangione, D., Senni, S., Puccioni, M., Grando, S. and Ceccarelli, S., 2006, The Cost of Participatory Barley Breeding. *Euphytica* (in press)

17. Singh, M., Malhotra, R.S., Ceccarelli, S., Sarker, A., Grando, S. and Erskine, W., 2003, Spatial variability models to improve dryland field trials. *Experimental Agriculture* **39**: 1-10.

18. Weikai, Y., Hunt, L.A., Qinglai Sheng and Szlavnics, Z., 2000, Cultivar Evaluation and Mega-Environment Investigation Based on the GGE Biplot. *Crop Science* **40**, 597-605.

19. Soleri, D., Cleveland, D.A., Smith, S.E., Ceccarelli, S., Grando, S., Rana, R.B., Rijal, D. and Labrada H.R., 2002, Understanding farmers' knowledge as the basis for collaboration with plant breeders: methodological development and examples from ongoing research in Mexico, Syria, Cuba and Nepal. In *Farmers, scientists and plant breeding: Integrating Knowledge and Practice* (eds D.A. Cleveland David and D. Soleri), pp. 19-60.Wallingford, Oxon, UK: CAB I Publishing International.

20. Lilja, N. and Aw-Hasaan, A., 2002, Benefits and costs of participatory barley breeding in Syria. A background paper to a poster presented at the 25th International Conference of IAAE, Durban, South Africa, 16-22 August 2003.

21. Ashby, J. A. and Lilja, N., 2004, Participatory Research: Does it Work? Evidence from Participatory Plant Breeding. New directions for a diverse planet: *Proceedings of the 4th International Crop Science Congress*. Brisbane, Australia, 26 Sep – 1 Oct 2004. www.cropscience.org.au

22. Ceccarelli, S., Grando, S., Tutwiler, R., Baha, J., Martini, A.M., Salahieh, H., Goodchild, A. and Michael, M., 2000, A Methodological Study on Participatory Barley Breeding. I . Selection Phase. *Euphytica* **111**, 91-104.

23. Ceccarelli, S., Grando, S., Singh, M., Michael, M., Shikho, A., Al Issa ,M., Al Saleh, A., Kaleonjy, G., Al Ghanem, S. M., Al Hasan, A. L., Dalla, H., Basha, S. and Basha, T., 2003, A Methodological Study on Participatory Barley Breeding. II. Response to Selection. *Euphytica* **133**, 185-200.

Acknowledgements

The authors thank the several donors who support participatory plant breeding at ICARDA: these include the OPEC Fund for International Development, the Governments of Italy and Denmark, der Bundesminister für Wirtschaftliche Zusammenarbeit (BMZ, Germany), the International Development Research Centre (IDRC, Canada) and the System Wide Program on Participatory Research and Gender Analysis (SWP PRGA).

3

Participatory Rice Varietal Selection in Rainfed Lowland in West Africa with reference to Burkina Faso

M.Sie, D.Hema, M. Ouédraogo, M.J.Sanon, S.Traore, L.Bado, A.Sanou, Z.Ouattara and S.A.Ogunbayo

The participatory rice varietal selection activity under the Comoé Rice Project in Leraba province Burkina Faso aimed to learn and conduct farmer-participatory rice varietal selection and distribution. The trial was established in rainfed lowland in Badini and total area used was 98 hectares. The materials were made up of 44 varieties in which 18 were Interspecific and 10 intraspecific and the remaining were improved varieties. Simple design without replication was used and the varieties were subjected to two levels of fertilizer application. Out of 570 collaborating farmers that participated in selection process, women were 450 which is about 80% and the field was visited three times, at tillering, flowering and maturity stages. Among 16 varieties retained by the farmers 6 NERICA-L and two new varieties have been released. The study did not show only involvement of women but also their willingness and active participation in activities. The project shows that a careful choice of research goals, targeting of environments and selection of user communities is required for participatory research to have an impact. Therefore, participatory research is seen to improve research efficiency and leads to more acceptable varieties and accelerating adoption.

Key words: Interspecific, intraspecific, lowland Nerica, participatory varietal selection, rice

In Africa, there are two major cultivated rice species, *Oryza sativa L* and *Oryza glaberrima Steud. Oryza sativa* originated from Asia and was introduced into Africa by the Portuguese around 1500 years ago. It has good agronomic traits but susceptible to most African stresses. *O. sativa* is divided into two groups, including *Indica* and *Japonica* sub-species [1,2] .The *Indica sub-species* originates from tropical Asia and is widely grown throughout the Tropics and Subtropics and is adapted to aquatic conditions. It has good tillering ability, long and slender grains. *Japonica* varieties have narrow and dark green leaves, tillers with medium height and short grains, and are adapted to upland conditions in West Africa. *Oryza glaberrima Steud* is an indigenous species of Africa and propagated from its original center, the Delta of Niger River, and extended towards Gambia, Casamance and Sokoto basin [3]. It has been cultivated since 3500 years [1,4]. It is adapted to African environments but prone to lodging and grain shattering when compared with *Oryza sativa* [5]. *O. glaberrima* has good genetic potential and plant vigor, and shows resistance/tolerance to major rice pest and diseases, e.g drought, blast, rice yellow mottle virus, nematode, AfRGM. O. glaberrima is grown in two principal ecosystems[6,7,8] . These useful traits in *O. glaberrima* are unique and need to be exploited[9].

Three types of rice cultivation are practiced in Burkina Faso: strict rainfed rice, irrigated rice with water management and lowland rice. In Burkina Faso, lowland rice covers 70 % of the rice cropping areas, but accounts only for 48 % of the country's production. The country has a high potential of lowlands, especially in the southern part where rainfall is 1000 mm or higher. That is why Burkina Faso, as part of its policy to increase rice production, has decided to give a paramount importance to this type of rice cropping.

It is in this context that the National Rice Program ('*Programme Riz'* undertook a study throughout the country to assess local ecosystems. This survey helped in collecting more than 600 samples of *O. sativa* and some *O. glaberrima*. This material was evaluated in the field. In addition, INERA introduced foreign genotypes and made intraspecific crosses in *O. sativa*

With a view to increasing biodiversity, the Africa Rice Center Irrigated Rice Program in Senegal undertook a number of interspecific crosses between *O. glaberrima* and *O. sativa(indica)* for irrigated rice. Lowland rice is grown both in rainfed and irrigated conditions and covers large areas in Burkina Faso; therefore new interspecific progenies were tested under lowland conditions. To save time that would be spent on assessing adoption of new varieties by farmers, a participatory varietal selection (PVS) was undertaken in collaboration with the DRAHRH (Direction Régionale de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques). SAVARIZ made available to rice farmers a large number of varieties adapted to lowland rice cultivation. These varieties were grown on farmers' fields, using criteria by scientists for their evaluation. Several improved rice varieties are evolved earlier rarely matched farmers' expectations. Such a situation could have been avoided if farmers were involved in the process of varietal evaluation and selection.

This study therefore laid emphasis on involving farmers as true partners in the selection process (Participatory varietal selection,PVS). The objective of strengthening dialogue between research and extension structures and farmers in this study was to help rice producers in identifying and selecting varieties that best meet their preferences, to accelerate adoption and dissemination of new technologies, and to motivate scientists to take into account farmers' preferences for plant and grain characteristics in the breeding programs.

Further foreign varieties introduced in Sahel countries (e.g TN1 susceptible to diseases and insects and one of the parents of BG 90-2 that is cultivated in Mali, Niger, Senegal and Mauritania, and likewise one of the parents of JAYA cultivated in Senegal and Mauritania) resulted in large areas occupying few varieties with narrow genetic base. Therefore, it was necessary to introgress those varieties to broaden genetic base with are resistance to major stresses such as the rice yellow mottle virus (RYMV). Further there was also a need to work on early maturing rice derivatives to enable double cropping. To increase rice production, interspecific hybridization between the African traditional rice, *Oryza glaberrima* and the Asian rice, *Oryza sativa* was undertaken with the support of the Africa Rice Center (WARDA). After its success, WARDA initiated other crosses of *O glaberrima X O sativa* for lowlands to combine high yielding ability of *O. sativa* with resistance of *O. glaberrima* to combat major constraints in the sub-region. After preliminary evaluation of the F1 material, selected F_2 material was sent to three countries, Burkina Faso, Togo and Mali for Further selection. Thus, about 740 interspecific lines were evaluated in these countries. Furthermore, to reduce time required to test adoption of the varieties by farmers, PVS in collaboration with the DRAHRH was conducted. Farmers were included in the selection process to reduce time required to move varieties to farmers' fields. In the selection process, gender differences became also explicit in varietal selection criteria.

Therefore, this study showed the emergence of a new set of interspecific lines adapted to lowlands that the national research programs may use in various tests in meeting farmers' needs.

Methodology

The trial was carried out in the upward inland valley of Badini in the Province of Leraba using the design developed in 1995 by the *Projet Riz Comoé* (ORC). Total experimental area was 98 ha; 570 farmers participated of whom 450 were women (about 80 %). The average area per farmer was 0.17 ha and the average yield was 2000 kg/ha. Along with varieties like FKR 19 local varieties such as

Wêrêwêrê, Zogoté, Benkawiri and Kamiakawere included in the trial.

Experimental Design

The trial included 44 varieties of which with 18 were derived from interspecific (Lowland NERICA) crosses and 10 from intraspecific crosses; the remaining were new popular check varieties. Varieties were planted in rows of length 2.4m spaced 0.25m apart with plant to plant distance also of 0.25m. Two levels of fertilizers were applied to the varieties

Treatment 1: 74N-46P-28K

200 kg /ha of NPK (14-23-14) at seeding and 100 kg/ha of urea (35 kg/ha 14 days after emergence and 65 kg/ha at panicle initiation)

Table 3.1 **Varieties Selected by farmers during three visits**

Rank	Variety		Yield Kg/ha	Total choice	Women's choice	Men's choice	Source
1	V17*	FKR 54	4791	58	21	37	Seed
2	V37**	WAS 189-4	2782	46	19	27	
3	V23*	BR 50-120-2	3772	37	21	16	Collection
4	V2	WAT 1184-B	2659	36	9	27	Varietal trial
5	V44	WAT 110-TGR-2-5	3899	24	10	14	
6	V13**	WAS 163-B-5-3	3068	23	4	19	
7	V12**	WAS 161-6-3	3751	20	3	17	
8	V21	Mahinplango	2364	17	11	6	Local
9	V16	FKR 52	3951	16	4	12	Seed
10	V6	WAS 129-B-IDSA-B-WAS-1-1	3377	15	8	7	
11	V14**	WAS 191-8-3	3525	11	5	6	
12	V7**	WAS 122-IDSA-1-WAS-1-1	1569	10	1	9	
13	V29	WAS 97-B-IDSA-WAS-1-1	3235	10	7	3	
14	V15**	WAS 191-9-3	2879				Varietal trial
15	V25*	TOX 4008-34-1-1-2	2282				Collection
16	V5*	WAS 114-B-IDSA-B-WAS-1-1	3091				

** Varieties selected for grain quality. ** Inter-specific derivatives (Lowland NERICA).*

Treatment 2: 46N-46P-28K

200 kg /ha of NPK (14-23-14) at seeding and 50 kg/ha of urea (25 kg/ha 14 days after emergence and 25 kg/ha at panicle initiation)

Agronomic performance

The average yield varied from 2955 kg/ha (normal dose of urea) to 2823 kg/ha (half the dose of urea); the overall average of the trial was 2890 kg/ha. Among the 22 genotypes that yielded better than this average, 6 were Lowland NERICA. The best yield was recorded by the variety FKR 54 liked both by women and men farmers. The average number of tillers was 28 per hill; and lowland NERICAs were among high-tillering genotypes. The average plant height was 100 cm.

Farmers' assessment

16 varieties were selected by farmers (Table 3.1). Among the 16, 6 were interspecific derivatives, 5 intraspecific derivatives, 2 (FKR 54 and FKR 52) newly released varieties; 1 local variety (Mahinplango) and 2 (BR 50-120-2 and Tox 4008-34-1-1-2) new varieties. The yield of these 16 varieties varied from 1569 kg/ha (V7) to 4791 kg /ha (V17). Half of the varieties selected by farmers were among the 10 top yielding varieties. The selected varieties V17, V2, V25, V21 and V7 performed better under (Treatment II) low level of inputs. The newly released variety FKR 54 was liked by farmers. Variety V14 was among the interspecific derivatives chosen by breeders during the last ROCARIZ monitoring tour also. Table 3.2 presents choice criteria for men and women while Table 3.3 presents rejection criteria.

Table 3.2 **Choice criteria for men**

S.no	Traits	Women		Men	
		n	p	n	P
1	Tillering	67	1	44	1
2	Productivity	39	2	30	3
3	Height	30	3	9	7
4	Cycle	16	4	7	8
5	Grain quality	12	5	10	6
6	Plant Vigor	11	6	43	2
7	Vegetative growth	5	7	18	4
8	Support water table	4	8	17	5

n: number of persons ordering the traits; p: rank of preference

Table 3.3 **Rejection criteria at second visit by farmers.**

Rank	Traits	Total number of farmers	Women	Men
1	Late duration	47	12	35
2	Poor plant vigor	42	33	9
3	Short height	21	6	15
4	Poor vegetative growth	12	8	4

Conclusions

The evaluation of 44 varieties of lowland NERICA, helped to record the rating of varieties by farmers for the first time. Further the study revealed not only the predominant role of women in selection but also their concern priority for the traits, plant vigor and wide leaf area canopy.

This study highlighted the following salient results:

- PVS minimizes the time taken for varieties to reach farmers
- Provides feedback to breeders
- It determines varieties that farmers want to grow
- Determines gender perception in varietal selection
- Assist breeding and selection processes
- It also contributes to developing a technology transfer process
- Allows farmers to select material adapted to their local fields and socio-economic conditions
- Helps to focus on biodiversity necessary to buffer against unpredictable climatic conditions, edaphic factors and biotic processes
- PVS approach hastens varietal release process
- Dynamic and requires:
  - Breeders to develop new and suitable lines,
  - Scientists, extension, NGOs and farmers to work together,
- The success of any PVS depends heavily on availability of large quality of seeds (plant) for selection across a large number of farmers.

- Sustainable funding is necessary to maintain momentum and expand activities to include community-based seed systems.

References

1. Porteres., 1956, Taxonomie agrobotanique des riz cultivés O.sativa linné et O.glaberrima steudel. Compilations d'articles du JATBA-Museum National d'histoire Naturelle. Paris

2. Pernes, J., Berthaud, J., Besançon,G., Combes, D., Leblanc, J. M., Lourd, M., Savidan,Y. et Second, G., 1984, Gestion des ressources génétiques des plantes : monographies. Tome I. Edition, Lavoisier. **212** pp.

3. Carpenter, A. J., 1977, The history of rice *in* Africa in rice. Buddenhagen, I. W. and G. J. Presley. Ed, Academic press, London-New york-San Francisco. 3 – 11.

4. Dembele, Y., 1995, Modélisation de la gestion hydraulique d'une retenue d'irrigation: application au périmètre rizicole de Mogtédo (Burkina Faso). Thèse doctorat option génie rural et des procédés, ENSA de Rennes (France). **156** pp.

5. Sie, M., 1991, Prospection et Evaluation Genetique des variet Prospection et Evaluation Genetique des varietés traditionnelles de Riz (*Oryza sativa L*. et *O.glaberrima steud* du Burkina Faso. **118**P

6. Besançon,, 1993, Biotechnology Applied Biochemistry (1993) 18, (93-102)

7. Ndjiondjop, *et al.,* 1996, Potentials and limitations of Biotechnology in Rice

8. Adeyemi, p. et Vodouhe, S.R., 1996, Amélioration de la productivité des variétés locales de *Oryza glaberrima* Steud. par des croisements intra et interspécifiques avec *Oryza sativa* Linn *in* Hybridations interspécifiques au Bénin. ADRAO, Bouaké (Côte d'Ivoire), 159 – 175.

9. Pham, J. L., 1992, Evaluation des ressources génétiques des riz cultivés en Afrique par hybridation intra et interspécifique. Thèse Docteur es sciences, Université de Paris XI ORSAY (France). **236** pp.

Acknowledgements

The authors are grateful to the West and Central Africa Rice Research and Development Network (ROCARIZ) and Africa Rice Center (WARDA) for its financial support and contribution to capacity building of the NARS.

4

Conservation to commercialization: Sustaining Kerala's rural livelihoods through utilization of the medicinal rice diversity

S. Leena Kumary

Kerala, with its age old traditions in the Ayurvedic system of medicine, is also famous for the diversity of rice varieties possessing medicinal properties. Varieties like Chennellu, Kunjinellu, Erumakkari, Karuthachembavu, Kavunginpoothala and Njavara are a few among those still grown by farmers for their medicinal value. Immense traditional knowledge also exists among the local people on their medicinal properties and use of these varieties for various ailments. Poor yield, poor publicity and insufficient marketing facilities limit the cultivation of these varieties to certain pockets. Wider cultivation of such varieties can be promoted once the undisturbed gene pool is genetically improved and the special properties of these varieties are validated. For instance, Njavara, the unique medicinal rice is believed to have been cultivated in Kerala for about 2500 years. In classical Sanskrit books of Ayurveda, it is grouped under "Shashtikam" due to its extra short duration of around 60 days.

This variety is popularly used in Ayurvedic treatment for paralytic conditions. Indigenous medicinal preparation using Njavara along with Kurunthotti (*Sida rectusa*) rejuvenates the muscles and nerves. At least two dozen uses of Njavara are quoted based on local knowledge which points to its potential use in developing health foods, baby foods and breakfast cereals in addition to its predominant role in Ayurvedic system of medicine. But the very architecture of this tall indica rice, coupled with its poor yield makes it less lucrative for profitable rice cultivation. Genetic improvement, conservation and production of this traditional cultivar in a participatory mode with strong market support can promote its cultivation substantially. This paper emphasizes the need for upscaling this valuable genetic resource and proposes an on-farm conservation cum multiplication strategy to establish a link between conservation and commercialization to enhance the security of livelihoods of Kerala farmers.

Key words: Conservation, Commercialization, Livelihood, Utilization, Medicinal rice, Diversity

Biological resources are vital to humanity that depends upon them for clean environment, food security, health care, social needs, livelihood, trade, industrial growth and economic development. The *Convention on Biological Diversity* (CBD) recognizes the need for countries to use their indigenous biological resources for socio-economic development and stresses the need for commercialization of the biological diversity for sustainable development, without which the rural communities, who are effective custodians and managers of biological resources, will not be benefited. The CBD also requests parties to respect, preserve and maintain knowledge, innovation and practices of indigenous and local communities for the conservation and sustainable use of biological diversity[1]. But unless institutional and policy support are provided to the local farming communities for ensuring their livelihood security, it will be imprudent to expect that they would continue to conserve biodiversity. This paper addresses related issues and suggests measures for ensuring livelihood security of Kerala farmers

Medicinal rice diversity of Kerala

The medicinal and curative properties of rice is well documented and ancient Indian records speak of the existence of rice varieties of curative value for various ailments as detailed in the Ayurvedic Treatise (Indian *Materia Medica*) of the 15th and 16th Centuries AD. Kerala, with its hoary traditions in the Ayurvedic system of medicine and many practicing physicians, continue to use rice and rice products in medicine though not to the same extent as laid down in the classical works of Susruta and Charaka, the great Indian pioneers in medicine and surgery[2]. Susrutha has classified rice into two broad categories, Saali rice and Vreehi rice. Saali rice are winter grown, characterized by red husk and white kernels, while Vreehi rice are autumn grown with different husk colours (ranging from white, straw, red, brown to shades of black) and red kernels. Ayurveda (the Science of Life) considers Saali rice as 'Laghu' meaning light or easily digestible, cooling, diuretic, capable of alleviating thirst. Traditional rice varieties of Kerala, Chennellu, Kunjinellu, Chembavu, Kalamappari, Neduvali, Velvali, Narikari, Erumakkari, Varakan, Poovali, Tanavala, *to* name a few, are believed to be Saali varieties of which Chennellu is considered to be the best. Vreehi rice are considered 'Guru*'* (heavy) compared to Saali rice. Varieties like Navara (Njavara), Karimkuruva, Perunellu, Ulimkathi, Valanellu, Chitteni, Modan, Aaru nellu were Vreehi varieties of Kerala [3].

But Njavara is considered light and equivalent to Chennellu (Saali rice) in its medicinal value. These medicinal rices are good for consumption also[4]. The wild and weedy forms of rice classed under *O.sativa* var. *fatua* are believed to possess medicinal properties and were used for preparing royal meals for the rulers in ancient Kerala. *Annoori* is a another wild rice (probably *O. granulata)*, used by the *kani* tribes in the treatment of small pox [5]

The rich and well known genetic diversity in rice in Kerala has been eroded by the advent of modern varieties. Most of the medicinal rices mentioned above are not in cultivation now. But some varieties like Chennellu, Kunjinellu, Erumakkari, Karuthachembavu, Kavunginpoothala, Njavara [6]are still grown by some traditional farmers on a small scale for their medicinal properties than for yield. Among these varieties, Njavara is considered most important medicinally. Chennellu and Kunjinellu are two traditional rice varieties indigenous to North Kerala, while Kavunginpoothala, Erumakkari and Karuthachembavu are indigenous to Central and South Kerala. Ayurveda treatment uses these varieties for various ailments including diarrhoea, nausea, cough, stomach pain and diabetes[5].

Of various medicinal rice varieties, the extra short duration variety Njavara is widely used in Ayurvedic treatment. It is used particularly in treating paralytic conditions and muscle wasting. It increases the growth of muscles and stimulates the nerve endings. The grains are sweet, acrid, oleaginous, aphrodisiac, diuretic, carminative and anti-dysenteric. The roots of this rice are said to be cooling, diuretic and febrifuge and are useful in burning sensation, dyspepsia, bilious fever and diabetes. It is also reported to have an array of other medicinal qualities, either used internally or externally, alone or in conjunction with other herbal preparations. Consumption of Njavara rice is recommended during the time of *pathyacharana* (observing strict time-schedule and keeping special rules and regimen normally after undergoing Ayurvedic treatments, especially the *Panchakarma*). This has a wide range of benefits including aphrodisiac. The oil prepared out of Njavara rice is used for a wide range of aches and painful conditions like cervical spondylosis, low backache, paralysis, rheumatoid arthritis etc. Of two ecotypes of Njavara - white and black glumed, white glumed Njavara is supposed by superior in medicinal value.

Thus, of all the medicinal rices, Njavara scores high for improving the livelihood security of rural farmers of Kerala. A farmer can sell Njavara rice for around Rs.40-50 a kg that could go up to Rs. 80 in favourable seasons, compared to Rs.12-15 a kg for ordinary rice. Yet the area under Njavara is not expanding. Possible reasons are –

- inadequate knowledge and non-validation of traditional knowledge based claims on the medicinal properties of Njavara,

- existence of a number of accessions claimed to be Njavara and lack of scientific data for identifying true Njavara,
- poor productivity of Njavara,
- difficulties faced by farmers in cultivating this highly lodging variety with asynchronous flowering, and
- low market base and insufficient market support.

Immediate concern of researchers and administrators should therefore be –

- clinical validation including identification of bio molecules that lead to the medicinal properties to Njavara
- legal protection of Njavara using relevant and available legislation
- collection of the unique diversity, purification and genetic improvement of the accessions through conventional and novel approaches,
- On farm conservation and seed distribution and
- maintenance and expansion of market base including export

Available leads to identification of bio molecules conferring medicinal properties to Njavara

The high concentration of Proline in Njavara rice compared to other rice varieties[3]may be one of the reasons for its high medicinal value. Ignatova and Gierasch(2006)[7] found that the osmolyte Proline may be protective against biomedically important protein aggregates that are hallmarks of several late-onset neurodegenerative diseases including Huntington's, Alzheimer's, and Parkinson's diseases ,opening up the possibility of small molecule osmolytes such as proline becoming therapeutically useful against neuro-degenerative diseases. Another candidate molecule is Gamma oryzanol / ferulic acid which appears to be most comparable with the action of Njavara in various painful conditions of the body like cervical spondylosis, low back ache, paralysis and rheumatoid arthritis. Gamma oryzanol, which is a potent membrane antioxidant is also reported to increase testosterone levels, stimulates the release of endorphins (pain-relieving substances made in the body), and promotes the growth of lean muscle tissue[8]. Since most of the healing properties of Njavara are comparable with the pharmaco dynamic and applied clinical effects of Gamma Oryzanol, the hypothesis is that either the variety Njavara has a high concentration of Gamma oryzanol / ferulic acid or the bioavailability of these components is much more in Njavara compared to other rice varieties which could explain the preference for Njavara in Ayurvedic treatments.

Significant genotypic variation exists among rice varieties in phyto chemical contents and genotypes with darker bran (dark brown, red and black) are reported to show a greater range in phenolic concentration. Menon and Potty (1999)[9] analysed the amino acid composition in different rice varieties and found that Njavara has higher total free amino acid content compared to other varieties. They also suggested that high sulphur containing amino acid, methionine, which is believed to be involved in the biosynthesis of thiamine; a B - vitamin could be responsible. Ferulic acid, an ubiquitous polyphenol is formed from the metabolism of the two amino acids, phenylalanine and tyrosine, and the finding that the contents of total free amino acid is higher in Njavara also points to the possibility of higher concentration of ferulic acid in Njavara rice. Research is also needed to analyse the contents of other bio molecules in Njavara having disease fighting properties viz., Vitamin E (tocopherols and toco trienols), and trace minerals like zinc, manganese, selenium, magnesium. etc. The extra short duration of Njavara also should have a role in its medicinal activity. In Nepal, the 60 day duration rice variety "Sathi" is reported to have religious significance in Hindu culture, revered as a food of divine health and used in religious offerings. It is note worthy that Ayurveda does not consider long duration varieties as good from medicinal point of view. For example, Anduvila Chennellu, a Saali variety which takes one year to mature was considered to increase some disorders in human system and hence not recommended for daily consumption.

Legal protection

Njavara is native to kerala and if grown elsewhere, its performance, and in particular, medicinal properties are not retained. There is then an immediate need to get this variety registered as a Geographical Indication (GI) under the Geographical Indications of Goods (Registration and Protection) Act (GI Act), 1999 so as to give exclusive rights to farmers of Kerala to produce Njavara using GI as a branding tool. As per the Act, only an association of producers or an authority established under law can apply for registration. In Kerala, a group of Njavara farmers have joined together and have formed a society which has been registered as "Njavara Farmer's Society ". The society should be encouraged to file application for registering Njavara with the GI Registry in Chennai and the Government should provide necessary technical support and back-up to give the farmers this GI protection and rights.

Collection, conservation and improvement of Njavara germplasm

Kerala Agricultural University has already initiated work on collection, characterization, evaluation and purification of Njavara accessions. Different accessions of Njavara have been collected from various parts of Kerala, characterized for qualitative and quantitative characters and evaluated for agronomic characters[6]. The traditional wisdom of the farmers have been utilized in identifying true Njavara types. Single plant selections with superior expression were made from purified Njavara accessions and are being evaluated for yield and other attributes. Appropriate breeding methods and organization of Njavara production through Participatory Plant Breeding to realize the potential of Njavara are being streamlined.

On farm conservation and seed distribution

A system comparable to the 5-tier system of participatory conservation of PGR proposed by Arunachalam (1998)[10] can be developed for on farm conservation and seed distribution of Njavara (Figure 4.1). Since many stakeholders are involved in this, the efforts must be coordinated across diverse sectors like the State Government, Local Self Government institutions, Research Institutions, Development/ Extension Departments, Non-governmental Organizations and Progressive farmers / Self Help Groups among the farming communities. The State Government will be the apex body with overall responsibility for providing and enforcing regulations and providing incentives and funds for the various activities involved and can function through local self governments. Research support can be provided by Kerala Agricultural University. Regional Agricultural Research Stations under the KAU and the Rice Research Stations under each Regional Station can co-ordinate the activities on collection, characterization and genetic improvement of Njavara. The main function of these research institutions will be to develop improved types of the Njavara landrace collected locally, catering to the needs of the local community through Participatory Plant Breeding .The traditional knowledge of the farmers can been utilized in seed selection. Improved Njavara types with better plant architecture, higher yield and medicinal value developed utilizing scientific data generated at research stations and evaluated in farmer's fields, maintenance breeding and genetic enhancement including fingerprinting would be valuable components of targeted upscaling of Njavara.

Value addition and Market Support

The present annual requirement of Njavara rice is around 150-200 tonnes for Ayurvedic hospitals alone. With the renewed interest in the traditional system of medicine, the requirement will increase in the years to come. The present irony is that Ayurvedic physicians complain of non-availability of sufficient quantities of Njavara at times of need and farmers find it difficult to market their produce. Government support price, and an effective link among producers, market and consumers would go a long way in the promotion of Njavara. Participatory value addition to Njavara as a baby food and health food could help in furthering its value including export. These avenues could stabilize and sustain a premium price for Njavara.

In conclusion, It is time that efforts are crystallized to forge a gainful collaboration among the Government, research institutions, farmers and traders.

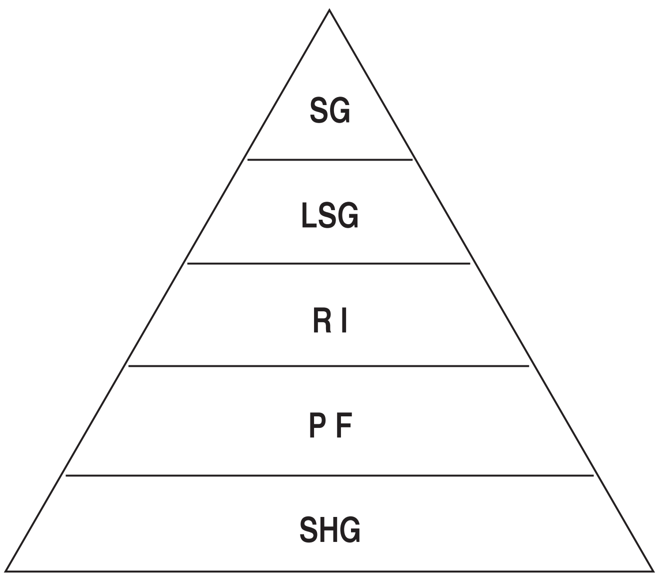


Figure 4.1 **A possible 5 –tier system of on farm conservation and Seed production of Njavara**

SG: State Government LSG: Local Self Govt RI: Research Institutions PF: Progressive farmers SHG: Self Help Groups

References

1. Kannaiyyan, S., (2006) Biological Diversity Act, 2002. In National Conference on Agro biodiversity held during 12-15th Feb, 2006 organised by National Biodiversity authority , Neelankarai, Chennai-41. p 1-6.

2. Sahadevan, P.C.,1966. *Rice in Kerala*.Ed. Agricultural Information Service, Dept.of Agriculture, Kerala state.

3. Nair, M.C., 2004. Comparative biochemical characterization of indigenous medicinal rice Njavara and selected cultivars of *Oryza sativa* L. Project report submitted to Kerala State Council for Science, Technology and Environment.

4. Menon, V. M. K., 1976. *Ashtangahrudayam*. Sahitya Pravarthaka Sahakarana Sangham.National Book Stall, Kottayam . 339-349

5. Sujith Kumar, C.K., 1999. " Krishi Malayalam" Akshara Samskrithi. Samskrithi Publications,Kannur, Kerala.

6. Leena Kumary, S., 2004. Genetic Diversity, Characterisation and Evaluation of Medicinal Rice in Kerala. In National Seminar on Medicinal and Aromatic Rices of Kerala. 19-21 August 2004, organised by MSSRF and Kerala Agricultural University.

7 Zoya Ignatova and Lila M. Gierasch (2006) Inhibition of protein aggregation in vitro and in vivo by a natural osmoprotectant PNAS 103(36), 13357-13361

8 Raxit J. Jariwalla .,(2004) Advances in rice-based products with potential benefits to health. California Institute for Medical Research, San Jose, California 95128

9 Menon, M.V. and Potty, N. N., 1999. Nutritional specificity and quality properties of medicinal rice "Njavara". Oryza. **36**(4): 315-317

10. Arunachalam, V., 1998. Genetic erosion in plant genetic resources and early warning system: A diagnosis dilating genetic conservation. FAO invited paper. Published in Internet (http://apps3.fao.org/wiews/EWS/EWSThmDiagnos.jsp) April 1998, **19** pp

5

On-farm participatory selection of Orange-fleshed Sweetpotato (*Ipomoea batatas* (L.) Lam.) for nutrition improvement in Nuapada district of Western Orissa, India

Sreekanth Attaluri, Sarath Ilangantileke and Subrat K Rath

Sweetpotato has been one of the important root crop in Western Orissa. The local varieties in Western Orissa farmers are relatively low yielding. The objective of the present study was to involve farmers in the assessment, identification and selection of those with superior yield performance and consumer acceptance by evaluating the local varieties with nutritious and improved germplasm of sweetpotato. Four CIP germplasms which are mostly orange fleshed (having high beta-carotene content) along with local were evaluated at Lerki and Babupalli villages (two sites) in Nuapada district of Western Orissa in Kharif (rainy season) 2005. Orange fleshed sweetpotato which contains high content of beta-carotene is a cheap source of Vitamin A. Twenty farmers of each village and surrounding areas participated in the trial harvest. At harvest, the tuber weight, the vine yield and dry matter content were determined by researchers. Farmers observed a number of characteristics and ranked each germplasm with respect to the following variables: pest attack, size of the tuber, general appearance, taste and presence of carotene (orange flesh color). A positive correlation was observed between general appearance and yield and harvest index in the trials. Farmers selected 3 superior germplasms from each trial for further multilocational trials and in different environments. Two germplasms namely IB-97-12/7 and CIP-SWA-3 performed equally good at both the sites.

Keywords: Sweet potato, farmer's participation, evaluation, improved germplasm selection, consumer acceptance

Sweet potato is generally considered a poor man's crop or small farmer's crop in the Indian sub-continent. Sweetpotato is required to meet the needs of the poor farmers for food security and as cash crop too1[1]. In South Asia sweetpotato is produced about 1.6 million tons, with India accounting for 68% of the total production, followed by 27% in Bangladesh and about 5% in Sri Lanka. Sweetpotato is an important crop for Sri Lanka and occupies 1.1% of the total cropped area, followed by 0.5% in Bangladesh and less than 0.1% in India. In India sweetpotato is mainly cultivated in the states of Orissa, Bihar and Uttar Pradesh. Orissa has the largest area under sweetpotato followed by Uttar Pradesh (Table 5.1).

Table 5.1 **Area, Production and productivity* of sweet potato in leading states in India**

State	Area (x 1000 ha)	Production (x 1000 MT)	Productivity (t ha^{-1})
Orissa	43.9	361.2	8.2
Bihar	9.9	135.2	13.7
Uttar Pradesh	25.6	302.1	11.8
Assam	8.9	31.0	3.5
Karnataka	3.1	23.3	7.5
Kerala	1.1	11.9	10.8
Tamil Nadu	1.9	32.2	16.9
India	(total) 114	(total) 1007	(average) 8.8

** Source: Indian Horticultural Data base – 2001*

Vitamin deficiency is an important public health problem in India today. A ready and cheap source of beta-carotene is the orange-flesh sweetpotato, which contains high counts of beta- carotene, largely responsible for the orange color of the flesh [2,3].

The economy of most of the districts in Orissa is rural and agrarian. Land holding pattern in most of the villages in the districts of Bolangir, Kalahandi, Nuapada, Ganjam and Gajapati varies much between marginal farmers and better off. The poor and marginal farmers struggle hard to get optimum yield because of the varied climatic conditions and the infertile land mostly belonging to the poor farmers. Frequent drought and sporadic rainfall has added to their poverty.

Improving crop productivity in such poor soil is one of the primary concern. Early maturing sweetpotato varieties provide higher edible energy per unit area per unit time than all other major food staples.

Micronutrient malnutrition is increasingly recognized as a serious threat to health and productivity of people worldwide. In India, while Vitamin A level is taken into consideration in the states of Uttar Pradesh and Orissa, the intake of Vitamin A is half of the RDA (Recommended Dietary Allowance-RDA is 600 micrograms of Vit.A) in the states of U.P and three-fourths of RDA in Orissa (NNMB, Hyderabad). Orange Fleshed SweetPotato (OFSP) is used as food based source as an alternative to the supplements for combating the Vitamin A deficiency. Night blindness, Bitot spots, Xerophthalmia and Keratomalacia are the major Vit. A deficiency problem. One possible solution to combat the range of Vitamin A deficiency in these areas is to essentially increase the availability of a cheap source of vitamin A rich food among people deficient in vitamin A. Orange fleshed sweet potatoes are of high priority due to its availability at affordable price when compared to other rich carotene vegetable like Carrot and fruit like Papaya, which are expensive. Improving vitamin A status reduces infant mortality by 23%.

The study involves farmer participation in the preliminary assessment of different germplasms of sweetpotato, which are mostly Orange fleshed sweetpotatoes. Farmers evaluated and selected sweetpotato germplasms from replicated trials at two sites. Farmer participation was intended to improve the knowledge of understanding of farmers preferences of different germplasm characteristics. This work is to evaluate the germplasm using farmer participatory and conventional approaches. The overall objective of the present study was to involve farmers in the assessment, identification and selection of those with superior yield performance and consumer acceptance by evaluating the local varieties with nutritious and improved germplasm of sweetpotato.

Materials and Methods

Management of the crop cultivation and Site characteristics

Nuapada district is situated in the Western part of Orissa state in India. Nuapada district is the tropical area receives annual rainfall around 1200 mm. The rainfall in the area is very erratic, drought situations is a regular phenomenon in this area and consists of high, medium and low land areas. Nuapada is under rainfed cropping zone where agricultural activities are dependent on the rainfall pattern and quantity. In low land areas the cropping pattern is Rice cultivation is normally followed by Pulses. In the medium land Rice is followed by onion and other vegetables where there is irrigation facility. Upland is usually covered under minor millets, millets, pulses, cotton, root and tuber crops and also with upland paddy (Rice). The names of some of the tribes residing in Nuapada are paharias, parajas, majhi etc. The soil type in Nuapada is mainly loam, sandy loam and black cotton soils. Food security and nutritional security for target group have become a great challenge for the resource people as well as the tribal dwellers. In the lean period especially in the months of March, April, May and June most of the people migrate to chattisgarh province (neighbouring to Orissa) in search of livelihood. Nutritional deficiency and health hazards are quite common in the districts of Nuapada and Bolangir districts of Western Orissa. As a result percentage of mortality rate (less than 5 years) and abortions in pregnant women are relatively high. This forms a platform for introducing orange fleshed sweetpotatoes in the poverty stricken areas of Nuapada district which is a short duration crop with low cost inputs, high yielding capacity and with high nutritive value for improving sustainable livelihoods.

Trial designed and managed by farmers

Generally farmers learn about new practices through visits to field stations, on-farm trials, or from other farmers. The farmers in these villages decided to plant and experiment with the new variety and practice as they wish. Also the farmers opined that with the available new germplasm of sweetpotato they would like to compare with their local variety. The basic idea to encourage such farmers decisions is that if the farmers themselves control the experimental process, they are likely to have more interest and information on the practice. Four CIP germplasms which are mostly orange fleshed (having high beta-carotene content) along with local were evaluated at Lerki and Babupalli villages (two sites) in Nuapada district of Western Orissa in Kharif (rainy season) 2005. The germplams of sweetpotato that were distributed to the farmers at Lerki and Babupalli villages were CIP-SWA-3, CIP-440127, IB-97-12/7 and IB-97-6/15. Also most of the farmers wished that they compare the improved germplasm with the local variety.The spacing that was given 60x30 cm which is a general practice. At three neighbouring sites in each village, 4 replications were made with one replication in each site with the 4 germplasms and the local variety which is as comparable as that of Randomised Block Design (RBD). Ten cuttings of each germplasm were planted in a row. No fertilizer or pesticides were applied. No irrigation was done except during planting since it was cultivated as a rainfed crop. Establishment and growth of plants at both the villages were good; no gap filling was required. Furthermore, because farmers trials usually have less contact with researchers than farmers in other types of trials (researcher designed trials), their views of a technology are less influenced by researchers' views. Finally, where as it is often necessary to provide some technical knowledge to farmers time to time.

Collection of data and measurements taken

During harvest, pest incidence (sweetpotato weevil: *Cylas formicarius*), data on fresh storage root weight, fresh foliage weight and dry matter content of storage roots were collected by researchers. For dry matter determination, medial sections of roots from each plot were chopped and a sample of about 200g was dried at 60 degrees centigrade for 72 h or until constant weight. Twenty farmers of each village and surrounding areas participated in the trial harvest. Farmers observed a number of characteristics and ranked each germplasm with respect to the following variables: pest attack, size of the tuber, general appearance, taste and presence of carotene (orange flesh color). Farmers evaluated the general performance of sweetpotato germplasm, dry matter content, pest damage, and defects using 5-point rating scales as follows:

For general impression and dry matter content, 1 was very poor general impression or very low dry matter content, 2 was poor or low, 3 was fair or medium, 4 was good or high and 5 was excellent general evaluation or very high dry matter content.

For pests and defects, 1 was for more than 75% of storage roots damaged, 2 was between 51-75% damaged, 3 was 26-50%, 4 was between 1-25% and 5 was for 0% damaged or defects.

For carotene content 3- point rating scale was used 1 was for high carotene(thick orange color), 2 was for medium(medium orange color) and 3 for low carotene (less orange color or no orange color) was determined or recorded.

Farmers observed root dry matter content by hefting storage roots, scratching the skin, biting the root and tasting the flesh, and by observing the amount of latex produced after slicing the storage roots with a knife. Farmers considered the following characteristics to be indicative of high dry matter content: 1) The storage root should be heavy; 2)The storage root is hard when it is bitten; 3) The skin is hard when it is peeled or scratched; 4) A relative sweet taste of the flesh; and 5) Little latex produced in the flesh. Root dry matter content was then rated using the scale described above. Farmers evaluated each plot in two replications of both trials and the researchers recorded the information obtained from them. The data collected by researchers, and ratings doen by farmers were analysed statistically with a focus on the variables yield, harvest index (HI), dry matter content(DM), pest attack, occurence of defects and general impression. Harvest Index ws calculated by dividing the fresh storage root weight by foliar weight plus fresh storage root weight.

Results and Discussion

A positive correlation was observed between general appearance and yield and harvest index in the trials. Farmers selected 3 superior germplasms from each trial for further multilocational trials and in different environments. Two germplasms namely IB-97-12/7 and CIP-SWA-3 performed equally good at both the sites(villages). There is significant difference in terms of yield between the improved sweetpotato germplasms and the local variety. The higest yield had been recorded for IB-97-12/7.

Table 5.2 **Rankings as given by the Farmer after harvest for each germplasm (combined both villages)**

Name of the germplasm	General Impression / Dry matter content	Pest damage (Weevil attack)	Carotene content (by appearance of thickness of color)
CIP-SWA-3	4	2	1
CIP-440127	3	3	3
IB-97-12/7	5	4	2
IB-97-6/15	2	4	2
Local	1	2	1

The highest ranking on the general appearance of the sweetpotatoes had been given to IB-97-12/7 and CIP-SWA-3 (Table 5.2). The carotene content is high for CIP-440127 which is in thick orange color and also as ranked by the farmers. As per researchers identificatioin CIP-440127 has 2178 ìg/100g of beta carotene content. There were similar trends in terms of yield, quality and the Harvest Indices in both the villages (Table 5.3 and 5.4).

Table 5.3 **Yield and other parameters after Harvest at Lerki village**

Name of the sweetpotato germplasm	Yield(t ha^{-1})	Harvest Index (%)	Dry matter(%)
CIP-SWA-3	13.56	66.55	29.50
CIP-440127	11.42	48.26	24.45
IB-97-12/7	14.28	58.44	27.41
IB-97-6/15	10.82	49.65	24.16
Local	8.46	42.46	18.32
CD (0.05)	0.69		

Table 5.4 **Yield and other parameters after Harvest at Babupalli village**

Name of the sweetpotato germplasm	Yield(t ha^{-1})	Harvest Index (%)	Dry matter(%)
CIP-SWA-3	13.92	66.01	29.50
CIP-440127	11.87	48.85	24.45
IB-97-12/7	14.01	58.98	27.41
IB-97-6/15	9.96	48.31	24.16
Local	8.55	41.64	22.32
CD (0.05)	0.53		

Conclusions

The participation of the farmers has helped in the quick identification of preferred sweetpotatoes for further testing over a range of sites, both on-station and on-farm. The farmer participatory method in sweetpotato varietal selection should be promoted as the study will be more farmer friendly. Farmer participation appears to be contributing to improving the efficiency and effectiveness of sweetpotato variety selection effort in the state of Orissa of India.

References

1. Scott, G.J., Otieno, J., Ferris, S.B., Muganga,A.K. and Maldonado, L.1999. Sweetpotato in Ugandan food system: enhancing food security and alleviating poverty. CIP Program Report 1997-98: 337-347.
2. Simonne, A.H., Kays, S.J., Koehler, P.E. and Eilenmiller , R.R. 1993. Assessment of carotene content in sweetpotato breeding lines in relation to dietary requirements. J. Food Compos. Anal. **6**:336-345
3. Takahata, Y., Noda, T. and Nagata, T. 1993. HPLC determination of carotene content in sweetpotato cultivars and its relationship with color value. Japanese J. Breed. **43**:421-427

6

The impact of new maize and rice varieties on the livelihoods of poor farmers in marginal agricultural areas of western India

J. P. Yadavendra and J. R. Witcombe

Limited participation of farmers in agriculture research and extension can result in low uptake of new farm technologies including the use of modern varieties. Participatory approaches can be used to rapidly and cost effectively identifies the best of already existing varieties in a process termed participatory varietal selection (PVS). However, new highly client-oriented breeding (COB) approaches can produce varieties better than those found by PVS. In COB varieties are bred to specifically meet the requirements of the client farmers. The impact of new maize varieties GM-6 developed through client-oriented breeding in India and ZM-421 introduced from Zimbabwe, on the livelihoods of farmers was surveyed in a sample of farmers in three states of Western India. High yields and other traits such as improved grain quality and earlier maturity were the favoured characteristics of the new varieties. Improvement, both economic and household food self-sufficiency, improved livelihoods, in turn. New varieties of rice, Ashoka 200F and Ashoka 228 bred by COB in Eastern India had also similar impact. While those impacts were achieved using seeds supplied, the challenge to produce a sustainable and affordable seed supply system yet remains.

Keywords: Impact; Client Oriented Breeding; Maize; Rice; Livelihoods.

Maize (*Zea mays* L.) and rice (*Oryza sativa* L.) are important rainy season crops for the indigenous (tribal) populations in the hill districts of Western India in the states of Gujarat, Madhya Pradesh and Rajasthan. The crops are grown on low fertility soils on undulating land and agriculture is a risky enterprise with severe droughts occurring, on an average, once in five years.

Existing research-extension approaches had not led to the use of modern varieties, so most farmers were still growing maize and rice landraces. A key assumption was that adoption of new varieties was poor not because of unwillingness to adopt new technologies, or non-availability of good varieties, but because low-resource farmers in remote areas had no access to such varieties. This problem was addressed through, PVS, a farmer participatory approach for identifying improved crop cultivars or varieties, [1,2]. However, the varieties identified by PVS were those pre-existing and not specifically bred to meet the requirements of the poor farmers in the target areas.

Participatory plant breeding techniques were used to produce more appropriate varieties. However, it is more useful to describe it as COB since the term explains high client orientation[3]. All breeding programmes have some degree of client-orientation but COB are programmes where explicit and systematic efforts are made to involve the clients. Using the purpose than the process provides for a more rigorous examination of the analytical framework, and why and when farmers should be involved.

When improved efficiency (rather than participation for its own sake) is sought, selections in segregating generations may not be made by farmers. But it is important to understand client needs, and participatory rural appraisals and PVS trials provide avenues, using which, maize and rice varieties could be bred.

We report here the impact of new maize and rice varieties developed in the Gramin Vikas Trust (GVT) project area encompassing the tribal region of Gujarat, Madhya Pradesh and Rajasthan in Western India. A survey using a household questionnaire was used to ascertain the impact of new maize and rice varieties on the livelihoods of farmers who had access to seeds of the new varieties.

Materials and Methods

Under a Western India Rainfed Farming Project the GVT walked on improvement of crops grown by the indigenous (tribal) populations in the hill districts of western India in Gujarat, Madhya Pradesh and Rajasthan.

In those districts, maize is usually cultivated on marginal soils under rain fed conditions and low-input management. Rainfall is low and erratic. The project area receives in 30 to 40 rainy days 700 to 1100 mm of rain in a year. Droughts are frequent almost once in five years and cause widespread crop failure.

Surveys designed to study the take up of the new improved varieties by farmers. The impact of project-developed or identified varieties of rice and maize was

Table 6.1 **Summary of the surveys conducted in GVT project villages in 2004**

Name of intervention	State[1]	Organisation conducting survey[2]	Survey month	Farmers interviewed (number)	Villages (number)
Rice	Guj	AAU	July	52	5
		GVT	June	21	4
	MP	JNKVV	June-July	47	9
		GVT	June	15	5
	Raj	MPUAT	July	30	7
		Total		**165**	**30**
Maize	Guj	AAU	August	24	4
		GVT	June	22	6
	MP	JNKVV	June-Aug.	25	6
		GVT	August	26	4
	Raj	MPUAT	April-June	33	6
		Total		**130**	**26**

[1]Guj = Gujarat; MP = Madhya Pradesh; Raj = Rajasthan

[2]AAU = Anand Agricultural University; JNKVV = Jawaharlal Nerhu Krishi Vishwa Vidhyalaya;
MPUAT = Maharana Pratap University of Agriculture and Technology.

studied through designed survey questionnaire from June to November 2004 (Table 6.1) by GVT staff or by staff of the State Agricultural Universities collaborating in Component C (the research component) of the GVT Western India Rainfed Farming Project. Some surveys were follow-up from those conducted in February 2004.

The surveys included only those farmers who were known to have had an opportunity to try them. Seeds were widely distributed by the project (Table 6.2). Hence, surveys were made in villages of the GVT project where the project had been working for several years. In total, 294 farmers were interviewed in a total of 40 different villages (11 in Gujarat, 16 in MP and 13 in Rajasthan).

Maize farmers were asked questions on two varieties: GM-6, bred in India [4] and ZM-421, introduced into India from the International Centre for Maize and Wheat Improvement (CIMMYT), Zimbabwe. Farmers were asked questions about the level of adoption, the variety's traits and details on seed that they received (Table 6.3).

Table 6.2 **Maize and rice varieties distributed in the GVT project area during 2001 to 2004**

	Seed distributed (t)				
	Maize		Rice		
Year	GM - 6	ZM 421	Kalinga III	Ashoka 200F	Ashoka 228
2001	—-	1.1	9.2	0.3	0.1
2002	15.3	1.4	10.4	22.4	4.3
2003	29.9	2.9	3.5	10.7	16.9
2004	—-	—-	0	3.0	6.1
Total	**45.2**	**4.4**	**23.1**	**16.1**	**28.0**

Table 6.3 **Maize surveys for adoption of GM-6 and ZM-421 conducted in GVT project villages**

Variety State	Organisation conducting survey	Number of villages						
		Common	Individual	2000	2001	2002	2003	Total
GM-6								
Guj	AAU	2 }	2	-	-	20	1	21
Guj	GVT	2 }	4	-	2	3	11	16
MP	JNKVV	2 }	2	-	23	2	-	25
MP	GVT	2 }	4	8	6	11	1	26
Raj	MPUAT	0	6	-	-	15	18	33
	Total	4	18	8	31	51	31	121
ZM-421								
Guj	AAU	2 }	2			14	1	15
Guj	GVT	2 }	3			5	3	8
MP	JNKVV	0	4			12	-	12
MP	GVT	0	1			3	-	3
Raj	MPUAT	0	2			0	9	9
	Total	**2**	**12**			**34**	**13**	**47**

For expansion of acronyms, see Table 6.1

Rice farmers were asked questions similar to those in maize. The rice varieties evaluated were Ashoka 200F and Ashoka 228 bred using client-oriented techniques[5] and Kalinga III that had been identified by PVS2 and had spread rapidly from farmer-to-farmer in the project area[6]. The survey data were entered in Excel spreadsheets and analysed by procedures available (Table 6.4).

Table 6.4 **Summary of the rice surveys conducted in GVT project villages in 2004.**

Variety	Survey by	No. of villages							
		Common	Individual	1999	2000	2001	2002	2003	Total
Ashoka 200F									
Guj	AAU	1 }	1				10	3	13
Guj	GVT	1 }	1				3	0	3
MP	JNKVV	1 }	4				5	8	13
MP	GVT	1 }	0				1	1	2
Raj	MPUAT	0	5				13	13	26
	Total	2	11				32	25	57
Ashoka 228									
Guj	AAU	1 }	4				18	3	21
Guj	GVT	1 }	1				4	0	4
MP	JNKVV	2 }	6				8	14	22
MP	GVT	2 }	0				1	6	7
Raj	MPUAT	0	5				13	13	26
	Total	3	16				44	36	80
Kalinga III†									
Guj	AAU	1 }	3	1	2	5	15	0	23
Guj	GVT	1 }	3		1	8	9	0	18
MP	JNKVV	4 }	1	2	6	2	7	0	17
MP	GVT	4 }	0		2	1	5	0	8
Raj	MPUAT	0	7		20	8	2	0	30
	Total	**5**	**14**	**3**	**31**	**24**	**38**	**0**	**96**

†For Kalinga III, adoption data was collected from 94 farmers and perception data from 90 farmers.

Results and Discussion

Farmers' perception of the varieties

Farmers' perceptions on the two maize varieties were favourable with significantly more farmers preferring both varieties for grain yield, fodder yield and cooked food quality (Figure 6.1) than those who preferred the local variety. However variety, ZM 421 was perceived by farmers to be of the same maturity as the local check, but opinions were equally divided on it being late or early to mature. Although a considerable proportion of farmers reported that the varieties were better for consumption, this was not reflected in market price, where those varieties were reported to fetch invariably the same price as the local variety. This indicates that grain merchants and consumers do not distinguish between different qualities of white maize in the market.

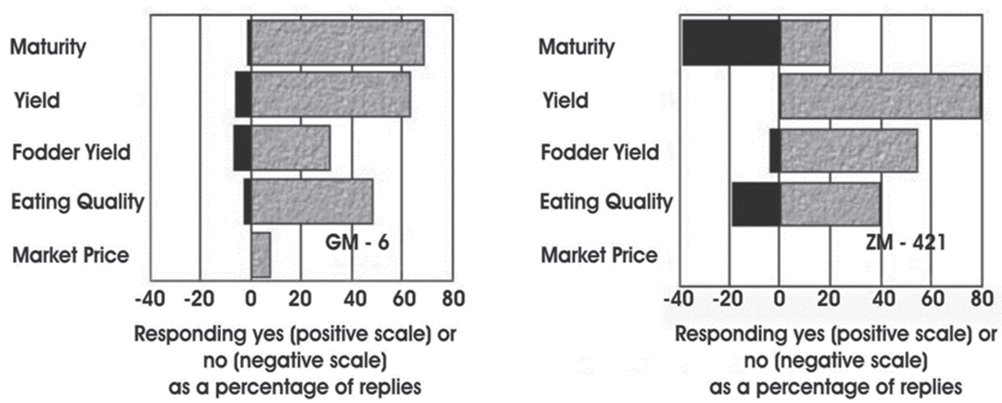


Figure 6.1 **Farmers' perceptions of maize varieties GM-6 and ZM-421 relative to local checks.**

All the three rice varieties were markedly preferred by farmers for the important traits of early maturity, high grain yield and high grain quality (Figure 6.2). However, all three were inferior in fodder production. Surprisingly, though the Ashoka varieties gave higher yield compared to Kalinga III, they did not get a higher score for this trait; the only difference was that many farmers reported that Kalinga III yielded less grain than the local. However, the superiority of the Ashoka varieties was reflected in the adoption data (see Figure 6.3) [3] .

Adoption of the new maize and rice varieties

All the farmers who received to seed of GM-6 grew it in the first year in 2001 (Figure 6.3). After the first year, farmers did not grow the variety. However, those who grew the variety again allotted more area (Figure 6.3). The most probable

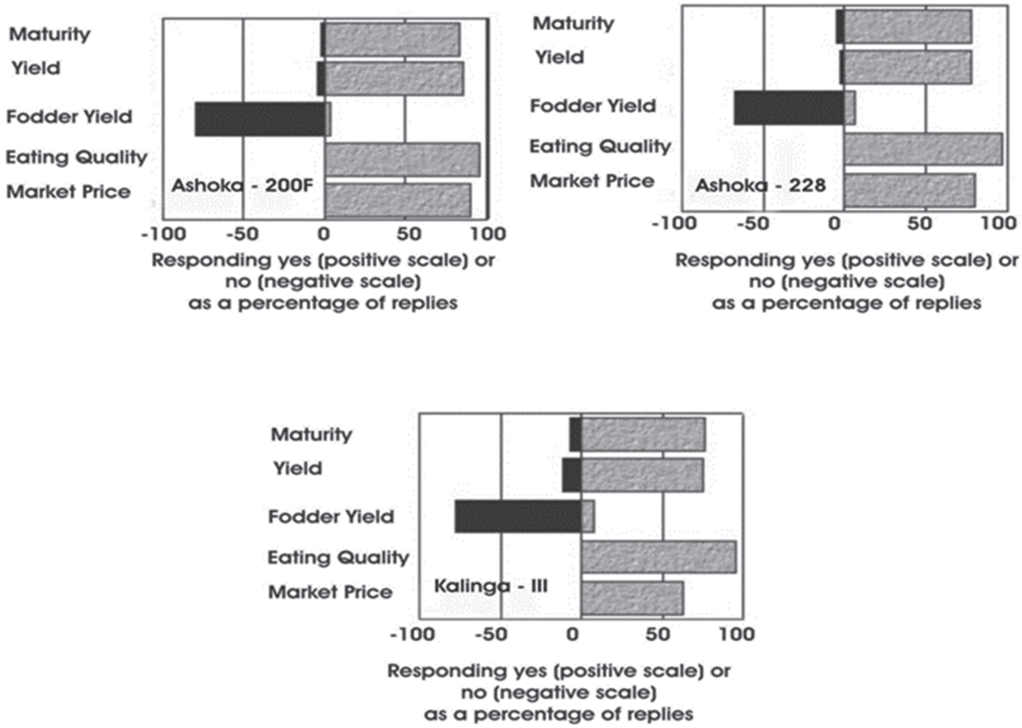


Figure 6.2 **Farmers' perceptions of three rice varieties, Ashoka 200F , Ashoka 228 and Kalinga**

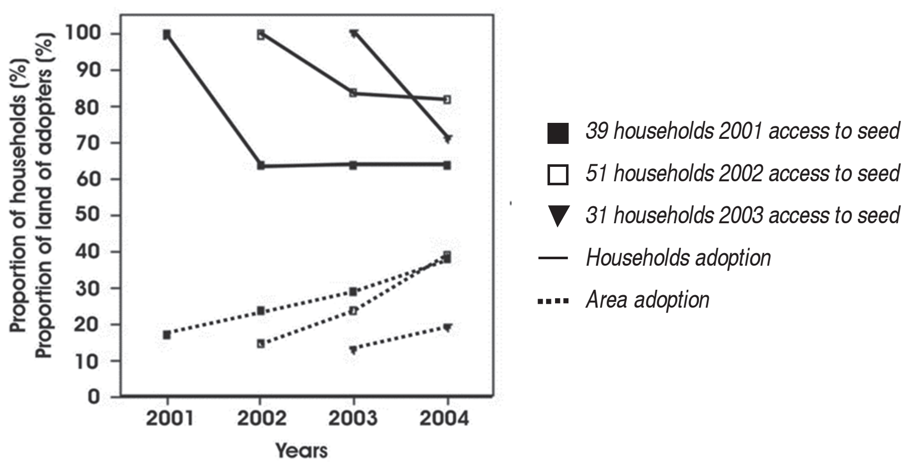


Figure 6.3 **Adoption as a percentage of farmers who had been given seed of GM-6 and the proportion of maize land they devoted to this variety.**

explanation for this pattern of adoption is that some farmers did not prefer the variety and yet others who preferred it, had not saved seed. Farmers who grew it a second time in 2003, also grew it in 2004.

Farmers who were given Ashoka 200F or Ashoka 228 continued to grow it in the 3 years. They allotted increased land in 2003 and 2004. Farmers replaced Kalinga III with these new varieties as evidenced by its reduction in the area, so the proportion of continuing adopters fell and the rate of increase in the amount of land slowed (Figure 6.4).

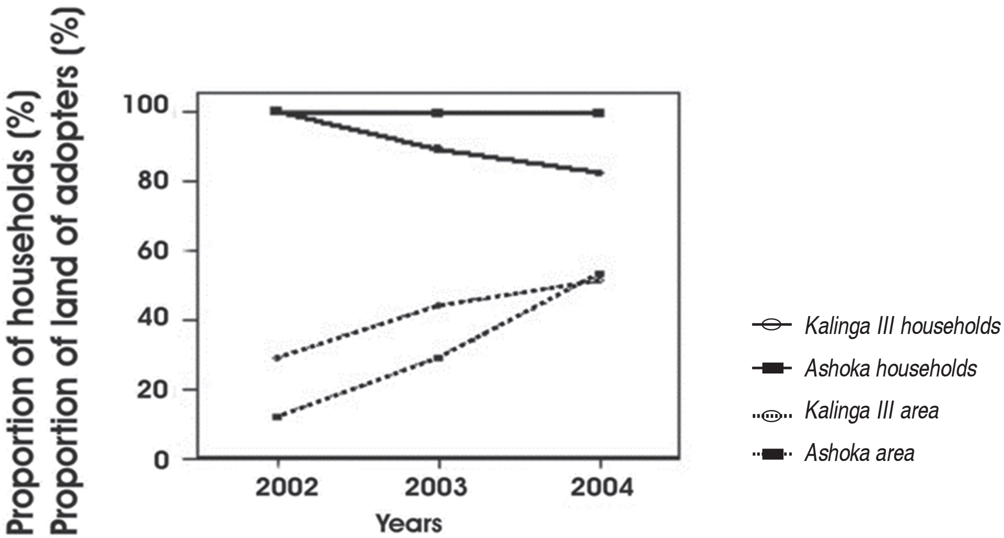


Figure 6.4 **Adoption as a percentage of farmers who had been given seed of the Ashoka varieties (Ashoka 200F and Ashoka 228 combined) or Kalinga III and the proportion of rice land they devoted to this variety.**

Impact of the new maize and rice varieties on livelihoods.

Farmers reported considerable impacts on their livelihoods with seed sales in maize increasing by 51% and food lasting by more than one month. Out of the 77 farmers 41 growing the new maize varieties reported an overall increase between 10 to 20% in their total income (Table 6.5). The impact of the rice varieties was less (26%) as rice occupies, on average, a smaller proportion of the farmers' land. It is also more difficult for farmers to answer questions about food availability, as rice is generally not the most important staple food. However, this qualitative examination gave useful information without having to collect data on total household economics.

Table 6.5 **Farmers' perceptions on the impact of the new maize and rice varieties on their livelihoods**

Seed sales (ton)		Food availability (months)		Number of farmers with increased income					
Before	After	Before	After	0 %	>0-10%	10-20%	20-30%	30-40%	>40 %
34	52	10.0	11.3	0	27	41	4	1	14
3.9	4.9	6.2	7.7	0	102	41	4	0	0

The new varieties give considerable benefits. Farmers perceived the superiority of the traits of new varieties. Those who had access to seeds and derived benefits continued to grow them. This strongly suggests that varieties newly bred would spread if seeds are made available to farmers and the yield and quality of the varieties are acceptable.

In the GVT research component the emphasis on the breeding new varieties, in relation to other possible changes in agricultural technology, was made because-

Plant breeding research has a high potential cost benefit ratio (breeding and selecting new varieties is very inexpensive compared to the potential benefits).

- The cost benefit ratio of adopting new varieties is high for farmers (the additional cost of seed can be zero if farmer-saved seed is used and the gains in yield can be substantial).
- No extra knowledge is required to grow new varieties as they do not require changes in management practices and
- Increasing adoption of the technology (a new variety) can occur without the need of external interventions if the seed spreads from farmer to farmer.

Nonetheless, the price of food grains is either declining or remaining static and hence increase in crop productivity is unstable. However, the benefits of a new variety are not restricted to the value of the additional harvest. Additional benefits are obtained, for example, when increased cash contributes to off-farm economy or provides additional labour opportunities in agriculture. Farming system also can provide additional income from crop diversification. Farmers tend to prioritise production of their staple food while increased productivity can free land for alternative, and more profitable crops. Early maturing varieties can facilitate timely harvest of post-rainy season (*rabi*) crops [3].

The introduction of Ashoka 200F and Ashoka 228 in eastern India [7] showed that the income earned reduced the need to borrow money and also helped in social benefits related to improved style of living and the like. However, such benefits were reported only by farmers who had adopted a new variety. Adequate availability of seed could have large and widespread effect. The general trend however, is that farmers distributed seed to others only after keeping sufficient seed for increased area on their own farm. Seed availability is crucial if impact is to be rapid and also to counter poor harvests in drought years. Seed supply from the formal seed sector has still not addressed the needs of poor farmers in remote villages. The formal sector-

- mainly produces high value certified seed and poor farmers cannot in afford its purchase,
- seeds outlets are situated far distant from the resident areas of poorer farmers, and
- seeds of varieties preferred and most appropriate for poor farmers (e.g., open-pollinated varieties of maize or upland varieties of rice) are seldom produced by Government agencies.

Additional forms of seed supply to the poor farmers are required. GVT has facilitated community-based seed production and supply in the project area and, in the cases documented so far, it has been successful. This approach needs to be further developed and expanded as an alternative to conventional seed supply.

References

1. Witcombe, J.R., Virk, D.R. and Farrington, J., 1998, Seeds of choice: Making the most of new varieties for small farmers. Oxford and IBH Publishing, New Delhi and Intermediate Technology Publishing, London

2. Joshi, A. and Witcombe, J. R., 1996, Farmer participatory crop improvement II: Participatory varietal selection in India. Expl Agric. **32,** 461:477.

3. Witcombe, J.R. and Yadavendra, J. P., 2006, Cultivating Partnershis: Better Choices for Rainfed farming. Gramin Vikas Trust, KRIBHCO Bhavan, NOIDA, India

4. Witcombe, J.R., Joshi, A. and Goyal, S.N., 2003, Participatory plant breeding in maize: A case study from Gujarat, India. Euphytica **130**, 413-422

5. Virk, D.S., Singh, D. N., Kumar, R., Prasad, S .C., Gangwar, J. S. and Witcombe, J.R., 2003, Collaborative and consultative participatory plant breeding or rice for the rainfed uplands of eastern India. Euphytica **132**, 95-108.

6. Witcombe, J.R., Peter, R., Jones, S. and Joshi, A., 1999, Farmer participatory crop improvement. IV. The spread and impact of a rice variety identified by participatory varietal selection. Expl. Agric.**35**, 471-487.

7. Mottram, A., 2005, Impact of New Upland Rice Varieties in Eastern India from Client-Oriented Breeding: Evidence from Whole Village Surveys. CAZS Natural Resources (CAZS-NR), University of Wales, Bangor, UK.

Acknowledgements

We wish to thank the people who were directly associated with this work in Western India Rainfed Farming Project of Gramin Vikas Trust, maize and rice scientists of Anand Agricultural University at Godhra and Nawagam, Maharana Pratap University of Agriculture and Technology, at Agricultural Research Station, Banswara and Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Campus – Indore and KVK, Jhabua

7

Traditional knowledge and enhancement of genetic diversity: the case of cassava diversity in Brazil

Nivaldo Peroni, Paulo Yoshio. Kageyama and Alpina. Begossi

This paper describes an example of traditional management that have amplified the intra specific diversity of a clonal crop. It also have implications in Participatory Plant Breeding. One of the goals for PPB is enhancement through increased access to diversity among and within crops and varieties. An understanding of traditional management systems that have enhanced intra-specific diversity on-farm, in particular for cassava (*Manihot esculenta* Crantz), is essential because of its clonal propagation system. Cassava served as model species to study traditional ecological knowledge among farmers from Atlantic and Amazon forests. Using a participatory approach, 115 local varieties were rated sweet or bitter by 67 households from both locations. The diversity and genetic structure of cassava was evaluated using population genetics, ethnobotany and applied anthropology. The study illustrated a strong relationship between itinerant agricultural cycles of traditional people's farming system (swidden cultivation) and amplified diversity of cassava. Intra- and inter- specific crosses between local varieties within farmer's cassava collections demonstrated vital links between traditional management practices and the dynamic nature of cassava diversity over generations. Farmers' perception, knowledge and traditional management practices in vegetative propagated crops such as cassava were important in securing their natural and biological resources and livelihood. It is therefore crucial to guarantee and support traditional or indigenous crop management practices for sustained and enhanced generation of new varieties.

Key words: *Manihot esculenta* Crantz; sweet cassava; bitter cassava; *Caiçaras*; *Caboclos*; Atlantic Forest, Amazon.

Formal plant breeding strategies are not finetuned to develop varieties adapted to marginal environmental conditions, such as high stress and consequent instability [1]. Traditional and indigenous farmers maintain high inter- and intra -

specific diversity, aiming to achieve food security in unstable conditions, both from environmental and social points of view. Participatory Plant Breeding (PPB) emphasizes those aims and the conservation of genetic diversity [2]. The vast knowledge of traditional and indigenous farmers play an important role in the development of local varieties (LV) that includes landraces, progenies resulting from inter- and intra- specific crosses and locally adapted modern varieties[2]. Local management, in addition to contributing to agrobiodiversity conservation, promote cultural and local rites and diverse preferences for diversity like medicinal uses, among others. One of the consequences resulting from farmers' management of local varieties has been the continuous evolution of traits under continuous selection. Despite the hype to the term "conservation", and to traditional and indigenous conservation roles as curators of diversity; there has been little emphasis on their role of generating new varieties. Even PPB approaches do not clearly define this role. Formal and informal exchange networks and enhanced access to public, private or common genebanks were focused as mechanisms for enhancing diversity but hardly any has studied the dynamic process behind farmers' local management.

Understanding this process is important to define PPB as a strategy and design participatory approaches enhancing farmers' management and use of genetic diversity.

Studies on vegetative propagated species such as cassava (*Manihot esculenta* Crantz), sweet potato (*Ipomoea batatas Poir)*, yam (*Dioscoreae*), cocoyam (*Xanthosoma*), and arrowroot (*Maranta arundinaceae* L.), have contributed to an enhanced understanding of the apparent paradox between clonal maintenance and propagation of genetic diversity, and emergence of new varieties, and Cassava has been used as a model species [3,4,5].

Cassava (*Manihot esculenta* ssp. *esculenta* Crantz) was domesticated about 7,000 BC in the South American lowlands and is still one of the main crops of Amerindian and traditional people in Brazil [6]. The study of its botanic origin has led to a better understanding of human actions related to its domestication, especially regarding the factors that contributed to the amplification of its intra- specific diversity [6,7].

Due to its allogamous behavior and frequent out crossing, the occurrence of a range of variability is usual. As a result, Cassava varieties correspond to "genotype families"[3,4]. Thus, the term "variety" has diverse meanings to different human groups. One vernacular name can imply different perceptions of phenotypic, ecologic, and cultural properties. Basically, traditional and indigenous people name two broad variety groups, based on the presence of cyanogenic glycosides (HCN) in the roots. Varieties with high cyanogenic potential (H-CNP) are named *bitter cassava* (or *mandioca-brava*), and those with low cyanogenic potential (L-CNP) are named *sweet cassava* (or *aipim*). In spite of the continuous quantitative expression of HCN gradually increasing from L-CNP varieties to H-CNP varieties, the folk classification has a dichotomous character.

The consequences of spontaneous crossing and the way in which ecologic and cultural events are integrated with general farm management by traditional and indigenous farmers have not been fully explored [3].

The present paper addresses therefore various related issues:

a. how the intra varietal diversity is genetically structured and what is its relation to traditional farmers' knowledge,

b. how and why local farmers' traditional management can augment the intra - specific diversity in a vegetative propagated crop, and

c. the potential linkages between traditional management and traditional knowledge with diversity-oriented participatory plant breeding programs.

Material and Methods

Field sites

South-eastern part of the Atlantic Rainforest

This coastland of 100km-extension at the south coast of the São Paulo state, Brazil, is located around the municipalities of Iguape, Ilha Comprida, and Cananeia (from 24°40´S to 25°10´S and from 47°20´W to 48°05´W). The climate is humid subtropical with annual average temperatures ranging between 21°C and 22°C; there is no defined dry season; the annual average precipitation varies from 1,700 mm to approximately 2,200 mm The predominant vegetation belongs to the Atlantic Rainforest domain, which is characterized by the Ombrophillous Dense Forest, occupying sandy soils with low natural fertility. The rural people of the region is known as *Caiçaras*, which is a mixed population from Portuguese, Amerindian and African descendents, who live at the South-eastern Brazilian coast. For a long time they were isolated from the rest of the country because of the difficult access through the mountains that pervades this part of the coast. *Caiçaras* are dependent on multiple subsistence activities; fishing is associated with the itinerant agriculture[8].

The slash-and-burn agriculture was the principal farm activity from the past until the second half of the twentieth century [5]. The current main economical activities among the *Caiçaras* are fishing and tourism; agriculture activities are exclusively subsistence oriented [5,8]. Unlike in the past, cassava flour does not fetch a market. The agricultural systems are nowadays characterized as poly-varietal, where cassava (*Manihot esculenta* Crantz), yam (*Dioscorea* spp.) and the sweet potato (*Ipomoea batatas* Poir.) are the main species, though they face a high risk of genetic erosion. In the study of 33 farmers we found 261 varieties were registered but approximately 30% of them were reported lost [5].

Negro River, Amazon

The Negro river is part of Central Brazilian Amazon with dominant lowland and highland forests. Highland forests are not periodically flooded, differing from the lowland ones, which suffers seasonal flooding [9]. Despite the several types of forests and the high diversity of the species, those forests were sustained by soils with low fertility

The study area included the middle River Negro, where the humid season extend to 9 months, with average temperature higher than 23.5º C. In that region, 33 household units were sampled from eight communities from the municipality of Novo Airão and Manaus (2º22´N - 61º05´W, to 1º38´N - 61º41´W). The rural riverine people is known as *Caboclos* who is a mixed population from Portuguese and Amerindian descendents. *Caboclos* share with *Caiçaras* many common characteristics, such as the use of swidden cultivation and small-scale fishing for their livelihood.

Ethnographic sampling local Knowledge and on cassava and local varieties

We used current techniques from ethnobotany and applied anthropology within an interdisciplinary structure of participatory research between 2000 and 2002 in samples including men and women. Stratified sampling and snowball methods [10] were used to identify a sample of 34 household units (HHs) in Atlantic Forest, who were resident at least for 5 years and practised swidden cultivation with cassava as the main crop. The 34 HHs were distributed across 16 *Caiçara* communities representing approximately 7% of the local population in these communities[5]. The sample from Negro River included 33 households from 8 *Caboclos* communities located in the right margin of Negro River between the Manaus and Barcelos municipalities of the Amazonas State. Semi-structured and open questionnaires were used to collect ethnobotanical data, which included questions concerning the use of the varieties, their place of origin, how long they were under local cultivation, management characteristics adopted, folk observations on crossing, and seedling germination of entries obtained from the seed bank.

In the region of the Atlantic Rainforest, 154 cassava entries were collected from 23 HHs, 137 of which were analysed using micro satellite genetic markers. The cassava entries represented 58 vernacular names given by the farmers[5]. Ninety-one cassava entries were collected at the Negro river region, representing 57 vernacular names in 33 HHs.

The collected entries of each variety were grown in plots (or *roças*), following a hierarchical sampling design in which plots represented entries from communities. The geographic position of each collected entry was it recorded through GPS in UTM. One cassava plant from each cultivated variety was collected.

Molecular analysis

Nine polymorphic micro satellite loci (SSR) were used in the analysis: GA21, GA126, GA131, GA134, GA136 and GA140 [11] and SSRY13, SSRY89 and SSRY164 [12]. The DNA extraction method followed Dellaporta *et al.*, [13]. The silver nitrate coloration method adapted by Bassam *et al.*, [14] was used and the genotyping was performed manually from the fixed gel.

The bands were analysed in two distinct ways:

a) As independent bands without allelism related to the fragments as present (1), or absent (0)

b) As multiple alleles from the 9 distinct loci. In this case, the term allele will be defined by their estimated molecular weight.

The genetic diversity parameters within the populations (Hs) and the total diversity (Ht) were calculated .The parameters were estimated from the average values among different loci.

The heterozygosis (H) is assessed by the genetic diversity index. The length of the alleles in pair of bases and the genetic structure were analyzed with the Genetix version 4.04 software [15]. The RSTCalc v. 2.2 software [17] was used to calculate genetic diversity among groups (R_{ST}) of varieties and plots (rocas). NTSYS version 2.02I software [16] was used for computing DICE similarity coefficient. The diversity structure was assessed using the agglomerative cluster algorithms average-linkage clustering (UPGMA).

Results and discussion

In spite of the process of retraction of farm among *Caiçaras*, followed by a loss of approximately 30 varieties in a time span of about 25 years[5] , 58 varieties with specific vernacular names are still cultivated by the C*aiçaras* from southern coast of São Paulo State (Brazil). Through the SSR microsatellite markers we could evaluate 137 entries from 58 varieties (defined by vernacular names), distributed in 18 plots, or *roças*.

Based on cluster analysis, 47 entries were grouped as bitter, and 46 as sweet, not considering the clones. But 12 of the 47 bitter entries were classified as sweet by the farmers. Likewise, from the 46 sweet entries, only 6 were classified as bitter by farmers (Figure 7.1). The congruence between scientific and farmer perception was thus high.

The genetic differentiation coefficient (G_{ST}), used to estimate the diversity among the groups of varieties, was 0.048 [1-(0,617/0,648)]. Comparatively, the R_{ST} value was 0.057 ($P<0.001$), showing that the divergence among the two groups is low, though significant, despite the higher diversity of the sweet varieties in comparison to the bitter ones, with most of the genetic diversity being within groups (Figure 7.1)

Based on the analyzed loci, heterozygosity within populations was $H_S= 0.628$ and the total diversity $H_T= 0.650$. Despite the small number of individuals per population, genetic analysis revealed that most of the diversity is concentrated within the *roças*, and the divergences among *roças* were limited. The fact that farmers live near each other, and the constant varieties´ changes between farmers in a regional level, explain the small genetic differences among *roças*.

Some of these varieties corresponded to varieties with the same local names, but identified as dissimilar genotypes, and some varieties with different names appeared to be of the same genotypes (Figure 7.1).

A total of 95 different genotypes (with an average of 8.1 genotypes per *roça*) were identified in the Atlantic Forest sample. In spite of cassava being propagated by clones, there are more genotypes than vernacular names used to identify the varieties. This kind of “intra varietal” diversity in clonal cassava varieties was observed by other authors [3,4,5]

Specific characteristics of the traditional management explain the “intra varietal” diversity identified by genetic data. Both Amazon and Atlantic Forest farmers observed and described cassava seed germination. Among 85 interviewed farmers

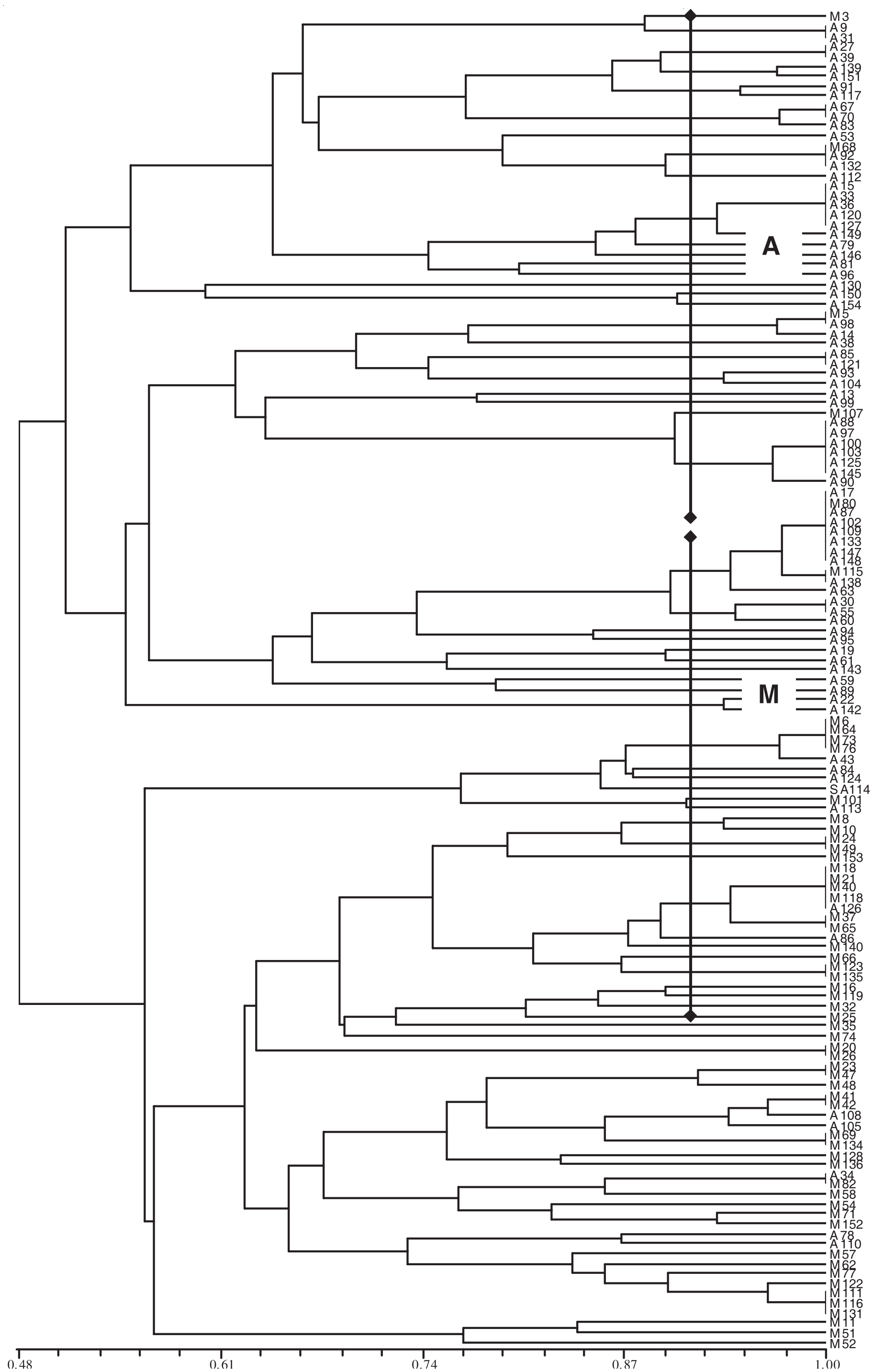


Figure 7. 1. **Dendrogram with 137 cassava samples from Atlantic Forest.**

Numbers indicate individuals, with the first letter indicating the type (A for aipins or sweet varieties, and M for mandiocas-bravas or bitter varieties). Cophenetic correlation index = 0.741.

Table 7.1 **Management characteristics of two itinerant traditional management systems.**

Place	Area[a]	Time span of use of each roça [a]	Age of the fallows where seed germination was observed (yrs)	Total number of cassava varieties
Medium Negro river, Amazon	1.00 ha	1-2 years	10,15,18,20,25	88
Southeastern Atlantic Forest	0.06 ha	2-3 years	4,5,7,10,15,20	58

[a] *Averages of a sample with 33 households from 8* Caboclo *communities, and 33 households from 17* Caiçara *communities*

70% reported that they knew the germination process, and they knew how to distinguish a plant germinated from seed from one a plant that was vegetatively propagated. Plants from seeds can be identified through several features, such as: a) it germinated outside of the *roça* where the stems (*manivas*) were planted; b) it had only one pivotal root; c) it germinated earlier than those vegetatively propagated.

The farmers described the event of seed germination as due to burning of dry vegetation (already cut), since the occurrence of seedlings in those fallow areas was high. The burning is a practice to prepare the soil for planting. 60% of interviewed farmers concurred that seed germination occurred after the burning and reported seed germination in *roças* left in fallow for 4 to 25 years (Table 7.1). We have counted 40 cassava seedlings in one *roça* of 400m^2 in a community called Aracari in Amazon. This *roça* had been burnt 15 days before the date of sampling and it were not cultivated yet. The *roça* was left as a fallow at least for 15 years. According to observations of Martins [18], factors such as the fallow time span, the absence of overlap between planting and blooming/fructification phases in *roças*, and the distance between already cultivated and recently opened *roças* would suggest that germinated plants in fact are from seeds in the soil. All interviewed farmers reported that they do not remove the seedlings germinated from seeds during and after planting. They keep the seedlings and incorporate them to their range of varieties.

Clement [19] stressed "the combination of slash-and-burn agriculture and micro-environmental heterogeneity in Amazon allowed rapid domestication processes due to the small sizes of managed populations (genetic drift), endogamy, selection and short cycle generations". Such events allow us to understand the scales of relationships and implications between the traditional farmers' management and the enhancement of cassava diversity.

Possible evolutionary consequences resulting from management in the *roças* studied and reported in this article are listed on Table 7.2. They suggest hypotheses of interaction between traditional agriculture management and dynamic evolutionary processes of a crop species. In a broad sense, the results showed how the interaction between farmers and a species such as cassava can favor genetic diversity, and in many cases can amplify the genetic variation.

One of the principal traits of life-history altered by men along domestication process is seed dormancy, in the case of seed propagated crops. Within the components known as "domestication syndromes", the elimination of seed dormancy was a drastic change in crop species because it allowed uniformity in germination and maturity, also guaranteeing rapid germination in optimum environmental conditions. In spite of some simplification in the dichotomy established for what is named as "seed agriculture" (predominant in subtropical and temperate environments) and "vegeculture" (predominant in tropical environments), the characteristics of dehiscence and dormancy seem to be contrasting in the two. Humans have not altered significantly the reproductive system of species such as cassava and sweet potato, and seed dormancy was not significantly altered in those species because its propagation is vegetative.

Table 7.2 **Summary of relationships between traditional management and evolutionary dynamic of a vegetative propagated crop (modified from Peroni and Martins [11]).**

Management	Evolutionary consequences
Plot clearing	Perturbation stimulating colonization
Plot planting	Establishment of a boundary-limited population (evolutionary unit)
Planting different species	Ecological combining ability
Planting different varieties	Favored hybridization process
Light colonizers control	Introgressive hybridization
Lack of seed collection	Natural dispersion and accumulation of seeds in soil
Return to old plots	Seed bank germination. Gene flow in time and space
Vegetative propagation	Maintenance of original genotypes and propagation of some spontaneous mutations

Table 7.2 illustrates some events that are common to a vegetatively propagated species, whose roots and tubers are used for food. The intra specific diversity, or number of varieties, can be amplified by migration, e.g., new varieties can be introduced through variety exchange as a cultural factor. This is very important, because many farmers are eager to experiment new varieties. These patterns of exchange favour diversity. Exchange is important in any species and especially in the case of cassava, because complexes of a diversity of varieties grown can contribute to natural crossing. Any cassava plot includes populations of individuals as clones, and genetic proximity between clone individuals can promote unsuccessful natural hybridisation. But when dissimilar individuals from different varieties are cultivated in proximity, the possibility of natural crosses increases, because the individuals are not closely related. In the history of cassava domestication, farmers have not attempted to change the reproductive structure of this species, they only focused on selection in its subterranean organs. When the farmers cultivate exchanged varieties, in close proximity, they increase the success of natural crossing. On an evolutionary context, farmers through this practice favour hybridisation and recombination.

Another important factor is the occurrence of mutations. Being a vegetatively propagated crop, emerging genetic variations are immediately fixed. Management practices interact directly with diversity and farmers' rigorous field observations influence the selection of favourable natural mutations.

During domestication, seed dormancy and dispersion ability were drastically changed by men for most crop species. In the case of cassava, changes in these traits have not been drastic, and the species still form soil seed banks, constituting thus a genotype reserve. The implications of this feature are very important. It implies a dependence of the cassava species on human beings to survive and reproduce. The species experiment both spatial and temporal variation, and a soil seed bank represents a gene stock that could be expressed when the ecological conditions turn favourable to this variation. Management can bring to fore these conditions, and again humans interact with this life-history trait in a complex way.

New recombinants resulting from diverse crossing, both between varieties and between species of the same genera (plot colonizers) can be stored in seed banks expanding the original variability. Since humans use vegetative propagation, new recombinants are fixed. Natural selection and conscious selection are responsible for the integration of new recombinants to the original variability. These evolutionary consequences exemplify how farmers were, and still are, capable to use vegetative propagation to fix novelties (new varieties, diversity).

The risks to the continuity of these evolutionary processes are high. In the studied locations, some characteristics related to genetic and cultural erosion, such as the reduction of cultivated area, changes and simplification of traditional management systems, and even the complete abandonment of farmer activity were markedly present. Factors important to the reduction of farm activities and to the loss of crop diversity were the historic land tenure problems and the inadequacies of public policies directed exclusively to Atlantic Forest *sensu lato* conservation, that could contribute to discontinuation of burning practices [5], breaking the human cultivation link with evolutionary consequences in life-history traits (like germination of soil seed bank). The reduction of farm activity would reduce the frequency of farmer exploration of genetic diversity, arising from continuous crossing and random mutations.

Conclusions

The folk taxonomy used by farmers to identify and classify the varieties as bitter and sweet have resulted in a clear genetic structure. Two distinct groups of varieties were found in the analysis of molecular markers and those groups reflect a deep knowledge of the varieties toxicity characteristics. The analysis of traditional management showed a complex relationship between the amplification of the intra specific diversity and the local techniques used in the swidden cultivation systems. Alternatives to this kind of agricultural system should incorporate continually genetic diversity to favour hybridization *in situ*. We have concluded that local management interact with different life-history traits of cassava, such as the seed dispersal and soil seed bank formation. These components have temporal and spatial influences in the amplification of the intra specific diversity of the crop.

It is important to understand how to guarantee and support, through participatory plant breeding interventions, the traditional or indigenous crop genetic diversity management practices, which can result in the continued and enhanced generation of new varieties, specially in case of vegetative propagated crop species.

The results emphasize the need for a systemic view of the process, considering the ecological and social functions associated with management. Morris et al., [20] have shown that, in some situations, PPB methods could lead to loss of genetic diversity if only a few genetically similar plant populations are taken up and grown by farmers, displacing an array of more diverse populations. It is important to realize that PPB strategies are focused more on the species than in the farming management and production systems turned to biodiversity management. A better understanding of farmer management systems allows a fully comprehension of the evolutionary consequences related to diversity conservation, but also to genetic enhancement of intra specific diversity. Therefore PPB programs should incorporate indigenous knowledge in a broad design of cultural and conservation frame, because crops and human culture are deep inter-related in a longer temporal scale. In a vegetatively propagated crop like cassava, PPB should emphasize on sustaining genetic diversity and continuing human-crop interfaces. Most important, the focus should be on supporting existing farmer management as it is. This is especially important within the centre of origin of a crop, because a high amount of diversity existing there is undergoing in a continuous process of management interaction.

References

1. Joshi, A. and Witcombe, J.R., 1996. Farmer participatory crop improvement II. Participatory varietal selection, a case of India. *Expl Agric* **32**, 461–477.
2. Cleveland, D.A., Soleri, D., and Smith, S.E., 2000. A biological framework for understanding farmers' plant breeding. *Econ. Bot*. **54(3)**, 377–394.
3. Sambatti, J. B. M., Martins, P. S., e Ando, A., 2001, Folk taxonomy and evolutionary dynamics of cassava: a case study in Ubatuba, Brazil. *Econ. Bot*. **55** (1), 93-105.
4. Elias, M., Penet, L., Vindry, P., McKey, D. and e Robert, T., 2001, Unmanaged sexual reproduction and the dynamics of genetic diversity of a vegetatively propagated crop plant, cassava (Manihot esculenta Crantz), in a traditional farming system. *Mol. Ecol.* **10** (8),1895-1907.
5. Peroni, N., ande Hanazaki, N., 2002, Current and lost diversity of cultivated varieties, especially cassava, under swidden cultivation systems in the Brazilian Atlantic Forest. *Agric. Ecos. Env*. **92** (2-3), 171-183.
6. Olsen, K.M. and Schall, B.A., 1999, Evidence on the origin of cassava: Phylogeography of *Manihot esculenta*. *Proc. Nat. Acad. Sci*. **96**, 5586-5591.
7. Peroni, N., and Martins, P. S., 2000, Influência da dinâmica agrícola itinerante na geração de diversidade de etnovariedades cultivadas vegetativamente. *Interc*. **25** (1), 22-29.
8. Hanazaki, N., Begossi, A., 2003, Does Fish Still Matter? Changes in the diet of two Brazilian Fishing communities. *Ecol. Food Nut*., **42**, 279-301.
9. Oliveira, A.A. and Mori, S.A., 1999, A Central Amazonian terra firme forest. I. High tree species richness on poor soils. *Biodiver. Conserv.* **8**, 1219-1244.
10. Bailey ,K.,1978., Methods of Social Research. Free Press, New York.

11. Chavarriaga-Aguirre ,P., Maya, M.M., Bonierbale, M.V., Kresolich, S., Fregene, M.A., Toehne, J. and Kochert, G., 1998, Microsatellites in cassava (*Manihot esculenta* Crantz): discovery, inheritance and variability. *Theor. Appl. Genet*. **97**, 493-501.

12. Mba R.E.C., Stephenson P., Edwards K., Mlezer S., Mkumbira J., Gullberg U., Apel K., Gale M., Tohme J. and Fregene M. 2001. Simple sequence repeat (SSR) markers survey of the cassava (*Manihot esculenta* Crantz) genome: towards an SSR-based molecular genetic map of cassava. *Theor. Appl. Genet*. **102**, 21-31.

13. Dellaporta ,S.L., Wood, J. and Hicks, J.R., 1983, A plant DNA minipreparation: version II. *Plant Mol. Biol. Repr. 1*, **19**.

14. Bassam, B. J., Caetano-Anolles, G., and Gresshoff, P. M., 1991. Fast and sensitive silver staining of DNA in polyacrylamide gels. *Analytical Biochemistry* **196** (80).

15. Belkhir, k. et al., 2003, GENETIX 4.03, logiciel sous WindowsTM pour la génétique des populations. Laboratoire Génome, Populations; Interactions CNRS UMR 5000, Université de Montpellier II, Montpellier (France).

16. Rohlf J., 1992, NTSYS-pc: numerical taxonomy and multivariate analysis system, version 1.70 (software). Stony Brook, New York.

17. Goodman, S. J., 1997, RST Calc: a collection of computer programs for calculating estimates of genetic differentiation from microsatelite data and determining their significance. *Molecular Ecology* **6**:881-885.

18. Martins, P. S., 1994, Biodiversity and agriculture: patterns of domestication of Brazilian native plant species. *Anais da Academia Brasileira de Ciencias* **66**:219-226.

19. Clement, C., 1999, 1492 and the loss of Amazonian crop genetic resources. II. Crop Biogeography at contact. *Econ. Bot*. **53**(2), 203-216.

20. Morris, M.L., Bellon, M.R., 2004, Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. *Euphytica* **136**: 21–35.

Acknowledgements

We are grateful to the Brazilian agencies that provided financial support for this research (FAPESP 97/14514-1 and 03/13688-9), and doctoral grants to N. Peroni (CNPq). We are also grateful to Natalia Hanazaki and Walter de Boef for insightful suggestions and text review, and to all the farmers, who kindly contributed in this study.

8

Indigenous Technical Knowledge Driven Crop Improvement

V. Arunachalam, Shankar Naik, Krishna Prasad and Vanaja Ramprasad

Indigenous Traditional knowledge (ITK) of ancient farming community is valuable in many ways. For example, they identify varieties, cultivars or ancient landraces that possess special traits. They set a priority to conserve such stocks over time.

Usually they are well – adapted to their growing areas and maintain the special traits under the cultivation practices of the farmers. Farmers who have stern faith in their ITK are not unduly influenced by the presence or introduction of high yielding varieties despite the comparatively low yields of their native land races.

Thalli region, off Bangalore is an area in the state of Karnataka housing rural farmers with high ITK. They prefer ancient landraces of millets and rice for consumption. Among millets, they grow in a large scale, finger millets (ragi, Eleusine coracana L.) and landraces of rice. Pichakaddi and Karigidda ragi, Bellinellu and Maranellu rice have been the popular landraces.

However farmers were unable to realize good yields from those landraces. Often they get less than 1000 kg of Pichakaddi (PK) ragi and slightly more of Belinellu (BL) rice. A major reason for such low yields was the high disuniformity of seed material. How such seed heterogeneity came about is not clear. In addition, farmers grow these crops in marginal lands mostly by broadcasting in the case of finger millet and with inadequate care in the case of rice.

Green Foundation, a non-governmental organization working with people in Thalli region was concerned about the impure seeds and deteriorating yields of PK ragi and BL rice. In a series of PRAs with farmers, it was found appropriate to attempt purifying the seeds and also improving methods of cultivation in participation with people.

But no idea of the 'type' plant of PK ragi or BL rice could be gained, as there is no published literature on those landraces. It was therefore decided to use the ITK of knowledge – holding farmers to detect 'type' plants in the mixed population of PK ragi and likewise of BL rice.

An interesting logic was used to locate knowledge holders. Essentially they are those identified as knowledge holders by a maximum number of respondents who were asked to identify knowledge holders from their personal knowledge. This method could locate a set of farmers whose ITK helped to detect true type plants of PK ragi and BL rice.

Such selections made by ITK holders were grown in proper field design. A set of ten quantitative traits were used to analyse variation in selected plant populations and make further selections. Three such iterative cycles of selection purified both PK ragi and BL rice. Superimposed with optimal methods of cultivation, farmers could realize relatively high yields with quality grains.

This paper describes the processes involved in such ITK driven participatory improvement of finger millet and rice.

Keywords: Indigenous Technical Knowledge, Landrace, Finger Millet, Rice, Participatory Plant Improvement

It is being increasingly realized that conservation of biodiversity, and agrobiodiversity, in particular can provide interesting options to secure livelihood security to poor rural and tribal farmers especially those who live in or near such diversity hotspots. Cultivation of those agro-resources is mostly driven by peoples' indigenous technical knowledge (ITK) handed on from generation to generation.

Thally block of Dharmapuri district off Bangalore is nearly 1000 m above sea level. The region receives summer rains during early April followed by monsoon sometime in June-July ending with post monsoon rain in December. A short winter and summer complete this cycle.

Crop rotation and inter-cultivation systems are practised making available various food crops including ragi (finger millet), and also pulses, oilseeds, vegetables, and fodder crops for their cattle. Women play a role in the management of farms and in selection of seeds, their conservation and processing. However changes have occurred in this basic pattern over years. Of various reasons, natural shift from predictable to unpredictable climatic environment is important.

There are 80,000 farming families in Thally block with 81,928 ha of forest and 36,638 ha of cultivable land. Of this, approximaely 25% is rainfed and 9 % irrigated.

The main crops of the area are paddy and ragi; paddy is cultivated in about 1975 ha of irrigated land, 650 ha rainfed land, while ragi is grown in about 14,015 ha of rain-dependent dry and undulating terrain. Various other crops like maize, red gram, green gram, sorghum, black gram, cowpea, groundnut, castor sunflower and soyabean occupy an area of 18000 ha (Source: Block Development Office, Thally). Most of the irrigated paddy varieties grown in the Thally block are introduced varieties, for instance, Mysore Mallige, Kichadi samba, Ponni, Bhavani, Vijaya, Madhu, IR-64, Tella Hamsa, and some of the rainfed paddy varieties grown are BeliNellu, Dodda Bhaira Nellu, Dhappa Nellu, and Kari Dodda Byru. In ragi, Indaf-1, Indaf-5, MR-1, Sharada, HR-911, Kari Gidda ragi and Pichakaddi ragi are varieties usually grown (Source: Tamil Nadu State Department of Agriculture, Thally).

A couple of decades ago, land races of finger millet like Karigidda ragi, Dodda ragi, and rainfed upland paddy were regularly grown but at present, they face extinction. Instead, 60–70% of the finger millets cultivated are improved varieties particularly of INDAF series. GREEN Foundation could, to a great extent, revive cultivation of rainfed upland rice or preserve them in the seed bank.

Hills with undulating terrains describe the general landscape. Night temperatures are low and can reach 10°C in winter; the summers are pleasant. The soil in the project area is mostly red laterite and the most common type is red sandy loam.

Finger millet is predominantly grown as a mixed crop with field bean, castor, red gram, sorghum, niger, mustard and amaranth. Different varieties (both local land races and HYVs) of rainfed and irrigated paddy are grown.

Farmers of Thally region grow a wide variety of crops with little knowledge on the need to use pure seeds for cultivation and also continue to maintain purity with conscientious seed selection. They mix different varieties of the crop at various stages of farming, be it sowing, harvesting or storing in a bid to minimize farming losses. Lack of knowledge on good quality seed led farmers to harvest and store the whole crop as such. Sowing impure seeds next year naturally gives a poor crop susceptible to seed borne infection, pests and diseases. Farmers reject those varieties because of their bad performance thus shrinking varietal diversity. Institutional breeding and promotion of high yielding varieties with little attention to their potential in marginal environments and other requirements like taste, straw yield and the like hasten the erosion.

Participatory rural appraisals with farming communities suggested that non-availability of pure seeds and knowledge deficiency of appropriate methods of cultivating landraces were main reasons why landraces of ragi and rice were going out of preferred cultivation. At the same time, the ITK of selected people on their characteristics was strong and stand good reason for incorporating it in modified cultivation practices.

At the time the Green Foundation took up the challenge of reviving and improving cultivation of the two specific LRs - Pichakaddi ragi and Belinellu rice, the following problems needed urgent solution:

- Despite preference for cultivation of LRs for their nutrition and quality attributes, the crops were low yielding, lack uniformity compounded by asynchronous maturity.
- At best, only seed mixtures of those LRs were available with traditional farmers.
- The resulting instability in yield performance was a disincentive for cultivation of those LRs.

Though definite reasons for seed mixtures could not be gathered, reasons suggested were common threshing yards, mixture resulting at household storage level, and such mixtures getting compounded when seeds were pooled and distributed, all of which must have come about over a long period of time.

Scientific purification of seed mixtures based on principles of genetics and plant breeding could provide a solution; but this would need knowledge on ‘type’ seeds of the LRs. Type seeds are those generating type plants with distinguishing phenotypes that could provide a basis of to eliminating non-type plants. However type seeds or plants are not readily available rendering the problem of seed purification more complex.

The Strategy

Farming communities were aware of a few knowledgeable farmers who could help identify type plants in the field; however, it was not known whether such farmers would individually identify same plants as type plants. In addition, variation in seeds supplied by farmers was usual. Instead of initiating seed purification and yield improvement from a crop raised from random seed lots, it was decided to use seeds collected from traditional farmers who used to grow those landraces.

The following steps were devised to carry out seed purification:

- Identify ITK holders
- Source seeds from traditional households that supply to others

- Identify type plants using ITK holders
- Record QTs that can characterize selected plants
- Analyze statistically QT variation
- Identify groups of plants that are similar in their performance defined by all QTs using joint performance scores across QTs
- Replicate this process at a few sites
- Finalize selection of plants /seeds for next cycle
- Repeat this iterative process over a few cycles

Identifying ITK holders on Pichakaddi ragi

The website, www.panasia.org.sg (IK manual) provides an elegant method of identifying ITK holders [compiled by Paul Mundy].

In short, the method suggests starting with a few (say 3 or 4) most ITK holders. It might be useful to start with people who are involved in activities relating to PK ragi. The following provides the next sequential steps:

- Ask each person to name (say upto 4) people in the village who have high ITK about PK ragi.
- Visit each person named. Ask them to name the people who they think have the most ITK on PK ragi. Add the new names to the chart and visit these new people.
- If necessary, repeat steps 4 and 5 until no new people are named.
- Draw a diagram showing the people named at each stage. Interconnect them across stages, arrows from each person pointing to the individuals each has named.
- Count and record the number of arrows pointing toward each person.
- The individuals attracting the highest number of arrows are the indigenous specialists on PK ragi.

This process was used to identify ITK holders on PK ragi. Search involved 6 villages and 11 farmers. There were 3 cycles of search enquiry, the first starting with 3 farmers. After 3 cycles, a team of 5 farmers could be identified as ITK holders on PK ragi (Figure 8.1).

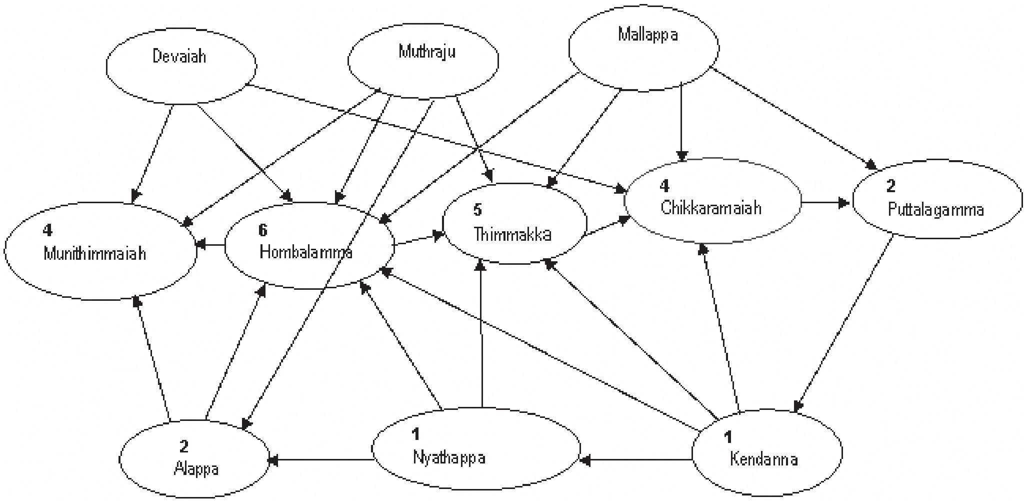


Figure 8.1 **Identifying the ITK holding farmers**

The farmers selected as ITK holders and the votes they won (N) are given in Table 8.1. When there was a tie, the final selection would depend on the farmers' judgment to select one or more as needed. In our case, we needed 5 ITK holders and out of the 2 farmers who got 2 votes each, one was selected as needed (see Figure 8.1).

Table 8.1 **Selected ITK farmers and their selection details**

F	N	C
Hombalamma	6	Rose
Thimmakka	5	Red
Munithimmaiah	4	Black
Chikkaramaiah	4	Blue
Puttalagamma	2	Green

F: Farmer; N: Number of people identifying F as ITK holder (See Figure 8.1); C: Colour of the tag allotted for selecting Type plants

Test verification of the methodology

It was thought fit to verify from the knowledge of people whether the method used succeeded in identifying the best of ITK holders. The background information on the selected ITK holders confirmed the effectiveness of the methodology.

For instance, Hombalamma aged 55 lives on the edge of the forest on the Karnataka – Tamilnadu border. She runs a family of nine and cultivates 10 acres of land single handedly. She has been the guiding light for the nearby villagers for various problem and solutions, be it health, family or agriculture related. Though illiterate, Hombalamma conserves and cultivates indigenous varieties of various crops like finger millet, sorghum, niger, pearl millet, groundnut and beans. Homabalamma has been growing Pichakaddi ragi for the last fifteen years and is an expert in identifying Pichakaddi ragi from other finger millets.

Puttalagamma is a 50 year-old farmer knowing most of the local crop varieties, their characteristics and agricultural practices. She and her husband, Chikkaramaiah (who has also been identified as ITK holder) own 5 acres of dry land and have been cultivating Pichakaddi ragi in 2 acres since the time of their forefathers, and were instrumental in conservation and distribution of Pichakaddi variety in her village and surrounding areas. She lays emphasis on seed purity.

In a remote village on a hillocki dwells 50 year-old Thimmakka. People have to carry water and supplies from below. This hard working women farmer understands the importance of local seed varieties and has been growing Pichakaddi for the last 20 years because this variety is best suited to that area.

Munithimmaiah aged 60 holds 7 acres of undulating land, often destroyed by rampaging elephants. His family of 9 cultivate finger millet, kodo millet, horse gram, sorghum, field beans, paddy etc, The family is innovative in their work. For example, they have built an all-terrain cart. Munithimmaiah is an expert in identifying various finger millet varieties specially Pichakaddi ragi.

Material and Methods

PK ragi seeds were sourced from 5 farmers (Table 8.2), through consultation at village level PRAs, of which the seeds supplied by the farmer P3 was found to be Orissa mandya and hence not included. The material was sown in red sandy loam soil during rainy season. The crop received farmyard manure at 5 tonnes per hectare. The material was sown in rows spaced 10 cm apart and plants within a row at 20 cm in plots of 3 m^2. Thus there were 15 rows each containing 30 plants. The experiment was laid out in 2 different sites, Laxmipura (S1) and Marupalli (S2) to account for environmental variation.

Each farmer was given coloured tags to select those that they believe are PK ragi, from the plant population growing in the field and is flowering. The farmers were told they should exercise independent decision and not influenced by plants

Table 8.2 **Seed sources and sites where grown**

Source	Village	
P1	Puttannana doddi	
P2	Laxmipura	
P3	Karadi doddi	Mandya Orissa -discarded
P4	Belalum	
P5	Chennangibyla doddi	
Site	Sowing	Harvest
S1: Laxmipura	6-7-2000	7-12-2000
S2: Marupalli	15-7-2000	15-12-2000

tagged already by the previous farmer. At the same time, they can tag the same plant tagged by previous farmer, if they think it was PK ragi. Since ITK holders were independently selected by a scientific process, the presence or absence of a tag in a plant is not expected to influence their decision. At the end of the exercise, there would obviously be plants carrying 5,4,3,2 and 1 tags in every row. We designated them as T5, T4, T3, T2 and T1 for convenience. This exercise was completed for the plants raised from each of the seed sources individually.

The ITK holding farmers' selection of plants proved to be logical since the number of plants in the category T5 was the lowest gradually increasing in the categories T4 to T1 (Table 8.3). The farmers' selection did also reflect the variation between sites (environmental variation) and also between the sources. The latter indicated that the level of mixtures in seeds from various sources varied in response to which the number of plants selected also varied. *A priori* therefore, there is evidence the farmers' selection was fair indicating their strength of ITK and their practical knowledge of PK ragi.

To characterize the plants on a set of quantitative traits (QTs) relevant to plant growth, and yield performance, observations were recorded on the following quantitative traits on all plants selected by farmers, site wise (S1 and S2), source wise (4 sources: P1, P2, P4 and P5) and selection depth wise (Tags/ plant: T5, T4, T3, T2 and T1) HT: Plant height (cm); TL: Number of basal tillers/ plant; CL: Number of culm branches/ plant; FL: Days to 50 per cent flowering; ER: Number of ears/ plant; FG: Number of fingers/ plant; GY: Grain yield/ plant; SY: Straw yield/ plant; GS: Grain size (weight/ volume); HI: Harvest index; PN: Plant population at harvest.

Table 8.3 **Distribution of farmer-selected plants of PK ragi at Sites 1 and 2**

Seed Source	Selection depth	Total		Seed Source	Selection depth	Total	
		S1	S2			S1	S2
P1	T5	2	2	P4	T5	1	2
	T4	8	5		T4	2	2
	T3	10	10		T3	9	15
	T2	16	20		T2	20	21
	T1	26	30		T1	50	25
		62	**67**			**82**	**65**
P2	T5	1	1	P5	T5	2	1
	T4	6	6		T4	8	3
	T3	11	7		T3	12	8
	T2	21	25		T2	15	25
	T1	26	30		T1	22	39
		65	**69**			**59**	**76**
				Total		**268**	**277**

Analysis of variation (Table 8.4) for various QTs showed high and significant variation between seed sources (SS), depth of selection (SD) and also their interaction in each of the 2 sites for almost all characters. This implied that though the ITK holders selected 'type' PK ragi plants on phenotypic appearance, there existed substantial morphologically expressed variation implying underlying genetic variation. It would then be essential to effect further selections based on joint performance of the various QTs.

A study of the mean values of various QTs in the two sites confirmed the earlier observations on the selection depths, T5 to T1 (Table 8.5). Except for some cases, plants in selection depth T5 to T1 had mean values in descending order of magnitude in general, confirming the efficiency of selection by ITK holders. When the means were ranked using Duncan's multiple range test (DMRT) individually first and the individual ranking were collated across QTs, it was found that the selection depths T5 and T4 were significantly different while there was no significant differences among T3, T2 and T1, in both the sites (see last column in Table 8.5).

It was then important to rank similarly the site-source combinations (noting that

Table 8.4 **ANOVA of Seed Sources (SS) and Selection Depths (SD) of PK ragi : Sites S1 and S2**

Source	d.f		HT		TL		CL		ER	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
SS	3	3	*	*	*	*	*	*	*	*
SD	4	4	*	*	NS	*	NS	*	NS	NS
SS X SD	12	12	*	NS	NS	NS	NS	NS	NS	*
Error	248	257	33.5	25.8	0.27	0.2	0.26	0.3	0.24	0.3
	FG		GY		SY		HI		GS x 10^{-4}	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
	*	NS	*	*	*	*	*	*	*	NS
	*	*	*	*	NS	*	*	*	*	*
	NS	NS	*	*	*	*	*	NS	*	NS
	0.14	1.2	0.25	0.6	0.56	1.6	16.40	8.7	0.48	0.6

Table 8.5 **Mean values of traits of farmer-selected plants of PK ragi: Sites S1 and S2**

SD	HT		TL		CL		ER		FG	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T5	77.8	87.0	1.7	0.8	0.7	0.7	1.7	1.3	4.7	2.8
T4	69.5	80.5	1.5	1.6	0.6	1.1	1.4	1.8	4.4	5.2
T3	68.0	79.9	1.4	1.3	0.3	0.7	1.4	1.5	4.2	5.2
T2	68.2	78.3	1.4	1.3	0.5	0.5	1.3	1.4	4.1	5.1
T1	68.6	79.7	1.4	1.2	0.5	0.5	1.3	1.4	4.1	5.0
	GY		SY		HI		GS		Ranked SD*	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
	3.3	7.0	4.5	11.4	42.0	38.2	0.19	0.19	1	2
	2.5	6.4	3.9	10.4	38.6	38.3	0.19	0.19	2	1
	2.5	5.7	4.2	9.7	37.4	37.0	0.18	0.19	3	3
	2.5	5.3	4.3	8.3	37.0	38.8	0.18	0.18	4	4
	2.5	5.1	4.2	8.0	37.0	39.0	0.18	0.18	5	5

*SD = selection depth; For column identifiers see text; * No significant differences among selection depths S3, S4 and S5 marked by a vertical line, in both the sites* site x source interaction was significant) for selecting plants from out of those selected by farmers. Using the error variance from the ANOVA, the means for every QT were grouped by DMRT; a score for each combination was allotted. Such scale neutral scores were added across QTs following the methods described in Arunachalam and Bandyopadhyay[1]. The final scores were arranged into 4 groups using mean and standard deviation of the final scores, as follows:

Group	Score value, x
G1	$x > m+s$
G2	$m \leq x \leq m+s$
G3	$m-s \leq x < m$
G4	$x < m-s$

The DMRT ranking provided 4 groups G1 to G4 in descending order of performance across the QTs (Table 8.6). To effect stringent selection in the first cycle, source-selection depth combinations that were common in various groups G1 to G4 in both the sites were identified (shown in bold letters in Table 8.6). Seeds of selected plants from those common combinations in Sites 1 and 2 were pooled and their progenies raised in the next season constituting the material for second cycle of selection.

The progeny population showed high uniformity. In order to be sure that such uniformity was present across all the QTs earlier used to characterize plants,

Table 8.6 **Source- selection depth combinations ranked on their performance across 9 traits at 2 Sites**

Ranked	Combinations	
Group	Site 1	Site 2
G1	P4T5, **P4T4**, P2T5	**P4T4**, P1T4, P5T4, P1T5
G2	P4T3, P1T4, P4T2, P1T5, **P1T2**, P4T1	P3T4, P1T3, P5T3, P1T1, P4T5, P5T5, **P1T2**
G3	P2T4, P1T3, P1T1, P5T5, **P2T3**, **P2T2**, P5T4	P2T5, P4T3, **P2T3**, **P2T2**
G4	**P2T1**, P5T3, **P5T2**, **P5T1**	P4T1, P4T2, **P2T1**, **P5T2**, **P5T1**

data on those QTs were taken in 1 sq.m. areas and 5 plants at random from each. Based on DMRT grouping, seeds from the 5-plant sample from selected areas were pooled and forwarded to the next cycle. In the next cycle, this process was repeated in 5 sq.m. areas marked at random and based on DMRT on key QTs from plants from the areas, the top two groups were selected and seeds from plants in those groups were pooled and used as the purified seed material for raising large test plot areas. All the cycles of experimentation were done in complete and equal participation with farmers in their fields. This helped the farmers not only to understand the scientific process behind seed purification, seed selection and multiplication but provided confidence for doing it themselves. Figure 8.2 illustrates the process and chronology of the scientific seed purification process.

Exactly similar process was used to purify seeds of the rice landrace, Bellinellu (BL). The process of purification of ragi and rice was implemented on a participatory mode with different sets of farmers concurrently. Therefore we are not repeating details for rice separately. At the end of the program, farmers' impressions were obtained on a random survey and the following major points emerged:

- Grain and fodder yields were better than the other local varieties
- Seeds were pure and bold
- Tillering capacity was improved substantially

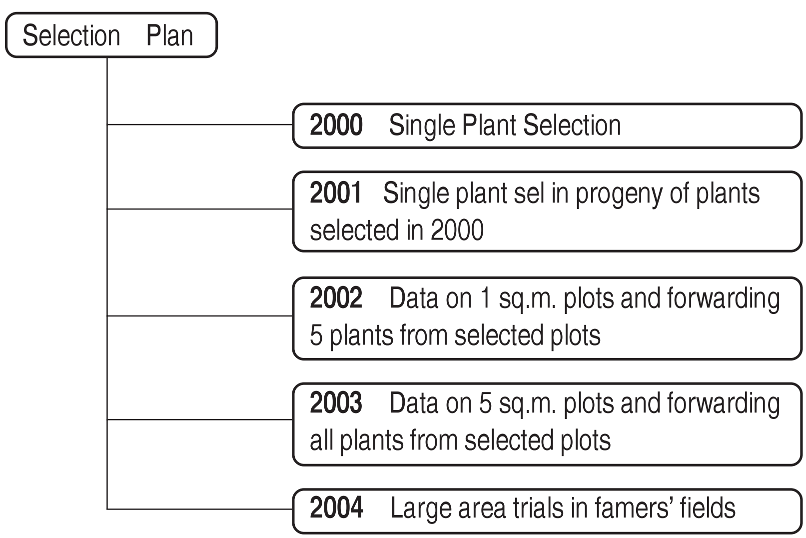


Figure 8.2 **The process of seed purification of PK ragi using ITK of farmers**

- Plants were uniform and possessed field resistance to pest and diseases compared to local varieties (for example, neck and finger blast disease of PK ragi)

Green Foundation could not evaluate farmers' plots of PK ragi and BL rice in in an organized way in subsequent years. A sample data (Table 8.7) indicated that the high yield levels were feasible and farmers' needed conscientious training and capacity building for sustained realization of high yields.

Table 8.7 **Yield performance of PK Ragi in farmers' fields**

Crop	No. of farmers	Area(acre)	Grain yield (kg/ha)	Straw yield(kg/ha)	Harvest Index
PK ragi	8	0.1 – 1.0	100 - 2500	400 - 7500	0.14 – 0.40
			Sample yields from 4 farmers		
			2500	3800	0.40
			333	666	0.33
			1666	7500	0.18
			1875	6250	0.23

However, scanning across farmers' fields growing PK ragi and BL rice in their traditional way and those adopting the modified practices taught during the process of seed purification (Table 8.8), it was evident the latter was significantly superior

Table 8.8 **Comparative yield performance of PK Ragi and BL Rice in 2004**

Farmers' Method	Modified practice
Minimal land preparation	Deep ploughing
Mostly no levelling	Levelling where absolutely needed
No or unspecified quantities of manuring in general	Farmyard manure @ 10-12 cartloads per acre and application of neem cake at the time of sowing as advocated by ITK
Haphazard broadcasting of dry seeds	Line sowing with spacing of 25 x 15 cm [Transplanting - 30 x 15 cm] of selected wet seeds
High seed rate on thick broadcasting 15 kg/acre	Optimal seed rate: 8 kg/acre Line sowing 1 kg/acre Transplanting
Small area in marginal land	Affordable large plots in fairly uniform land
No cultural operations	Thinning: 15 days after sowing; Hoeing and earthing up: 45 days of after sowing

Table 8.9 **Comparative yields obtained under farmers' and modified practices of cultivation of PK ragi and BL rice**

		Mean Yield kg/ha	Range	c.v.	No. of farmers
PK ragi	A. Farmer method	1917	1500 - 2250	12.4	13
	B. Line sowing	2393	2000 - 2550	9.8	8
	B/A	1.25			
BL Rice	A. Farmer method	2125	1400 - 3000	26.0	8
	B. Line sowing	3217	3000 - 3500	8.0	3
	B/A	1.51			

c.v. - coefficient of variation

for realizing gainful yields (Table 8.9). Further, while yields under farmers' traditional practices were low and erratic, as shown by the high coefficients of variation, yields under modified practices were high and stable.

Salient Results

After establishing purity of PK ragi and BL rice and also ensuring production of pure seeds of those landraces, farmers including the selected ITK holders were asked to state the criteria on which they identified 'type' plants from the mixed population of plants in initially. According to them, the following characteristics were important in PK ragi:

- Dark brown coloured rings at inter-nodal region and pale pink coloured stem
- 3 – 4 culm branches
- 3-4 ear heads per plant
- Dark brown, fist shape earhead with rough textured thick grain arrangement on fingers
- Relative lodging resistance
- Non-shattering of grains
- Curved-in top fingers with advancing maturity
- Fine textured dense straw (leaves and stems)
- Bulkiness of flour on cooking

We note that the QTs we used for selection took into account most of those criteria, a reason why the selection and purification process was rapid.

Women, in particular were concerned mainly with good cooking quality and palatability.A survey conducted with women farmers indicated that one bundle of straw of Pichakaddi ragi was equal to two bundles of straw of improved variety (Indaf – 5) and the straw of PK ragi was much preferred by livestock due to its palatability, that was absent in other improved varieties of finger millet. Based on experience, women farmers observed that one measure of Pichakaddi ragi flour was adequate in food preparation (like ragi balls) that needed two measures of flour of any improved high yielding variety ragi flour.

An analysis of this study and gains of PK ragi and BL rice realized by farmers have confirmed that farmers' ITK is a valid tool for addressing difficult problems, though the pathway for using ITK efficiently is challenging. Though ITK would help in a first stage selection and purification, it may not lead to immediate genetic purity. It would need evaluation of QTs related to plant performance, and not necessarily yield alone, over a few iterative cycles. With advancing cycle, strategies to evaluate and select from large areas should also advance. In this effort, statistical tools and methods of analysis and evaluation play a significant role. This case study demonstrates that the process adopted is rewarding and replicable. However proper follow-up with people is crucial to sustain the benefits of the interventions; this was however deficient in this case.

Nevertheless this study stresses that farmers' ITK is valuable, needs recognition and reward and if properly channeled, would lead to enormous benefits for the society.

Reference

1. Arunachalam, V. and Bandyopadhyay, A., A method to make decisions jointly on a number of dependent characters. *Indian Journal of Genetics and Plant Breeding*, **44**: 419-424.

9

Mainstreaming social and gender concerns in participatory rice varietal Improvement for rainfed environments in Eastern India

Thelma Paris, Abha Singh, V N Singh and P C Ram

'Participation' and 'participatory' have become such fashionable terms recently that any kind of activity involving a group of people is termed 'participatory'. The ideal participatory research is when the people are genuine participants in different stages of the research activities rather than simply "involved" as data givers or recipients of research findings. Participatory means people actively participate by implementing and taking control of all activities during the research process. Just as there are numerous participatory rural appraisal (PRA) tools used in problem diagnosis and identifying technology options, participation of farmers in rice varietal improvement projects should not be seen as an end in itself. Rather, it should be seen as a means to an end – namely the production of varieties that are better adapted to the needs of end users in their given agro ecological environments.

Thus a major challenge facing managers of institutional breeding programs is to figure out ways to foster increased participation by end users. Unfortunately however, 'participatory research for development' does not automatically result to participation or inclusion of marginalized groups of the society including poor women who contribute significantly in rice production and post harvest activities including seed selection, storage and processing rice for various products. Moreover, examples of how social including gender analysis add an important dimension to assessing the potential benefits of participatory rice varietal improvement are rare.

This paper first provides the background of the participatory rice varietal improvement program of the International Rice Research Institute (IRRI) in collaboration with the National Agricultural Research and Extension Systems (NARES) in Eastern India. It describes the participatory methods and tools used in incorporating social and gender concerns in the stages of plant breeding process; identifies several constraints experienced

by the researchers in including women at the initial stage of the project; discusses the positive social benefits due to inclusion of the marginalized groups of the society (lower caste and women from poor farming households) and discusses challenges that will have to be overcome to mainstream social and gender concerns into end-user based participatory approaches in rice varietal improvement programs.

Keywords: Participatory research, women, social benefits, gender analysis, rice varietal improvement

"Participation" and "Participatory" have become fashionable terms recently that almost any kind of activity involving a group of people is termed "participatory". Ashby[1] warned that "as these terms embrace a multitude of meaning, and these meanings become correspondingly dilute, a serious threat is posed to the use of the term participatory research. The risk is that a catch-all definition of participatory research is destined to fall out of fashion and to be discarded as fashion changes, without even receiving the serious scientific evaluation of its potential that a rigorous but less trendy use of the term would invite". Morris and Bellon[2] also expressed their concern that "participatory research has become something of a mantra in some circles, but it is important to keep in mind that more participation in plant breeding research is not necessarily better". They emphasized that "participation should not be seen as an end in itself. Rather, it should be seen as a means to an end – namely the production of varieties that are better adapted to the needs of end users". Moreover, not all kinds of research can be participatory and participatory research is not a substitute for conventional research. Participatory research will be more effective if backed by formal research or conducted in parallel with on-station research. As the problem moves toward more diverse and complex environments, farmer participatory research is increasingly necessary.

One of the lessons learned in participatory research for development is that a technology is better adapted if the user is genuinely involved in the different stages of the process rather than being simply "involved" as data providers, observers or on-lookers of on-farm experiments or recipients of research findings. This involvement of the user, male or female farmer provides a sense of ownership as he/she has some control of the use of inputs and outputs used.

Thus a major challenge facing managers of institutional breeding programs is to figure out ways to foster increased participation by end users. Unfortunately however, most research projects which claim to practice "participatory research for development" aimed at poverty alleviation does not automatically result to participation or inclusion of the marginalized groups of the society, especially the poor rural women, despite more than a decade advocacy efforts to provide men and women equitable access to knowledge and resources.

As observed by Gujit and Shah [3], despite the claims to inclusiveness that comes with advocacy of participation in development, “the language and practice of ‘participation’ often secures women’s worlds, needs and contribution to development, making equitable participatory development an elusive goal. They state that:

“It is bewildering that the fields of participatory development and gender remained far apart, both in theory and practice, despite their goals of social inclusion and societal transformation. More gender-responsive forms of participatory research and development would have many benefits. Misunderstanding or ignoring women’s needs not only affects the women themselves but also, quite obviously, has a negative impact on the immediate family and the wider community. Furthermore, the process of inclusion, if constructed appropriately, can help raise women’s confidence, open up space for their views, and ease oppressive gender relations.”

Castillo[4] reiterated that “social exclusion is one phenomenon deeply embedded in culture and in tradition which deserves to be rooted out in its many forms if the poorest of the poor are to benefit from development programs intended for them”.

In view of these concerns, this paper presents the experience of the International Rice Research Institute (IRRI) in collaboration with National Agricultural Research and Extension Systems (NARES) in mainstreaming social concerns (including gender issues[3]) into a participatory rice varietal improvement program for stress environments. It provides the background of this participatory rice varietal improvement program at IRRI in collaboration with NARS in eastern India, describes the participatory methods and tools in incorporating social analysis (including gender analysis) in the different stages of participatory plant breeding process, identifies several constraints experienced in including women in project activities, discusses the positive social benefits due to inclusion of the marginalized groups of the society – the lower caste and women from poor farming households and presents challenges ahead in mainstreaming social concerns (gender analysis) into participatory research for development.

By comparison, developing improved rice varieties for non-irrigated areas has been slow and frustrating. Farmers who depend entirely on rainfall are often much poorer than those in irrigated areas. They produce only one rice crop per year and obtain yields that are lower on average compared with those of irrigated rice farmers. They sell less of their output, depending heavily on their rice crop for basic household food security. Because their cash incomes are low, and rice is prone to drought and floods, farmers in rainfed areas minimize risk by applying much less fertilizer than do irrigated rice growers. They continue to grow traditional varieties with low yields but which can withstand stresses such as drought, submergence or both and problems soils. Thus, most cultivars grown by farmers are traditional and only a few of the released cultivars are grown widely. For example, for rice in India, the average age of cultivars in certified seed production ranges from 12 to 17 years in the states of Gujarat, Madhya Pradesh and Rajasthan[5]. Studies of Kshirsagar and Pandey, [6] revealed the low adoption rate of improved varieties for marginal environments when compared with the irrigated environment.

The main reasons often suggested for this low rate of adoption are the following: farmers have inadequate exposure to new cultivars; farmers may not have access to or information about seeds of new varieties; new varieties selected on research stations may not outperform traditional varieties under farmer management; and improved varieties may not meet farmers' end use and cooking quality requirements[7]. The first two reasons maybe addressed through institutional and policy reforms. To address the last two reasons, farmers need to grow a wide range of new cultivars in their fields through participatory varietal selection (PVS). In PVS, farmers can select pre-release advanced lines and already released varieties and compare them with the performance of the variety they currently grow. The complexities of developing acceptable cultivars for variable and stressful rainfed environments require that breeders and social scientists work together to identify farmers' requirements. In India, IRRI's collaborative breeding networks facilitate their adaptation for rainfed rice breeding. Rainfed rice breeders in eastern India have worked with IRRI researchers since 1992 through the Eastern Indian Rainfed Lowland Shuttle Breeding Network to develop improved varieties for drought and submergence prone areas. The network links small and isolated rainfed rice –breeding programs and allows them to exchange promising breeding lines and evaluate them in a broad range of environments. It serves a vast area, encompassing eight states with 24 million ha of rainfed rice lands, and has proven to be an excellent laboratory for integrating participatory methods in rainfed breeding programs.

In 1997-2000, the farmer participatory breeding project "Farmers and Scientists - Building a Partnership for Improving Rainfed Rice in Eastern India" was conducted by IRRI and six national agricultural institutions under the Indian Council of Agricultural Research (ICAR) in Eastern India in response to the low adoption rates of improved varieties. This project, funded by International Development of Research in Canada (IDRC) was conducted under the umbrella of the Consultative Group of International Agricultural Research (CGIAR) System wide Initiative on Participatory Research in Plant Breeding and Gender Analysis (PRGA) organized by the International Center for Tropical Agriculture (CIAT) in Columbia.

The main research objectives of this project were to: 1) test the hypothesis that farmer participation in rainfed rice breeding can help develop suitable varieties more efficiently; 2) identify stages in a breeding program where farmer participation has the most impact; 3) develop and test a methodology for effectively involving farmers in the testing program and improve understanding of men and women farmers' criteria for selecting specific rice varieties and 4) differentiate between influence of farmer participation and decentralization of the breeding process and develop rice varieties suitable for heterogeneous rainfed environments, which meet farmers' preferences[7].

To pursue these objectives, social scientists were included in the research team at the onset of this project. The project had two components: the plant breeding and social science component.

Plant breeding

The plantbreeding component included participatory plant breeding (PPB) and participatory varietal selection. PPB refers to farmer selection with unfinished materials with a high degree of genetic variability while PVS refers to farmer selection of finished or near finished varieties [8]. Testing and selecting in different locations representative of the targetbreeding environment is known as decentralized breeding[9]. As defined above, decentralized breeding can be done without farmer involvement and PVS and PPB do not necessarily imply that they are done in multiple environments (decentralized). As suggested by Courtois et.al.,[7,] we need to define the breeding operations for which participation is most necessary. Farmers' participation in goal and selection criteria settings and/or selection by farmers within well-chosen prerelease varieties may be enough to increase the rate of adoption. Then farmers' participation in the breeding process itself, which is one degree of complexity further, may not be necessary". On the other hand, the acceptability of a variety may depend on characteristics that are difficult for scientists to measure and quantify, so it is likely to be advantageous to ensure that farmers participate in the evaluation of finished cultivars before they are released. The objectives of this component were to develop and evaluate a methodology for participatory improvement of rice for heterogeneous environments and to produce materials suited to farmers' needs.

Socio-economic

The objectives of this component were to establish a farmers' typology based on socio-economic variables assumed to be important in the varietal choice process like market integration, importance of rice for the household, wealth, gender, caste, education etc. to guide the establishment of breeding goals, and their possible differentiation for various farmers' groups. Other information gathered were on type of production systems (sources of irrigation, soil type, land type), the diversities of varieties grown, farmers' crop management practices, gender division of labor in different rice operations and seed management systems. This component also sought men and women's selection criteria for certain varieties and their reactions to a range of cultivars and breeding lines[10].

Based on the experiences learnt from 1997 to 2000, IRRI in collaboration with plant breeders and social scientists began to refine participatory varietal selection methodology by adapting the mother and baby trial design and by involving more women farmers from 2001 to 2003[11]. IRRI and other research centers of the Consultative Group of International Agricultural Research as well as other research groups have been using PVS methods in various forms. PVS became an integral component of the Consortium of Unfavorable Rice Environments (CURE) which addresses the need for suitable varieties for drought, submergence and salt-affected areas. CURE includes several agricultural research institutions namely Narendra Deva University of Agriculture and Technology (NDUAT), Faizabad, eastern Uttar Pradesh; Central Rice Research Institute (CRRI), Cuttack, Orissa; Indira Gandhi Agricultural University (IGAU), Raipur, Chhattisgarh; Central Research for Upland Rice Station (CRURRS), Hazaribagh, Bihar. PVS is also currently conducted under CURE in other countries namely Laos, Philippines, Indonesia and Bangladesh.

This paper will focus on the collaborative research between IRRI and NDUAT in Kumarganj, Faizabad located in eastern Uttar Pradesh. The following section discusses IRRI's strategies in incorporating social and gender concerns in the stages of participatory rice breeding process.

Incorporating social and gender concerns in the stages of participatory rice varietal improvement process

It is usually fair to say that the earlier use of participation occurs in a breeding process, the more opportunity users are given to influence the objectives, breeding strategy and final outcomes. However, the extent to which users can realize this opportunity depends on the degree of participation. The participatory rice varietal improvement process has several steps. These are setting breeding goals, evaluation of new rice lines, and wide diffusion of seeds and assessment of benefits of PVS[12].

Table 9.1 show how social and gender analysis were incorporated in each of the step of the process by a team of plant breeder and social scientists from IRRI and NDUAT.

Breeding goals

Conventional rice breeding programs typically develop new varieties in two steps: First, breeders cross existing varieties to produce large populations of progeny lines for development through pedigree selection, selecting the best plants according to plant type, disease resistance and eating quality. Breeders repeat this process for several generations, until the selected lines are stable and uniform in all important traits. In the second step, researchers subject the line to replicated yield tests on the originating research station and then on other well-managed research –station fields within the target region. Farmers were rarely consulted on their selection criteria or on the trade-off they apply between traits except by few plant breeders. Farmer input comes only at the very end of the process, when newly released varieties, usually one or two per year, are evaluated in on-farm demonstration trials. Researchers decide which the important traits are and more attention is given to measurement of yield and other agronomic characteristics[7].

Through PVS, plant breeders can include farmers' criteria in setting the breeding goals. Varieties are evaluated on farm by farmers. Farmers' opinions and knowledge are used and more attention is given to grain quality and other traits which farmers like. Thus plant breeders and social scientists work together to determine the needs and preferences of both men and women farmers in their specific agro-ecological environments. Knowledge about the target farming system(s) and farmers' needs are important in identifying appropriate objectives and targets for a breeding program. This information was obtained using several methods and tools which are explained in detail below:

Table 9.1 **Strategies and methods used in mainstreaming social and gender analysis in participatory rice varietal improvement for rainfed rice environments**

Stage in the breeding cycle	Strategies and methods
Setting breeding goals through cultivar needs assessment	■ Survey of varieties by area planted, landtype, cropping systems, farming systems ■ Conducted baseline socio-economic surveys with social and gender-differentiated information ■ Conducted social and gender analysis ■ Assessed male and female farmers' criteria of useful traits of rice varieties through participatory ranking using graphic illustration of traits and open-ended interviews
Evaluation of new rice lines on station and on-farm managed by researchers	■ Included visiting male and female farmers in selecting new lines before harvesting rice ■ Used simple methods of rating e.g preference analysis of varieties by males and females
Evaluation of new lines on farmers' fields managed by farmers	■ Included male and female volunteer farmers in farmer-managed trials ■ Conducted focus interviews with separate groups (males or females) and individual male and female farmer cooperators
Wide diffusion of seeds/scaling up	■ Distributed farmer-preferred varieties to active male and female farmers in many villages representing the target environment ■ Conducted seed health improvement training conducted for both men and women farmers ■ Enhanced capacities of NARES in participatory research and gender analysis through IRRI training courses
Assessment of benefits of PVS both by researchers and farmer cooperators	■ Conducted study on women's decision-making ■ Measured women empowerment index ■ Collected oral testimonies of women cooperators of farmer managed trials

Source: Authors' experience

Baseline socio-economic surveys

- Select the target site. Plant breeders and social scientists together identified the villages in Siddarthnagar representing submergence and in Faizabad representing drought and submergence
- Villages were selected based on the following criteria: should be representative of the target region, production, system, land types.
- Village level characteristics were obtained through Participatory Rural Appraisal (PRA)
- Sample farming households (50 per village in each district) were interviewed
- A pre-tested structured questionnaire was used to collect information related to agricultural condition (area planted to rice by landtype, varietal diversity by landtype, cropping systems, degree of market orientation; importance of livestock; degree of mechanization, farming practices, share or rice to total income, etc). Gender differentiated questions were included in the questionnaire.
- Socio-economic characteristics of the households by social class, farm size, religion and ethnicity, by kinship (nuclear or joint), literacy rates between principal males and principal females were collected.
- Gender analysis was done by asking "Who does what in crops (rice, non-rice crop, livestock) off-farm and non-farm activities; Who has access to farm inputs, and knowledge, training and extension activities? Who has control of resources? Who benefits? How many hours/days are spent per hectare in rice production by adult males and females? This was done to compare the labor contributions of female (family, exchange and hired) with males and to find out whether there are gender-specific tasks. These information were analysed by social class.

Participatory ranking using graphic illustration of traits.

Based on the baseline information, a participatory ranking method was used to elicit male and female farmers' criteria for selecting rice varieties according to land elevation (related to hydrology and soils) and to determine the trade offs they made between traits. The method used is described below:

- Basic information was collected from male and female heads of rice farming households (name, age, sex, caste, size of landholdings, elevation of rice plots, etc).

- Twenty cards were prepared, each card showing a rice varietal trait which was developed with the help of plant breeders. The cards were presented and explained to the farmers.
- The researcher asked the farmer; in what landtypes do you grow rice? Among these landtypes which is most important to you? Within the upland, which of these cards/traits do you consider the most important when selecting a variety? Which ones are not important? Please discard the the rest of the unimportant cards/traits.
- The researcher asked the farmer, if I give you 16 ana, (16 ana=100 paise, 100 paise = 1 rupee) how much value (weight) will you give to each of the remaining cards/traits? Here the farmer can think carefully whether she/he value other traits aside from yield.
- An average weight was then computed, by dividing the sum of all values assigned per trait by the number of respondents, and then calculating the proportion of each trait to all traits.

This participatory method showed that farmers were not only interested in yield per se but on multiple traits depending upon their livelihood needs. There were traits common to men and women and traits which women considered important but were not mentioned by men and vice versa [10,13].

Since this is like a game, the women had fun and felt at ease in providing the information. This method was powerful in documenting gender differentiated user preferences by land type, and socio-economic class. However, the prepared cards limited the range of traits that could be considered. Open-ended interviews revealed for example, the importance of purple-colored rice variety as a strategy to identify and an eradicate wild rice at an early stage of crop growth in specific cultural conditions, but this was not included in the card set and was not mentioned by respondents during the exercise. Further informal interviews disclosed a preference for late to medium varieties designed to provide rice for gift giving during the important Diwali festival – but this kind of social motivation for trait preference also did not emerge in the card exercise. Thus the researchers concluded that the card method needs to be combined with a prior round of open-ended enquiry [10].

Evaluation of new rice lines on station and on-farm

Participatory varietal selection is a trial design wherein farmers select finished or near-finished lines. The degree of farmer participation varies on the type of control and ownership of the research process. These trials can be classified into researcher-managed trials and farmer-managed trials or farmer-led trials. These two trials are complementary.

Researcher-managed trial

- Breeders conducted parallel experiments on - station and on farmers' fields using similar sets of fixed varieties (13-25 advanced lines and a local check) suited for the specific hydrological conditions in the area. The advanced lines were selected from the IRRI Shuttle Breeding Program and from breeding programs of project partners in eastern India.
- Men and women from different social groups (small, marginal and large farms) visited the individual plots with the sets of lines and visually ranked the genotypes grown on farmers' fields.
- Farmers and breeders ranked the same set of varieties grown on-station and on-farm. Ranking was ordered from best to worst. Breeders recorded duration, plant height, and yield for each trial.
- After ranking, discussions were made on the characteristics they liked or disliked and reasons for ranking were recorded in diaries.
- The Kendall coefficient of concordance and the Spearman rank correlation coefficient were used to analyze the agreement of ranking of the genotypes among farmers, among breeders, between farmers and breeders [7] and between male and female farmers [10].

Farmer-managed trial

- Plant breeders and social scientists together identified the villages which represent the problem (drought, submergence and saline/sodic prone).
- Participating farmers were selected based on the following criteria: rice growers should have a strong interest and commitment in participating; should have fields which are representative of the problem; should represent the majority of the social groups particularly the disadvantaged groups in the community.
- Volunteer farmers were given seed samples of 1-2 kgs each of 5 to 10 lines which were selected from the Mother trials.
- Researchers then visited the farms twice the season and asked the male and female farmers which lines they like and dislike and which line they would like to continue to grow next season.

Several lessons were learned from the 3 years of experience in developing and testing the methodologies for farmer, led breeding. These lessons were related to the concerns such as there were too many lines to rank, too many varieties were included in on-farm experiments, women's work burden increased in harvesting and threshing crop samples and in conducting sensory evaluation tests There were lines which ranked high in researcher-managed or mother-trial but were rejected by women farmers due to post harvest and eating qualities.

Refinements in the participatory varietal selection

Based on the lessons learned from 1997 to 2000, refinements were made in the participatory varietal selection. The challenge was to further simplify the systematic approach to include farmers' criteria in rice varietal selection and to include them in the early evaluatin of new rice lines under their own management.

Use of preference analysis in researcher-managed trials

Preference analysis (PA) is a fast and efficient way of collecting information about which varieties farmer preferred in a mother (researcher-managed) trial. These trials allow researchers to identify a small group of varieties (3-10) that yield well under farmer management, and are chosen by farmers as desirable in the participatory approach process

- Farmers were invited to visit the researcher-managed trial. These farmers were representative of the main ethnic and social groups in the community. Both men and women farmers were invited to join.
- A stake with a bag or envelope attached to it was placed in front of each plot in the trial. It the trial is replicated, this should be done only for the best replicate.
- Each farmer was given 4 paper ballots. Men and women received ballots of different colors.
- Farmers were asked to "vote" for varieties they would like to grow on their own farm by placing a ballot in to the envelope in front of their preferred varieties.
- Votes were counted by researchers and reported to the group of visiting farmers.
- The whole group visited the two varieties receiving the most votes, and farmers were asked to explain why they like these varieties.
- The whole group then visited one or two of the varieties receiving the fewest

votes, and farmers were asked to explain what are the negative traits of these varieties.

- A preference rating was generated for each variety by expressing the number of votes cast for that variety as a proportion of the total number of votes cast.

This method works best with groups of about 10-12 farmers. Its advantages include the ease of doing with illiterate farmers, especially women, its simplicity and speed (it can easily be completed by 2 researchers with a group of 10 farmers evaluating 20 varieties in an hour or so) and the fact that it generates both a numerical preference rating and a descriptive list of the advantages and disadvantages of the preferred varieties. Its main disadvantage is that it can only detect preferences for pre-harvest traits. Cooking and eating quality traits are not usually conveniently assessed using PA, although some programs have used the method for this purpose. It is best to include only varieties known to be of good quality in PVS traits. In this exercise, women evaluators can predict the yield performance by counting the number of panicles[11].

Use of farmer ratings in farmer-managed trials

Usually, each participating farmer receives two to three test varieties. These "baby" trials, as they are often called (the "mother" being the earlier researcher-managed trial) are repeated many times over. By minimizing their own involvement, researchers ensure that the trials are managed in the same way as the rest of the farmers' crop and variety-always an important consideration in rainfed rice research – to minimize the cost per trial. Rather than harvesting and weighing crop samples, researchers often identify preferred lines by relying on farmer ratings of the varieties, both relative to each other and to the farmers' own variety. In addition to direct questions about yield and quality, farmers are asked if they plan to grow the variety next year or have given seed to friends or relatives. Eagerness to grow a variety again, and neighbors demand for it, are strong indications that it is preferred[11].

Baby trials (farmer-managed trials) have two objectives: a) to assess the performance of varieties on a large number of farms; and b) to help disseminate new varieties. The steps were:

- Plant breeders and social scientists together identified the villages to represent the problem (drought, submergence and saline/sodic prone)
- Volunteer farmers who would like to try new lines were finally selected based on the following criteria: rice growers should have a strong interest and commitment in participating; should have fields representative of the problem;

should represent the majority of the social groups in the community. Women who were actively engaged in farming were encouraged to also test and manage new lines on their own fields. .

- Farmers were given samples of 1 to 5 kg (usually 3 kg is adequate) of each of two or three varieties selected from the farmer-managed trials.
- Farmers planted these varieties on their own farms and managed by themselves.
- Researchers then visited the farms twice during the season; first visit was to ensure that the trial was established and the varieties could be identified and second visit was to ask farmers to rate the varieties relative to each other and to their variety.

Assessed the diffusion of lines selected through PVS

In 2004, the team assessed the dissemination of lines selected through PVS. A structured questionnaire was used to assess the spread of the PVS lines through the years. Qualitative information was also obtained through focus group discussions. Results showed that of all the varieties grown, 10.4 % and 17.6% in Faizabad and Siddarthnagar districts respectively were PVS lines[14] . The most frequent improved varieties used in Faizabad were Sarju-52, Swarna Mashuri and Sambha Mashuri. Similarly, in Siddarthnagar, Sambha Mashuri was still the most popular variety due to its high yields, suitability to land type, tolerance to moderate drought and submergence. Thus, it remains a challenge to introduce a variety, which is better than Sambha Mashuri. A higher proportion of the farmers in some pockets of Siddarthnagar still grow traditional varieties such as Sarya and Bengalia in uplands and Jarethwa, Lalsengar ,Darogwa and Bhaislot due to stress tolerance in low lying and flash flooded areas. Farmers have special interest for *Kalanamak* (traditional variety grown long time ago) and few other varieties, which are aromatic and command high price in the market. Hybrid rice is increasingly becoming popular in some areas of Faizabad where supplementary irrigation sources are available and which are nearer the markets where seeds are more accessible.

Measuring women's empowerment

Who makes the decision in rice varietal choice, acquisition and disposal is important in participatory rice varietal improvement. In India, which a patriarchal dominated society, the male heads of households are considered as the only decision-maker in the family. Decisions on rice production including varietal choice are often made by the male heads because they are the main income earners, have greater access to extension and training programs than women. Men are more mobile than women who are limited to move around due to social and religious restrictions. However, with the increasing out-migration of male family members in Faizabad and Siddarthnagar, women's roles are beginning to shift from unpaid family labor to *de facto* farm managers. In the research sites, the incidence of seasonal and long-term male labor out-migration is high. Wives are left behind with greater household and farm managerial responsibilities. Thus decision-making questions were related to the presence and absence of the principal males [14].

We hypothesized that the absence of male head impinges a larger burden on females in terms of household responsibilities and in the absence of males, female gain relatively more empowerment than in their presence. Thus, we tested a methodology for measuring women's empowerment. We hypothesized that women's empowerment is higher when she can make decisions even if her husband is present. Thus the wife is "highly empowered" when she gets a high score. Social scientists interviewed wives of cooperators and non-cooperators of PVS on their participation on decisions regarding varietal choice, acquisition and disposal. A women empowerment index (WEI) in rice production was derived by identifying the decision maker and activities where decision is made. The score is the women empowerment index where 1 = decision is made by other members in the absence of the husband; 2 = by husband, when he is present without consultation of wife, 3 = by wife in the absence of the husband; 4 = jointly by husband and wife, or jointly with others in the absence of the husband, 5 = by wife, even when husband is present . Results show that female cooperators both in the drought prone and submergence prone villages participate jointly with their husbands in making decisions regarding varietal choice. However, in the drought prone areas, wives are highly empowered in making decisions in keeping the seeds for the next season and whether to keep the seeds for consumption or sale[18].

Constraints in involving women in research activities

Despite the good intentions of including women from marginalized groups in the project activities, there were a number of constraints which the researchers faced during the duration of the project. These can be classified into social and cultural constraints, logistical problems, and institutional constraints (Table 9.2).

Social and cultural constraints

During the early village visits, it was difficult to convince marginal and lower caste farmers to try new seeds. There was a feeling of mistrust and suspicion on scientists

Table 9.2 **Constraints faced by the researchers in involving women and other disadvantaged groups in participatory rice varietal improvement projects**

Constraints /problems	Strategies to overcome these constraints
Social and cultural constraints	
Difficulty in convincing marginal and lower caste farmers to try new seeds.	The researchers explained goals and objectives of the project.
Mistrust and suspicion on scientists who ask too many questions during surveys	Social and biological scientist visited the villages frequently
Farmers among rainfed farms are worried that they will pay for the losses of new seeds due to drought	Assurance that they will not pay for the losses incurred due to biotic and abiotic stress. However, they need to take care of the seeds as they are expensive. They suit their landtype or soil type. They should keep the seeds to grow for the next season .
Poor women especially those who belong to the disadvantaged social groups were unwilling to join activities in the public domain. Poor women were busy with farm tasks and household chores	Researchers conducted their interviews with women inside their homesteads. Researchers adjusted the time of their interviews and meetings
Poor women lacked confidence in telling us their perceptions even though they are knowledgeable	Participatory ranking method using graphic illustration of traits was used like a gameResearchers built rapport by frequent visits in the village
Logistical problems	
Drudgery of females from farmer cooperators increased in harvesting and threshing small quantities	Elite lines/varieties to be grown and managed by farmers were reduced to 2-3
Limited seeds of new lines, restricted the number of cooperators especially the women	Seeds were brought from the farmers and multiplied in the experimental farms
Too many lines to rank in researcher-managed trials	Rating instead of ranking was used evaluating the new rice lines
Women farmers mixed the seeds of different lines	Men and women were trained on seed health improvement particularly maintaining purity of

	seeds from seedbed to planting until post harvest. Many followed the improved practice. New seeds were provided accordingly (2-4 kg) so they have less chances to mix.
Institutional constraints	
Lack of trained female scientists on participatory rice varietal improvement	Identified female social scientists/extension specialists to work with the interdisciplinary team. Training courses specified the need for nominating female participants.
Insensitivity of male scientists on social and gender issues	IRRI organized a training course on Impact of Rice Plant Breeding which includes PVS and social/gender analysis
Lack of trained scientists on the application of participatory approaches in research and extension	IRRI organized a training course on Applications of Participatory Approaches in Research and Extension which covers PVS and how to interact with men and women farmers.
Scientists' assumption that benefits of new varieties are scale and user neutral, that poor and rich farmers, men and women can have achieve the same type of benefit from new varieties	Social scientists facilitated focus groups discussions between plant breeder and different social categories of farmers especially on field days during evaluation of different lines. This helped changed a lot of assumptions.

who ask too many questions during surveys. Farmers among rainfed farms were worried that they will pay for the losses of new seeds due to drought or floods. To encourage farmer participation, the researchers explained the goals and objectives of the project and gave an assurance that they will not pay for the losses incurred due to biotic and abiotic stress. However, they need to carefully manage the seeds from production until storage and keep the purity of the seeds for the next season. The team also indicated that they will buy the seeds from the farmers for further distribution. Our women especially those who belong to the disadvantaged social groups were unwilling to join activities in the public domain. They were too busy with farm tasks and household chores.

Majority of the women interviewed were illiterate. They were hesitant to speak to male researchers, especially one on one. They required husband's or senior male's or mother-in-law's permission to engage in discussions outside their usual tasks. They lacked confidence in telling us their perceptions even though they are knowledgeable.

To overcome these constraints, female social scientists conducted their interviews inside their homesteads or in the fields where they work. Meetings were conducted separately for men and women to avoid the dominance of men in the discussions. Researchers adjusted the time of their interviews and meetings to allow the women to finish their household chores. They used participatory methods in the elicitation of traits they value. The research team also conducted frequent visits and informal interviews as individuals or by groups to build rapport with the women. Inclusion of a female member of the research team who could relate to the village women was most useful.

Logistical problems

The women complained that dehusking paddy manually and handthreshing the small quantities of new rice cultivars were too laborious and time consuming. There were too many lines to rank in researcher-managed trials. Thus, the varieties to be grown and managed by farmers were reduced to 2-3 varieties according to their landtypes. Rating instead of ranking was used in evaluating the new rice lines.

Limited seeds of new lines restricted the number of cooperators especially the women

During the 2nd year, the researchers bought seeds from farmer cooperators and multiplied them at the experimental farms. This increased the number of cooperators, including women who were willing to join the project and test the new lines on their own fields.

Women farmers mixed the seeds of different lines

Men and women were trained on seed health improvement particularly maintaining the purity of seeds from seedbed to planting until harvesting. Many followed this improved practice. New seeds were provided accordingly (2-4 kg) so that they have less chances to mix. A farmer participatory experiment comparing clean vs unclean seeds were initiated for those participated in the training course.

Institutional constraints

Farmer participatory research becomes a full time activity particularly during the peak seasons and when farmer ratings have to be done. Unfortunately, not all rainfed breeding programs have social scientists to work with plant breeders and farmers. Moreover, national research teams lack trained female social scientists on participatory rice varietal improvement. To overcome these constraints, IRRI organized a training course on Rice Breeding for Impact training course which includes topics and field practicum on PVS and social/gender analysis. This training course specified the need for nominating female participants. Training in PVS methods-including survey methodology and art of eliciting from farmers, not least women and marginalized groups is now part of the IRRI Training Center's advanced plant-breeding curriculum. Identified female social scientists/extension specialists to work with the interdisciplinary team.

Many male scientists are insensitive to social and gender issues. One reason for this is their perception that the male head of the household is the only farmer in the family and sole decision maker on household and farm-related matters. However, with the increasing male labor out migration, either on a short term or long term basis, women are compelled to make farm related decisions, including varietal choice. Another reason for lack of recognition on the important roles of women as farmers is scientists' assumption that benefits of new varieties are scale and user neutral, that poor and rich farmers, men and women can achieve the same type of benefit from new varieties.

To change these assumptions, IRRI organized a training course on "Applications of Participatory Approaches on Research and Extension which covers PVS and how to interact with men and women farmers. Social scientists facilitated focus group discussions between plant breeder and different social categories of farmers especially on field days during evaluation of different lines. This helped changed a lot of assumptions. Moreover, plant breeders who work with farmers now realize the importance of including women farmers in participatory research and extension. Thus, male agricultural scientists are now beginning to realize the importance of eliciting women's perspective particularly gender differences in selection criteria and preferred traits

Factors which influence farmers' selection criteria

Farmers select varieties based on several factors such as environmental, economic, cultural and social (Table 9.3) While it may be difficult to combine all their preferred traits into one unique variety because of genetic correlations, it is important that both men and women have a "basket of choices" of varieties suited to their needs and agroecosystems.They are discussed in the section below:

Table 9.3 **Male and female farmers' perceptions of useful traits in selecting rice varieties using graphic illustrations of traits, eastern Uttar Pradesh**

	Both male and female farmers	Male farmers only	Female farmers only
Lowland/ submergence	Grain yield Grain price Taste and aroma Post harvest quality Adaptation to soil/andtype Biomass quality	Tolerance to submergence Resistance to pest and diseases Responsive to fertilizer	Taste Cooking characteristics Shape of grains Competitiveness with weeds
Upland/drought prone (Faizabad)	Grain yield Duration Tolerance to drought Biomass quality Resistance to lodging Response to fertilizer	Biomass quality Response to fertilizer	Post harvest quality. Cooking characteristics Competitiveness to weeds
Lowland/ submergence prone (Faizabad)	Better grain yield Medium duration (125-135 days) Biomass quality Resistance to submergence or drought Adaptation to soil/landtype	Responsive to fertilizer Resistance to pest and diseases	Shape of grains (bold and pure) Cooking characteristics Postharvest quality Competitiveness with weeds

Source: Informal interviews by the authors

Environmental factors

Socio-economic surveys in eastern Uttar Pradesh revealed that a major determinant of varietal choice is the conscious attempt of farmers to match varieties with the landtype. Each field position in the topo-sequence corresponds to a risk of drought or submergence. In Faizabad (drought prone, more upland than lowland fields, dairy animal raising is more popular), farmers preferred genotypes with drought tolerance. In Siddarthnagar (submergence prone, more lowland than upland fields, less livestock,) farmers' prefer slightly late maturing genotypes, which have submergence tolerance and short fine/short medium bold grains. For the lowlands and submergence-prone ecosystem, long-duration, photoperiodsensitive, semi-tall and tall varieties were well adapted. For the uplands and shallow-depth medium lands, short to medium duration varieties, were preferred to escape the terminal drought

Economic, cultural and social factors

As farmers become integrated into the market they may prefer to specialize and plant a few high yielding modern varieties or high valued traditional rice varieties that provide them with higher incomes. In this project, farmers in Siddarthnagar prefer to grow "Kalanamak" with good aroma and premium price in the market, despite its low yields. They have a strong preference for aromatic varieties with long fine aromatic grain, because they are used as gifts for special occasions (marriage) and for religious ceremonies. Similarly, traditional varieties were perceived to be better for preparing puffed rice and other rice products Poor farmers were more interested in the quality of leftover rice that should remain tender and soft. These characteristics are found in traditional varieties.

Farmers preferred different grain types according to their socioeconomic status. In Faizabad, farmers and field workers of lower castes with small landholdings preferred varieties with bold/coarse grains, that give them a feeling of fullness or satiety due to their slow digestibility. Poor farmers who eat rice in mid morning prefer left over rice which remains soft (Table 9.4) The higher-caste farmers with large landholdings who sell rice to the market preferred fine slender grains that command a higher price. In general, small holder farmers from the lower castes used rice mainly for consumption, while farmers from the upper caste with more land sold their surplus. Farmers in the uplands of Hazaribagh preferred varieties that do not require high inputs. Farmers who depend on family labor preferred varieties with a range of maturity dates so that harvests can be staggered.

Gender-specific roles

Gender-specific roles in rice production, post harvest, consumption, and livestock care. At all the sites, there are gender-specific tasks in rice production. Women from poor farming households provided most of the labor in rice production (pulling seedlings, transplanting, weeding), post harvest (winnowing, handthreshing, seed drying), and seed management (selection and storage). Men were mainly responsible for land preparation, application of chemicals, and transporting inputs and products. As shown in Table 9.3, male and female farmers in Faizabad agreed that grain yield and duration were the most important traits when choosing varieties for upland and lowland areas. However, women gave more importance to such traits as competitiveness to weeds and post-harvest qualities such as ease of

Table 9.4 **Example of farmers' assessment of farmer-managed farms in submergence prone rice environments**

Lines (location)	Name	Positive traits/Negative traits
PV5	NDR9730015	Medium plant height Suitable to land type Submergence tolerant Medium/bold grain size Good straw good tillering capacity Good for puffed rice (female preference)
PVS 3 and PVS	NDR97300189	High yield (more than 4 t/ha) Suitable to land type Plants are taller (>1 meter) Stalks are sturdy Does not lodge Harvesting and threshing operations are slightly a problem because plants are tall (female opinion) Prefers NDR9730018 than NDR9930111 because of its grain size. It is long and slender and fine like Basmati. It has high demand for social occasions eg. wedding; Felt rich because they can eat rice like Basmati Sold all Sarju 52 which they used to grow Both varieties have long duration – 5-10 days late than Sambha and Sarju 52 which they commonly grow but will prepare nursery earlier. Left other lines NDR993011 because it has bold grains even though its yields are higher. Does not have good taste
PV510	NDR9730020	High yield – more grains per panicle than (NDR-40032) Suitable to land type Medium plant height Resistant to lodging (hardy stem) Resistant to pests and diseases Longer panicles Grains are long and cylindrical and finer than PV 59 (NDR9730013) Higher milling recovery Good taste Left over rice remains soft Good for special social occasions Easy to harvest and thresh Gives a feeling of satiety

Source: Paris et.al., [10].

dehusking, or threshing, and high milling recovery or suitability for different food preparations (e.g., puffed rice). Women prefer medium or semi-tall varieties that are easier to thresh, as well as varieties that have a good quantity and quality of rice straw for livestock. Moreover, they prefer varieties for specific rice products that they make such as puffed rice In other research sites in Raipur, Madhya Pradesh where participatory ranking of traits was done, women consistently identified straw quantity and quality as important, whereas the men never mentioned these criteria. Women's criteria for varietal selections were likely to be related to their roles and responsibilities [10,13]

Compatibility with existing cropping systems

For medium lands farmers preferred medium-height varieties (110-135 days) that allowed the timely sowing of a following crop of pulses, wheat or vegetables. In another research site in Bhubaneswar, Orissa, farmers rejected certain rice varieties that had dense root growth because they inhibited the establishment of a relay crop of pulses (black gram) broadcast into the standing rice crop [10] .

Other livelihood uses of rice and rice byproducts

Subsistence farmers choose varieties according to the adaptation to different user needs: food, livestock fodder, thatching roof, and cash. Farmers grew more than one variety not only because they farm heterogeneous rice fields but also for different end users. In the uplands, farmers preferred such tall varieties as Brown Gora, Vandana, RR151-3 and Kalinga III because they need the straw for animal fodder. Other farmers grew traditional varieties with a purple-pigmented based in drought-prone areas in Bihar, Madhya Pradesh, and Cuttack. This trait helped farmers distinguish weeds from rice especially in direct-seeded fields where weeds are a major problem [13].

Positive outcomes of social and gender analysis from the project

Advocates and practitioners of participatory research for development are optimistic that participatory rice varietal improvement projects show great promise for making varietal development efforts for unfavorable rice environments more responsive to the needs of technology users, particularly members of poor rural households that are not well integrated into the market economy [12,15]. How can participation lead to positive outcomes? Positive here means effectively bringing about changes that made technical and social science research more focused on poverty reduction and social inclusion issues. As the project's objective is to alleviate poverty and at the same time promote gender equity, the project seeks to involve different socio-economic categories of farming households and the marginalized groups particularly the women farmers living in stress environments, it is expected that the project will have a significant positive social impact.

We hypothesize that the incorporation of intended beneficiaries, both men and women, in the innovation process can affect the efficiency of the process itself. The interaction with researchers may affect the beneficiaries as well, both at the individual and community levels, by building social and human capital [16]. Below are the positive outcomes of including women in the rice varietal improvement process. Thus despite several above-mentioned constraints faced by researchers, several positive outcomes emanated by mainstreaming social and gender concerns in the rice breeding program. These are:

- Plant breeders have a clearer understanding of farmers' selection criteria including social (gender roles) and cultural differences which were considered in breeding objectives
- Inclusion of poor women as visiting farmers in evaluating the performance of new lines in researcher-managed trials (mother trial design)
- Farmers are exposed to many varieties of new lines and have many varieties to choose from
- Inclusion of active poor women farmers as farmer cooperators in farmer-managed trials
- Both men and women farmer-cooperators were able to make better objective evaluation of the new genotypes using their resources
- Promotion of farmers' rights particularly farmer to farmer exchange of new seeds
- Faster uptake of new varieties in rainfed areas
- Men and women have better access to seeds and new knowledge
- Approval of varieties from PVS by formal release system which do not only consider yields but also other traits by poor farmers who are subsistence oriented
- Farmers, men and women rather than the breeders make the final decision to accept or reject new varieties
- Improved women's empowerment
- Better understanding of the factors which influence women's empowerment

IRRI's Current Efforts in Mainstreaming Participatory Research and Gender Analysis in the Strategic Plan 2007-2015

Adopting the Millennium Development Goal (MDG) on eliminating extreme hunger and poverty opens profound new opportunities for IRRI to improve the economic and social wellbeing of poor rice consumers and farmers who are increasingly are female [17]. IRRI's mission for 2007 to 2015 is to reduce poverty and hunger, improve the health of rice farmers and consumers and ensure environmental sustainability through collaborative research, partnerships and strengthening of national agricultural research and extension systems. Under MDG1, some of the objectives are to:

a) enhance household food security and income in rainfed areas of Asia through improved varieties and management practices that can double yield and reduce yield variability under stress conditions. Research will focus on the development of elite disease and pest-resistant lines and management practices that can double current yields in drought-prone, submergence prone, and salt-affected areas and demonstrate the potential with farmer participatory research at selected sites particularly in eastern India

b) *improve food security and farmers' income in rice-growing countries in East and Southern Africa through improved rice varieties and cropping systems*. Research will demonstrate in at least three countries improved varieties with yield of at least 4 tons per hectare and crop management practices that are compatible with the needs of women farmers.

c) *develop new genotypes that can potentially double yield under drought stress in rainfed environments*. One of the targets to meet this objective is to tag alleles that increase rice productivity under drought stress for marker-aided breeding and validate them in farmers' field through participatory experiments and use them widely in NARES breeding program.

Under MDG 3, some of the objectives are to:

a) enhance the nutrient content of 20 percent of the rice produced in targeted areas of endemic poverty

b) reduce the prevalence of mineral (iron and zinc) and vitamin A deficiencies in women and children in targeted areas of endemic poverty through consumption of more nutritious rice.

Challenges Ahead

Introducing PVS into a rice varietal development program can help accelerate the adoption of improved varieties developed for rainfed rice environments which can tolerate drought, submergenc and sodicity. IRRI recommends that PVS should be included as a standard process of all rainfed rice breeding programs dealing with rainfed environments. However PRGA in IRRI in collaboration with NARES, have to deal with several challenges:

1. *Validation of elite lines of pre-released varieties on farmers' fields as a standard component of the plant breeding process*. Biotechnology, and the use of gene mapping and marker aided selection have much to offer for the development of varieties tolerant to submergence, drought and sodic soils. For example, already a gene for submergence tolerance (Sub1) has been incorporated into Swarma, a widely grown variety in South Asia, which is being validated by NARS through farmer-participatory experiments in eastern Uttar Pradesh, India and Bangladesh. The improved germplasm can withstand submergence 10-12 days. Another gene for salt-tolerance (Saltol) has been fine mapped, and has been introgressed with marker assisted breeding to develop improved lines [17].

Minor genes for various sub-component traits of drought tolerance in rice have been mapped, and this information is being utilized to develop improved varieties with drought tolerance. Promising genotypes are ready to be included in PVS in eastern India.

If rice research succeeds in incorporating modern traits that help withstand climatic and soil related stresses, modern varieties will be adopted more extensively in the unfavorable ecosystems. The yield stability of the varieties will reduce risk in rice cultivation, thereby providing incentives to farmers to adopt modern varieties and to apply inputs in optimal amounts that will, in turn lead to further yield increases

2. Develop and test more efficient and reliable methods of eliciting methods and analyzing end-user preferences particularly for farmer-managed trials.

3. Determine modes of participation that ensure equitable compensation for participating farmers.

4. Develop varietal evaluation methods capable of generating credible data of widespread acceptability

5. Data on farmer perceptions and demand for seed need to be considered by varietal release committees, rather than the almost total reliance presently placed on yield data from scientist-managed yield trials.

References

1. Ashby, J.A., (1997). What do we mean by participatory research in agriculture?. In: New Frontiers in Participatory Research and Gender Analysis: proceedings. Centro Internacional de Agricultura Tropical

2. Morris Michael. and Bellon Mauricio., (2004), Participatory plant breeding research: opportunities and challenges for the international crop improvement system. Euphytica **136**: 21-35, 2004

3. Gujit. and Shah., (1998), The myth of community : gender issues in participatory development. London: Intermediate Technology Publications

4. Castillo, G., 2006, Participatory research and development in practice: A review of reports from the capacity development program for PR & D in South Asia. Unpublished Mimeo. CIP-UPWARD, Philippines.

5. Virk, D., 1998. The regulatory framework for varietal testing and release in India. In: J.R. Whitcombe, D.S.,Virk & J. Farrington (Eds). Seeds of Choice: Making the Most of New Varieties for Small Farmers, pp. 69-84. Intermediate Technology Publications, London, UK.

6. Krishnagar ,K.G. and Pandey, S., 1995, Diversity of rice cultivars in a rainfed village in the Orissa State of India. In: Proc Seminar 'Using diversity: enhancing and maintaining genetic resources on farm', June 19-21, 1995. International Development Research Center, New Delhi, India.

7. Courtois, B., Singh Bartolome,B., Chaudhury, D., McLaren ,G., Misra, C.G., Mandal ,N.P., Pandey ,S., Paris, T.P., Piggin, C., Prasad ,K., Roy ,A.T., Sahu, R.K., Sahu, V.N., Sarkarung ,S., Sharma, S.K., Singh, A., Singh, H.N., Singh, O.N., Singh, N.K., Singh, R.K., Singh, R.K., Singh, S., Sinha, P.K., Sisodia, B.V.S. and Takur, R.. 2001, "Comparing farmers and breeders ranking in varietal selection for low-input environments: a case of rainfed rice in eastern India. Euphytica **122**: 537-501, 2001. Kluwer Academic Publishers, Netherlands.

8. Witcombe, J.R., Joshi, A., Joshi, K.D. and Sthapit, B.R., 1996. Farmer participatory crop improvement: I. Varietal selection and breeding methods and their impact on biodiversity. Experimental Agriculture **22**:443-460.

9. Ceccarelli, S., Bailey, E., Grando, S. and Tutwiler, 1997. Decentralized, participatory plant breeding: a link between formal plant breeding and small farmers. In: New Frontiers in Participatory Research and Gender Analysis, pp65-74, CIAT, Cali, Columbia

10. Paris, T.R., Singh ,A., Luis, J., Hossain, M., Singh HN., Singh, S., and Singh, ON. 2001. "Incorporating gender concerns in participatory rice breeding and varietal

selection: preliminary results from eastern India. In Lilja, N., Ashby, A. and Sperling, L., (eds) Sept. 2001. Assessing the impact of participatory research and gender analysis. Cali Columbia: Participatory research and gender analysis program, Coordination office; International Center for Tropical Agriculture.

11. Atlin, G. and Paris, T., 2004, Participatory Variety Trials for Rainfed Rice Cultivar. Training Material for Plant Breeding Training Course. International Rice Research Institute (IRRI) Rice Knowledge Bank. IRRI, Los Banos, Laguna.

12. Sperling, L., Ashby, J., Smith, M., Welzien, E. and McGuire, S., (2001). A framework for analyzing participatory plant breeding approaches and results. Euphytica No.**122** No 3 (2001).

13. Sahu, R.K., Sahu,V.N., Sharma,M.L., Paris,T.R., McAllister,K., Singh,R.K. and Sarkarung, S., 2001, Understanding farmers' selection criteria for rice varieties: a case in Madhya Pradesh, eastern India. In CIAT 2001. An Exchange of Experiences form South and Southeast Asia. Proceedings of the International Symposium on Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement, Pokhara, Nepal, 1-5 May 2000. Cali, Columbia: Centro Internacional de Agricultural.

14. Paris, T, Singh A, Luis J and Hossain M (2005). Impact of male outmigration on rice household economic and gender roles: a case in eastern Uttar Pradesh, India. Economic and Political Weekly Vol XL, No. 25 June 18-24, New Delhi, India pp. 2522-2529.

15. Almekinders, C.J.M. and Elings, A., 2001, Collaboration of farmers and breeders: participatory crop improvement in perspective. Euphytica **122**:425-438.

16. Johnson, N., Lilja ,N. and Ashby, J., (2000). Using participatory research and gender analysis in natural resource management. Working Document No.10. Consultative Group of Internatinoal Agricultural Research (CGIAR). Participatory Research and Gender Analysis. Centro Internacional de Agricultura Cali, Columbia: Centro Internacional de Agricultura

17. International Rice Research Institute (IRRI) 2006. Bringing hope, improving lives. Strategic Plan 2007-2015. International Rice Research Institute, Los Banos, Laguna, **61** pp.

18. Paris, T, Singh A, Singh V.N and Atlin G (2005) Assessing the impact of participatory research on rice breeding on poor rice-farming households with emphasis on women farmers: A case study in selected districts in eastern Uttar Pradesh, India. Eds (Lilja N, Dixon J, Manners G, La Rovere R, Helling J and Feldstein H.S. In New Avenues in Impact Assessment on Participatory Research and Gender Analysis. Summary Proceedings of the Impact Assessment Workshop, held at CIMMYT Headquarters, Texcoco, Mexico, October 19-21, 2005,p.**38**

10

Gendered Knowledge and Gender Relations: Case studies in Two Agro-biodiversity-rich Locations

R.Rengalakshmi, Smita Mishra, Susanta Sekhar Chaudhury, E.D.Israel Oliver King and Trilochana Ray

The expression "Knowledge is Power" is common, but assumes special significance in the contemporary context, where the future is seen as a "Knowledge Society" and those without knowledge are seen to be disempowered. Women in traditional agricultural communities around the world have long been known for their specialized knowledge related to seeds including selection, storage, management and exchange. Experiential knowledge arises out of the experiences and routines of daily life, and hence gendered knowledge also arises from the gendered roles and responsibilities of men and women in different situations and communities. It is argued that in traditional agricultural communities, this experiential knowledge gave women an important role in decision-making, at both the family and community levels. In consequence, status accrued to women at both levels, contributing to equitable power relations between genders.

But in the modern world, no community is isolated from larger social and technological changes, and in the era of globalization, the speed and nature of change have become both bewilderingly rapid and full of novel and unpredictable elements. Changes in the agricultural production systems across different agro-ecosystems have led to consequent changes in gender roles, responsibilities and knowledge. How are these changes affecting gender relations/women's status? How does agro-biodiversity loss relate to the possibilities for knowledge as power? Is women's traditional specialized knowledge still valued, and valued enough to give them social status? On the other hand, if circumstances lead to lack of demand for such knowledge, and it becomes socially devalued, how would this affect gender relations at the family and community level? These questions were sought to be explored in two traditional communities in two different locations, well known for their rich agro-biodiversity, one in small millets and the other in rice. The paper is an exploration of themes, theorizing on the data available as a result of M.S.Swaminathan Research Foundation's (MSSRF) field interventions.

Keywords: Gender, power, tribal women, Agrobiodiversity, gendered knowledge, seed selection.

Gendered Knowledge In Two Communities

The Two Locations

The two sites, Kolli Hills and Jeypore, are located in the Eastern Ghats with varying climate and cultural characteristics. A culturally homogenous *Malayali* tribal group inhabits Kolli Hills in Tamil Nadu, whereas in the Jeypore tract (undivided Koraput district), Orissa, twenty-nine tribal communities are present, of which three groups namely, *Gadaba, Paroja* and *Bhumia* are dominant in the study area. Diversity of small millets in Kolli Hills and traditional landraces of paddy in Jeypore are the focus of attention in this paper.

Malayalis in Kolli Hills are early migrants from the plains at the beginning of the sixteenth century[1]. The mainstay of the economy is agriculture, combined with cattle herding and pig rearing, supplemented by collecting Non-Timber Forest Products (NTFP), and by working as labourers in coffee plantations or migration to other districts/states as wage labourers. Little millet, proso millet, kodo millet and Italian millet are the four common small millet species which have been cultivated with wider intra-specific diversity on terraced beds (mid slope) as well as rocky terrain (highest slope) under rainfed conditions. Of the total workers, 88 % are cultivators (of whom 90 percent are small and marginal holders), 7 % are agricultural labourers and 5 % are other workers[2]. Small millets, grain legumes and wild yams supplemented with rice and wheat served as their staple food. The traditional agriculture of Malayali people has been undergoing changes during the last three decades, due to the introduction of cash crops such as tapioca, coffee and pineapple[3]. Consequently their diet have changed and the main staple today is rice.

In Jeypore, however, the tribes are original inhabitants who have domesticated rice[4]. Agriculture is the main activity, supplemented by NTFP collection, hunting, fishing and wage-earning. Both shifting cultivation and settled agriculture are practised under rainfed conditions at the subsistence scale, and cultivation is carried out at different altitudes[5]. Of the total workers, 39 % are farmers (70% of which are small and marginal farmers), 26 % are agricultural labourers and the remaining 35 % are other workers[6]. Rice is the main crop raised in three distinct seasons. Rice supplemented with ragi, pulses, vegetables and forest products form the staple food. In recent years, sugarcane, maize, tobacco, ginger, vegetables and cashew are being grown as cash crops in uplands[7].

Loss of Crop Genetic Resources

During the last century, agro-biodiversity loss has been triggered by many factors. Advances in enhancing the productivity of major crops like wheat, rice and maize have resulted in the replacement of numerous minor cereals and millets, legumes, tubers, oilseeds and vegetables. The loss is also associated with changes in the local culture and dietary habits over time. Today, the fate of global food security is linked to the performance of less than ten crops out of nearly 7000 edible species[8]. Besides threats to global and national food security, hidden hunger and malnutrition arising from dependence on too few crops are likely to have a negative impact in the future. Also, the disappearance of agro-biodiversity results in loss of local knowledge on the management and conservation of local resources[9]. Most importantly, gender issues of roles, access, control and decision-making and related local knowledge systems have undergone changes, and marginalized women's knowledge and status[10] and decision-making power[11].

In both the study sites, the area under cultivation as well as the number of landraces has been declining. The area under cultivation of sorghum, pearl millet and small millets in Kolli Hills has declined from 1799 ha during 1970-71 to 766 ha during 2003-04. During 1883, tapioca was not even listed as a cultivated crop in Kolli Hills[12], whereas in 2003-04, the area under the crop was 5,848 ha. This was mainly due to assured market linkages, better prices and crop loans for cultivation[13]. In proportion to the decline in area, landrace diversity has become reduced, as farmers excluded certain landraces largely due to changes in the cropping system geared to commercial crops[14]. Agricultural intensification driven by the assured market for tapioca, lack of market for small millets, less supportive government policies, erratic climatic factors, drudgery in processing of millets and decline in per capita land availability are other important factors speeding up the erosion of diversity of millets. The introduction of rice in the Public Distribution System (PDS) and Noon Meals Programme in schools has begun to have an impact on culinary preferences. In addition, the menace of wild animals and changes in cultural values and lifestyles has reduced the preference for millets[14].

Jeypore tract being the secondary centre of origin of rice, the diversity of rice landraces here is enormous. To explore and collect the extant rice germplasm, the Central Rice Research Institute, Cuttack, India collected about 1,750 land races of rice from the Jeypore tract in 1955-60. But in 1995-96, the MSSRF could document only 256 land races of rice from the area[15], pointing to the rapid rate of loss of genetic diversity in a span of forty years. An important factor behind this loss was the spread of High Yielding rice Varieties (HYV) with subsidies for seed and fertilizers by Government agencies. In fact, by 1996-97, thirty-six percent of the land was under HYV[16] and by 2005-06 this became eighty five percent[6]. Presently, only small and marginal farmers in remote areas cultivate land races. Recently, the central area of the Jeypore tract received irrigation facilities from Kolab river, which has brought more area under high-yielding rice and commercial crops like sugarcane, maize, cotton, and sunflower, with improved vegetable varieties[7].

Gender Relations and Practices

The prevailing gender relations both at the household and community levels in the two sites show differences as well as commonalities in different aspects.

To take commonalities first, in both the communities, family type is nuclear (even though joint family is the ideal norm in Kolli Hills), descent is traced through the male line, society is patrilineal and residence is patrilocal. Divorce and initiative for divorce can be from either spouse, and the father takes responsibility for the children of divorced parents in both the sites. Similarly, in both the cases, women do not inherit land or any other permanent assets, despite their substantial contribution to the household economy. Also, leadership is restricted to male members only in the traditional Panchayat, and also for priests and traditional healers' in both sites. However, in the absence of male children, daughters may inherit property[17,18]. In both the sites, men and women are involved in local marketing; women take the lead in local trade, while men lead in marketing products that involve external traders and cash transactions[7,19].

There are also differences between the two communities. For example, traditionally polygamy (men with more than one wife) was allowed in Kolli Hills, but now monogamy is practised; while in Jeypore, monogamy, and arranged marriages are considered ideal, with the consent of both son and daughter, but personal choices are accepted. In Kolli Hills, the daughter on her marriage is now given dowry either in cash or kind, though earlier bride price was practised; whereas in Jeypore bride price is still the custom[17,18]. In Kolli Hills Sankritised god worship is common, mother goddess and ancestral worship are still common in sacred forests[20] and Christianization is a recent trend in the terrain due to evangelical movements of different denominations and missions of Christianity, whereas in

Jeypore animism, nature worship, fetishism and ancestor worship are still common. In both the sites, women have access to all types of lands. However, in Kolli Hills, decisions related to the choice of crop are seldom decided by both, and mostly men decide[21], while in Jeypore women make decisions on mixed farming in uplands, and in addition to that, joint decision-making is the norm for medium and low land. Women have control over their own income and manage the household in both the sites, but in Kolli Hills men have control over common earnings. Traditional Panchayat systems are completely dominated by men; and women are not allowed even to participate in the meetings in Kolli Hills. However, but rarely, a woman may attend, if her presence is essential for finding a solution to a specific problem related to her, such as divorce[17], whereas in Jeypore women participate in the *palli samithi* meetings. Regarding mobility, Jeypore women are much freer compared to Kolli Hills, where women's mobility is restricted to the market and relatives' houses. Nowadays, after the formation of Self Help Groups, women are going to banks, government departments etc on their own in both the sites[7,19].

This brief comparative account of selected ethnographic details gathered in two different tribal cultural contexts indicates that gender relations are somewhat more egalitarian in Jeypore than in Kolli Hills.

The roles and responsibilities of women and men in small millet cultivation in Kolli Hills indicated that women do most of the tasks, which need more energy and time when compared to men[21] and require specialized skills and do not involve any money transactions[22].

Gender Roles and Responsibilities in Seed Management

Social, economic and cultural factors determine the gender division of labour, which in turn influences responsibilities, knowledge and decision-making capacity in various agricultural activities. However, the roles are dynamic depending upon changes in the socio-economic, cultural and political climate. According to Davison[23] the gender relations of production are socio-economic relations between men and women described by differential labour tasks, control over resources (land and income) and decision-making. The role and responsibility of men and women of the two tribal communities of both Jeypore and Kolli Hills vary widely. In small millet cultivation, the critical area is decision-making, especially in crop selection and agronomic management, and in this regard gendered knowledge plays an important role. Table 10.1 clearly discloses the structure of roles and

Table 10.1 **Gendered roles and decision-making in seed management, exchange and utilization**

Roles	Kolli Hills[21]						Jeypore[24]					
	Women		Men		Both		Women		Men		Both	
	R	DM	R	DM	R	DM	R	DM	R	DM	R	DM
Seed Management												
1. Identifying quality grains	✓	✓	-	-	-	-	-	-	-	-	✓	✓
2. Separating quality grains for seeds	✓	✓	-	-	-	-	✓	-	-	-	-	✓
3. Drying with care	✓	✓	-	-	-	-	✓	✓	-	-		-
4. Seed treatment (plant leaves /other methods)	✓	✓	-	-	-	-	✓	-	-	-	-	✓
5. Arranging storage containers & cleaning	✓	✓	-	-	-	-	✓	✓	-	-	-	-
6. Monitoring of pests and periodical drying	✓	✓	-	-	-	-	✓	✓	-	-	-	-
7. Storing seeds	✓	✓	-	-	-	-	✓	-	-	-	-	✓
8. Checking seed quality	✓	✓	-	-	-	-	-	-	-	-	✓	✓
Seed Exchange												
9. Managing seed lending	✓	✓	-	-	-	-	-	-	✓	-	-	✓
10. Checking seed quality before exchange	✓	✓	-	-	-	-	-	-	-	-	✓	✓
11. Getting back the seeds from borrowers	✓	✓	-	-	-	-	-	-	✓	-	-	✓
Seed Utilization												
12. Monitoring pests	✓	✓	-	-	-	-	✓	-	-	-	-	✓
13. Winnowing			-	-	-	-	✓	✓	-	-	-	-
14. Drying	✓	✓	-	-	-	-	✓	✓	-	-	-	-
15. Pounding and polishing	✓	✓	-	-	-	-	✓	✓	-	-	-	-
16. Removing stones and chaff	✓	✓	-	-	-	-	✓	✓	-	-	-	-
17. Preparation of food items	✓	✓	-	-	-	-	✓	✓	-	-	-	-
18. Storing and using husk as pig/cattle feed	✓	✓	-	-	-	-	✓	-	-	-	-	✓

R- Role , DM – Decision making

decision-making processes of men and women in seed management, exchange and utilization in the two sites.

Table 10.2 summarizes the gendered contributions to varietal selection. Though both men and women are involved in crop selection, knowledge of varietal characteristics, as well as selection criteria varies, largely due to the gender division of labour and age. In Kolli Hills, older women (> 40 years) identify and classify using phenotypic characters, geographical distribution, agronomy, relative gastronomical qualities and use more than the younger generation (<40 years) The younger age group is often not able to distinguish much among the various landraces, perhaps due to the lack of experience and less frequency of interaction with different landraces[25]. The study on wild foods among the tribal communities of Wayanad district of Kerala also confirms that along with gender, age is also an important variable in differential knowledge[26].

However, in spite of women's vital role in seed management, generally women are not involved in the crop improvement programmes. Swaminathan[28] pointed out that very little research is in progress on the role of women in the conservation and sustainable management of biodiversity. At the same time, when women's knowledge and skill are lost, it not only leads to decline in agro biodiversity, especially among under-utilized and neglected species/varieties, but also to loss of status for women[29].

Findings From Interventions

In this backdrop, an attempt was made to study how interventions to strengthen the conservation, enhancement and utilization of agro-biodiversity in the two sites affected the process of agro-biodiversity loss, adding value to women's knowledge and consequently affecting women's status/gender relations. The interventions tried between 1999-2000 to 2005-06 to revive the cultivation of small millets in Kolli Hills were through creating demand and market linkages, while in Jeypore between 2000-01 to 2005-06 the productivity of traditional paddy landraces were enhanced through crop improvement. In the process, laterally cultivation-enabling services like seed banks, market linkages, and drudgery reduction in processing were facilitated. Market linkages and Community Seed Banks (CSB) in both the sites, and crop improvement in Jeypore were the chosen intervention activities. Studies of the gender roles and responsibilities in agriculture, especially with regard to seed selection and management had already been carried out in Kolli Hills[21], and were carried out in Jeypore during the interventions[24] casting light on gendered knowledge and practices.

Table 10.2 **Gendered knowledge, criteria and decision making in seed selection**

Category	Kolli Hills	Jeypore
Knowledge of landrace characters/ characterization	Women use geographical distribution, edaphic requirements, plant height, shape/ arrangement of grain in panicle, ease in processing, meal quality, and impact on health; men use method of harvesting, cropping system and maturity periods and productivity[25].	Women use leaf sheath colour, husk and grain tip color; men use grain taste, panicle weight and degree of grain filling. Both use plant height, panicle length and tillering vigor[24].
Criteria for selection of seed	In panicle selection, both men and women use size, maturity of the panicle, and absence of chaff, ill-filled grains, and pest and disease infection. But men use good panicle alone as main criterion whereas women consider vigor of whole plant with well-filled grains in panicles[14].	In field selection, the whole family is involved, and uses disease- free plants, lengthy, well-filled panicles, and bright-coloured huselection of seed sk as criteria. In the threshing yard, women alone are involved and collect, clean and remove under-sized, off-colored grains/ stones[7].
Preferences for landrace selection	Stability and productivity by men, meal quality, resource availability, easy of processing and multiple uses of the crop by women[21].	Women consider cooking quality, suitability for value-addition like popped/puffed rice, milling quality, rice: husk ratio and men look for taste, yield potential and market value [27].

I. Interventions in Kolli Hills

The various factors responsible for the decline in millets production over the last few years, leading to the disappearance of many landraces, has already been mentioned. It was therefore felt that developing a strong market demand would be a new and powerful strategy to promote the cultivation of this nutritious food crop, and conserve biodiversity represented in the landraces. Reduction of the drudgery of women involved in processing was facilitated by putting in place dehusking machines and new mechanisms developed to make seeds available in desired quantity.

Market Linkages

These were developed in two phases. In the first phase, a direct market linkage was established between the local cultivators and the Tribal Co-operative Marketing Development Federation of India Ltd. (TRIFED), the government marketing agency for tribal produce, to sell the product as whole grain without any value addition. Women and men millet growers from 30 villages were mobilized into seventeen Self Help Groups (both men and women were members of SHGs) with equal representation to all the millet-growing areas. Area-based procurement centers were opened in the villages where SHGs functioned, which helped farmers to sell the grains directly. Price fixation was also done in a participatory way, and women were involved in making decisions on the prices. From the second year onwards, the minimum procurement price was announced even before cultivation began, and assurance was given by TRIFED to buy the product from farmers, which encouraged farmers to cultivate small millets. Table 10.3 indicates the amount of grains marketed during this period through TRIFED[30] with a small gain of about Rs 1000 per household in a year (three to five months crop duration in a year). This arrangement came to an end in 2002 due to the price offered by the TRIFED being lower than the previous year.

Table 10.3 **Quantity of small millet grains marketed through TRIFED**

Year	Quantity (Kilograms)	No. of farm households	Gross return to farmers (Rs)
1999-2000	10,000	56	65,000
2000-01	12,500	88	84,375
2001-02	12,500	112	86,250

In the second phase, from 2002-05, a different system was organised; dehusked grains and flour were marketed in urban centers (both metropolitan and local), to enable farmers to get an additional Rs 1 per kg, and also as an income-generating activity for the SHGs. A diesel-driven dehusking machine was introduced in two villages, with the twin objectives of catering to market demand and increasing local consumption by reducing women's drudgery. An additional facility to mill paddy grains was launched as a microenterprise to two SHGs (one mixed SHG group in the northern part and one men SHG in the southern part). Table 10.4 indicates the amount of millets marketed as value-added products and the gross return to the local men SHGs. The returns to value-addition are significantly higher than the returns to farmers.

Table 10.4 **Quantity of dehusked grains/powdered small millets marketed in urban centers**

Year	Urban-metropolitan		Urban-local level		No.of farm	Gross returns (Rs)	
	Little millet (kg)	Italian millet (kg)	Little millet (kg)	Italian millet (kg)	households supplying grain	Farm house holds	SHGs
2002	5600	5000	-	-	53	68,900	2,65,000
2003	1400	1200	120	130	29	18,525	65,625
2004	5600	5200	119	130	73	74,583	2,20,988
2005	3500	3000	940	545	64	53,898	1,67,125

In this system, processed product marketing was entirely carried out by the men SHG and women SHGs were involved in local grain procurement.

Community Seed Banks

Farmers' decisions on the seed source are a critical variable influencing genetic variation. They usually prefer to use their own source of seed, and in case of need, they get seeds from neighboring farmers through seed exchange, which is considered the most reliable source of seed. Farmers, especially women, resort to exchange when genetic/agronomic performance of the cultivated landraces is poor, or at the time of seed scarcity resulting from crop failures, or temporary discontinuity in cultivation (3-4 years). The traditional horizontal seed networking among farmers has evolved to facilitate access and ensure availability of seeds, but though the network is functioning effectively in Kolli Hills, the intensity of the process has been declining over the last two decades as a result of reduction in the area under millets. To ensure availability of seed at the village level, five CSBs were established, managed by five SHGs (four women and one mixed), covering an average of four to five nearby hamlets each. On an average, there were 10-12 members in a group; in the case of the mixed group, care was taken to include women in leadership positions either as Secretary or President. The management follows the traditional seed exchange norms; the kind of landraces stored in each of the CSBs varies depending upon the local requirement, and SHGs decide this at the time of establishment. Table 10.5 shows the role of women and men in the management of the seed bank. Women carry out almost all the activities[21].

Table 10.5 **Activities of women and men in Seed Bank**

	Activity	Kolli Hills		Jeypore		
		Women only	Both Men & women	Men	Women	Both
1.	Collection/deposition	-	✓	-	-	✓
2.	Maintaining registers	✓	-	✓	-	-
3.	Seed weight measurement	-	✓	-	-	✓
4.	Checking physical seed purity	✓	-	-	✓	-
5.	Drying of seeds	✓	-	-	✓	-
6.	Cleaning of seeds	✓	-	-	✓	-
7.	Insect control with mix of dried leaves	✓	-	-	✓	-
8.	Monitoring storage pests	✓	-	-	✓	-
9.	Seed germination	✓	-	-	-	✓
10.	Lending to farmers	-	✓	-	-	✓
11.	Cleaning and periodical maintenance	✓	-	-	✓	-

II. Interventions in Jeypore

In Jeypore, it was found that the major problem with landraces was their low yield leading to a cycle of poverty. Tribal farmers were also unable to cultivate HYVs due to lack of access to assured irrigation and inputs. Non-availability of quality seeds or financial support for proper cultivation of landraces compounded the problems, resulting in shortfalls in annual food consumption and low incomes. In order to improve productivity and production while conserving and enhancing the genetic diversity of landraces, agronomic intervention and crop improvement activities were selected as the major strategy. In addition, facilitating and strengthening the supply of local seeds was also taken up as a supportive strategy.

Crop Improvement/Participatory Plant Breeding

The common agronomic problems associated with low productivity were sub optimal land preparation, use of impure and poor quality seeds and broadcasting of seeds. To overcome these constraints, land preparation with farmyard manure, selection of seeds before sowing, raising of nurseries with line sowing, line transplanting and selection of main panicles for seed were introduced. Intensive training on these modified agronomic practices was conducted and targeted at agricultural operations that have a bearing on both women and men.

Seed purification was initiated in 1998 to tap the yield potential of the landraces. Out of 26 land races, six land races (two best land races from each land category) were selected by farm families according to their yield performance, for large-scale demonstration in 2000. At the end of this exercise, the land race *Kalajeera* (average 4 tons/ha) was found to have a potential for gainful marketing for its quality and selected for large-scale production and marketing[31]. In this process, women's knowledge and skills (Table 10.2) were fully drawn upon and utilized, making them full partners in the process. Training was provided on seed selection before harvest. Farm families, particularly women, learnt to select panicles from the mother and primary tiller and successive steps of seed purification. Over a period of three years, this led to better quality seeds and increased yield (Table 10.6).

Table 10.6 **Spread and yield of *Kalajeera***

Details	2002	2005
Villages	5	11
Area (Acres)	14.2	67
No of farm families	26	83
Total Grain Yield (t)	13.80	29.30 grain sold to NAFED 8.50 grain self consumption and 7.50 pure seeds

Market linkages

Increased productivity due to improved agronomic practices and seed purification stimulated interest among farmers leading to an increase in the area under cultivation of landraces. '*Kalajeera* was planted for sale of seeds and grains, and other landraces for consumption. Earlier, farmers were not able to meet their subsistence needs, but now the interventions resulted in surplus grain for sale in the market'[32]. Three kinds of market linkages were developed. Initially sales were promoted in only exhibitions and fairs like PARAV - 03 at Koraput and International Year of Rice 2004 celebrations at Jeypore for *Kalajeera.* Local marketing of the grain was promoted as nutritious hand-pounded rice. 2500 kg of hand-pounded rice @ Rs.18.00 to 20.00/kg were sold in local markets and also through door-to-door campaigns[33]. In 2005, a market linkage was established with NAFED (National Agricultural Co-operative Federation of India Ltd.) and 29.3 tons of grains @ Rs 10/kg were sold.

Community Seed Banks

Traditionally, farmers exchange seeds by borrowing them from neighbors and friends, and returning them with interest at the time of harvest. This mode was adopted as a management practice in the CSB. Trainings were provided on CSB management, distribution, sale, and record keeping. CSB have been set up in seven villages, each managed by a local management committee consisting of a President and Secretary (male in the case of all but one woman President) and four members, three of whom are women. This has boosted the confidence of women in collective management of seeds as well as providing choice, quality, safe storage and timely availability of seed. In addition to this, the process of pure seed production has been initiated in seven villages, thereby providing seed security at the village level. There has been continuous increase in the number of borrowers and the quantity of seed transacted over the years. Men and women's roles in Seed Bank functions are given in Table 10.5 [24]. Women have an increased workload as well as responsibilities as a result of this activity, but cannot participate in record keeping because of their less education as well as tight workload.

Discussion

In order to study the impact of these activities on gender relations/women's status, the area under millet cultivation in Kolli Hills was taken as a proxy indicator to assess the changes, because women's skills and knowledge are maximally utilized in the cultivation of small millets. In Jeypore, the area, spread and improved productivity of landraces were taken as proxy indicators, because of women's high involvement in the entire process, and the utilization of their knowledge and skills in the conservation and cultivation of paddy landraces.

In Kolli Hills, since the introduction of a cash crop from the 1980s on a large scale with buyback arrangements from nearby agro-industries located in the foothills, Kolli Hills agriculture started to shift from subsistence towards commercial farming and traders emerged as a strong force. The area under small millets cultivation started declining rapidly between 1970-71 and 1999-2000; however, since 2000, there has been slight increase in the area under cultivation (Table 10.7). It is not possible to say on the basis of one year's data if the trend has been arrested or reversed permanently. Market linkages, value addition and access to dehusking facility in Kolli Hills might have generated some awareness and motivation to take up cultivation among both women and men farmers. But it should be noted that such small interventions might not be enough to arrest or reverse the overall decline over the entire area. It is suggested that with the continuing decline in area under millets, and consequent decline in the use of and demand for women's

Table 10.7 **Declining trend in cultivation of millets in Kolli Hills**

Year	Little millet (samai)	Italian millet (thinai)	Kodomillet (varagu)	Prosomillet (Panivaragu)	Total
1970-71	-	-	-	-	1799
1996-97	-	-	-	-	967
1999-2000	135	189	141	-	465
2000-01	227	176	161	103	667
2001-02	224	168	159	100	651
2002-03	252	172	163	60	647
2003-04	323	243	141	59	766

Source: Department of Agriculture, Namakkal, Tamil Nadu[34]

specialized knowledge and skills, the social value of women's gendered knowledge would also decline, adversely affecting women's status in the family and community.

In Jeypore, an opposite trend is indicated by the increase in productivity, area and spread across a number of villages of the cultivation of landraces, notably *Kalajeera*, in the region, as a result of improved agronomic practices and seed purification (Table 10.6). Women's traditional knowledge and skills in seed selection (Table 10.1 and 10.2) have been fully utilized in these activities. In addition, intervention on improved agronomic practices has helped the women to gain new skills and knowledge on cultivation, reduced women's burden in weeding and harvesting, and given them more employment days in paddy transplanting. So it is postulated that women's status in both family and community will remain at the current level or increase, since their knowledge is valued.

With regard to women's role in marketing as well as in CSBs the situation is somewhat different. Women's participation in marketing is directly linked to its location. The earlier phase of direct marketing of grains at Kolli Hills itself facilitated eight women SHGs to participate in all aspects of marketing, whereas their participation in distant urban markets during the second phase has been restricted. Direct marketing helped them to take up new roles in the market, enhanced mobility and linkages with institutions, and also gave visibility to their knowledge and expertise in small millet cultivation[30]. But the second market linkage for the value-added products has been handled completely by members of one male SHG and there is no participation by women. In a patriarchal community, the mobility of women is customarily restricted; hence since women's participation in the market has been further reduced, and this reduces the space for women to take decisions related to marketing. The domination of men SHGs in external marketing can be considered as the typical outcome of the traditional practices of a patriarchal society, in which men have greater access to both economic opportunities and productive resources as farmers and value adders. Rao's[35] study among Santal tribes of Jharkhand also reported that external market linkages for forest produce supported men, while women have lost control over income, adversely affecting gender relations. The strategy of using external market linkages to create an economic stake in conservation needs to be carefully planned for an equitable sharing of benefits between men and women.

In Jeypore, landraces of rice, traditionally sold by women in local markets, fetched only low prices. However, since 2003, some of these landraces have entered external markets due to the purification and quality seed production, much higher prices are being obtained. Women's participation in the external market is practically nil; for similar reasons as in Kolli Hills, though women continue to be active in local marketing and barter of rice, vegetables, seasonal food items, forest produce and fuelwood.

As far as the seed banks are concerned, both in Kolli Hills and Jeypore, women were active participants in the earlier informal seed exchange system, so the CSB strengthened them, helped them to source seed without much difficulty and provided seed security. Women's skill and knowledge in seed management have been recognized and utilized in the management of CSBs. In Kolli Hills, the entire management, including all the 11 functions, is carried out entirely by women. In Jeypore, the management committees are mixed, and the functions divided according to skills (Table 10.6). However, the various processes involved in managing CSBs have increased both the workload and responsibilities of women members considerably. While women's status in the community has increased, they have also been burdened with extra responsibility and the most time-consuming tasks, and record keeping (in Jeypore) is done entirely by men, because women are engaged in multiple productive and reproductive activities. It is not clear how this trade-off will work out in the long run, and whether it will be beneficial to women.

Conclusions

The study indicates that interventions attempting to reduce the decline in small millet cultivation and of traditional paddy diversity in Kolli Hills and Jeypore respectively have considerable potential to affect women's status both positively and negatively. While it is too soon, and the interventions are on too small in scale, to draw firm conclusions, trends are clearly visible. The value of women's specialized knowledge, based on use and demand for such knowledge, would clearly be linked to the rise or fall of production of the particular crop. If small millets continue to fade away, or vanish, in Kolli Hills, knowledge about them would no longer be valuable or needed by the community, and that would affect women's status adversely. On the other hand in Jeypore, where women's traditional knowledge as well as new skills are visibly helpful and adding to the prosperity and welfare of the community, it would have positive effects on their status. As regards the impact of new marketing strategies and new social institutions like the CSBs, there is evidence on both sides, and no clear conclusions can be drawn. In the long run, gendered knowledge in agro-biodiversity can play a significant role in bringing about more equitable gender relations only when women's knowledge is fully recognized, utilized and rewarded.

References

1. Thurston, Edgar. and K. Rangachari. *Castes and Tribes of Southern India*. Vol.IV (K to M): Cosmo Publications, New Delhi, 1909

2. Joint Director of Agriculture. *StatusJ Report of Nammakkal District*, Dept. of Agriculture, Nammakkal, Tamil Nadu, 2000.

3. Vedavalli.L Jeyanthi.M. and R.Rengalakshmi. Reviving and revitalizing the conservation traditions of women and men of tribal communities, (Unpublished), 1999.

4. Sharma, S. D., Smita Tripathy and J. Biswal. Origin of *O. Sativa* and its ecotypes. In *Rice Breeding and Genetics – Research priorities and Challenges* (ed. Nanda, J.S.), Oxford and IBH, New Delhi, 2000, pp. 349-369.

5. Senapati, N. and Sahoo, N.K. Orissa District Gazetteers- Koraput. Orissa Govt. Press, Cuttack, 1966, pp 155-187.

6. Deputy Director of Agriculture. *Status Report of Koraput district*, Dept. of Agriculture, Jeypore Division, Orissa, 2005.

7. Sharma, S. D., Smita Tripathy. and Pratima Gurung. Case study - Jeypore tract, Orissa. In *Gender Dimensions in Biodiversity Management* (ed. Swaminathan, M.S.), Konark Publishers, New Delhi, 1998.

8. M.S.Swaminathan Research Foundation. Enlarging the basis of food security: role of underutilized species, In *Proceedings of the Consultative workshop on Enlarging*

the basis of food security: role of under-utilized species, MSSRF, Chennai, 1999, **28**, p. **2**.

9. Knabe,F and J.Nkoyok. Overcoming barriers: promoting women's local knowledge. *Knowledge Management for Development Journal*, 2006, **2(1),** 8-23.

10. Zwelfel, H. Biodiversity and appropriation of women's knowledge. *Indigenous Knowledge and Development Monitor*, 1996, **5(1)**: 9-12.

11. Ramdas, R. Sagari, Nitya S. Ghotge, Ashalatha, Nandini Mahur, M. L. Sanyasi Rao, N. Madhusudhan, S. Seethalakshmi, N. Pandu Dora, N. Kantham, E. Venkatesh and J. Savithri. 2004. Overcoming gender barriers: local knowledge systems and animal health healing in Andhra Pradesh and Maharashtra. In *Livelihood and Gender: Equity in Community Resource Management*, (ed. Krishna, S.), Sage Publications, New Delhi, 2004, pp. 67-91.

12. Le Fanu, H. *Manual of the Salem District in the Presidency of Madras* Vol 1.Madras: Government Press, 1883.

13. Joint Director of Agriculture. *Status Report of Nammakkal District*, Dept. of Agriculture, Nammakkal, Tamil Nadu, 2004.

14. Rengalakshmi.R. Conservation biology of Little Millet (*Panicum sumatrense* rothex roem. A schultz) landraces of Kolli Hills, South India, Ph.D. Thesis (unpublished), University of Madras, Chennai, 2004.

15. Tripathy Smita, P.Gurung. and S.D. Sharma. Intellectual property contribution with regard to rice genetic resources by tribes of south Orissa, India. *Plant Genetic Resources Newsletter***,** 2005,**141**,70-73.

16. Directorate of Economics and Statistics. District Statistical Handbook of Koraput, Government of Orissa, 1996.

17. Vedavalli, Case study - Kolli Hills. In *Gender Dimensions in Biodiversity Management* (ed. Swaminathan, M.S.), Konark Publishers, New Delhi, 1998.

18. Harijan and Tribal Welfare Department. Tribes of Orissa, Tribal and Harijan Research-cum-Training Institute, Government of Orissa, Bhubaneswar, 1990.

19. Kumar-Range Shubh. *Like Paddy in Rock: Local Institutions and Gender Roles in Kolli Hills*, M.S. Swaminathan Research Foundation, 2001.

20. Oliver King.E.D.I. Sacred forests of Kolli Hills, Tamil Nadu, India: A study on Botany, Ecology and Community interactions, Ph.D. Thesis (unpublished), University of Madras, Chennai, 2006.

21. M.S.Swaminathan Research Foundation. *Rural and Tribal women in Agro biodiversity Conservation: An Indian Case Study*. M.S. Swaminathan Research Foundation, Chennai; FAO, Regional Office for Asia and Pacific, Bangkok, 2002, p **8**.

22. Jayshree Vencatesan, R.J.Ranjit Daniels and Madhav Gadgil. Women and Environment. In *Women of India: Colonial and Post Colonial Periods* (ed. Bharati Ray), Sage Publications, New Delhi, 2005, p 236-255.

23. Davison, J. Land and women's agricultural production: the context. In *Agriculture, Women and the Land: the African Experience* (ed. Davison.J), Westview Press, Boulder Colorado, 1988.

24. Chaudhury, Susanta S. and Ray.Trilochana. Gender roles and decision-making in seed management and seed bank operations, (Personal communication), 2006.

25. Rengalakshmi. R. Folk biology of minor millet landraces, Kolli Hills, South India, *Journal of Ethnobiology*, 2005, **25 (1),** 59-70.

26. Narayanan,Ratheesh M.K., Swapna, M.P and Kumar, Anil N. *Gender Dimensions of Wild Food Management in Wayanad*, *Kerala.* M.S. Swaminathan Research Foundation, Chennai, 2004, p **26**.

27. Sharma, S. D., Smita Tripathy and Pratima Gurung, Chronicling Intellectual Property Contributions of Tribal/ Rural Women and Men of Orissa with reference to Conservation and Enhancement of Rice Genetic Resources. (Unpublished), 1996.

28. Swaminathan, M.S. (ed.). *Gender Dimensions in Biodiversity Management*, Konark Publishers, Delhi, 1998, pp.3-6.

29. Howard P. L. Women and the plant world: an exploration. In *Women and Plants: Gender Relations in Biodiversity Management and Conservation,* (ed. Howard, Patricia L.) Zed Books, London in association with Deutsche Gesellschaft fur Technische Zusammenarbeit and International Development and Research Centre, 2003, pp. 3-7.

30. Rengalakshmi.R. and K.Balasubramanian. Bioconservation and utilization of minor millets. M. S.Swaminathan Research Foundation, Chennai, 2002, p **34**.

31. Arunachalam,V, Chaudhury,S., Sarangi,S., Roy,T., Mohanty,B., Arivudai Nambi, V. and Smita Mishra. Rising on Rice: The Story of Jeypore. A Manual, M.S.Swaminathan Research Foundation, Chennai, 2006, p **39**.

32. M.S.Swaminathan Research Foundation. Fourteenth Annual Report 2003-2004: Biodiversity and Biotechnology: Programme Area 200. MSSRF, Chennai, p **48**.

33. M.S.Swaminathan Research Foundation. Fifteenth annual Report 2004-2005: Biodiversity: Programme Area 300. MSSRF, Chennai, p **61**

34. Geographical Returns of Kolli Hills, Directorate of Agriculture, Government of Tamil Nadu, 1970-71, 1996-97 and 2004-05.

35. Rao, N. Enhancing Women's mobility: Transport and gender relations in the Santal Parganas, Jharkhand. In *Livelihood and Gender: Equity in Community Resource Management*, (ed. Krishna,S), Sage Publications, New Delhi, 2004, pp. 248-274.

Acknowledgements

The authors express their deep sense of gratitude to Ms. Mina Swaminathan, Advisor, MSSRF for guidance on conceptualization and interpretation of the data, for critically reviewing the paper at various stages and constructive comments on the first draft of this paper. They are also grateful to Prof. M.S.Swaminathan, Chairman, and Dr.M.Velayutham, Executive Director, MSSRF, Chennai for their constant encouragement. Sincere thanks are due to all colleagues at Jeypore and Kolli Hills, and particularly Dr.N.Anil Kumar, Dr.P.Thamizoli and Dr.L.Vedavalli, Dr. N.R. Jagannath (Program Officer, SDC, New Delhi) Dr. Nitya Rao, Ms.Sumi Krishna and Dr.C. Manjula for their critical comments and suggestions to improve this paper. They pay their humble tributes to those tribal men and women for their participation and inputs to this study.

11

Benefits of Tribal Women's Activities in Watershed Areas: Agragamee's Experience in Orissa

Vidya Das and Binod Das

Tribal Orissa in India today epitomizes acute poverty and hunger, displacement and distress migration, socio-economic and political exclusion, loss of biodiversity, water scarcity, livelihood loss and food insecurity, declining quality of life and poor natural resource management. Historically, indigenous communities have been known for their self-sufficiency and richness of biodiversity. But the mutually regenerative relation of tribals to their land that sustained their life for centuries has been disturbed and usurped by market-led development, indiscriminate commercial excess and relative apathy of the state. As a result, tribals have lost their lands and livelihoods, rights and roots. The 'KBK' (the undivided Koraput, Kalahandi and Bolangir districts) region in particular is among the poorest in the world, presenting a complex picture of under-development, resource degradation, socio-economic exploitation, weak political role for tribals and poor infrastructure. The increasingly erratic climatic conditions of the region, combined with the undulating and highly sloping topography has made the region ecologically fragile, with indiscriminate human intervention and commerce causing severe imbalances and environmental stress. Remedying the ecological degradation and acute poverty adopting a sustainable course of 'development' necessitate recognition of the symbiotic dependence of tribal lifestyles and economics on land, water and forest, and actions impinging human and ecological security.

Keywords: Agragamee, watershed areas, women, Traditional knowledge, organic farming, social cost benefits

Agragamee (meaning 'pioneer' or 'marching forward') is a non-governmental organization with a mission to promote all aspects of tribal betterment through a radical human-ecological approach that integrates development and social change with eco-protection. It has so far worked directly in 8 districts – Rayagada, Koraput, Nawarangpur, Malkangiri, Kalahandi, Nuapara, Phulbani and Mayurbhanj – and indirectly in fifteen districts through partner-NGOs. Its strategy has been to empower people with awareness, means, rights, skills and opportunities needed to check exploitation and enable them to manage in a sustainable manner their resource base, mostly forest and hill slopes in rain-fed regions.

Watershed remained key intervention towards preservation of natural resources present within the watershed area, and enhancement of skills of watershed users in farming and off farming activities. In the process opportunities are created for income generation of landless, marginal farmers and women headed households, and capacity building of the community through training, workshops, and exposure visits. The concept of integrated watershed development came into prominence after the Indian Council of Agricultural Research (ICAR) advocated it as an appropriate strategy and implemented model projects to demonstrate the application of the concept in several locations. The idea was accepted as part of official policy in the early 1970s but did not make much difference in the way programmes were designed and managed, or on their impact on quality and productivity of rainfed lands. There is a general consensus that client participation particular of women in programmes is abysmally poor. Agragamee hence emphasized women participation in subsequent watershed programmes.

Agragamee has been involved in watershed development since 1993 with the support of local partners. Women constitute 50 percent beneficiary in all watersheds. Their contribution to the success of the programme has been immense. These watersheds are spread over five tribal districts of the State supported by German Agro Action. Plantation, land development, water harvesting, agriculture development, organic vegetable cultivation, grain banks, nursery development, biodiversity conservation, off farm activities and campaign for education and health were some of the activities of women farmers. In addition , the of traditional knowledgeof women farmers is given due to weight.

Women and Seed Preservation

For a long time past, women farmers have a major role in crop selection and discouraging pesticides in storage and preservation. Natural treatment including process such as drying, cooking, smoking and picking has been advocated for preservation. But women farmers often lack facilities for using those techniques. Encouraging women to add value to firm produces is currently seen as a way of alleviating poverty. Most farm families find it difficult to store grains from a good harvest even for one season. It is major challenge to store home grown staple food crops for almost a year with only basic preservation. Yet proper storage of seeds at domestic level is essential to ensure and enhance food security. The traditional skills and knowledge of women in fabricating different structures and containers with locally availably eco-friendly materialsRequires efficient channeling for sustainable storage of grains at village level.

Therefore indoor storage structures (Dundi, Sinduka and Kothi), out door storages (Amara, Olia) and underground storages –Khanni were promoted . The women farmers used neem leaves and neem tips to keep off storage pests of paddy, ragi and pulses. Women farmers have collected 100 varieties of indigenous seeds of paddy, vegetable and millet seeds.

In the case of crops like maize and millet, cobs and panicles are tied into bundles and left hanging till the next season of sowing. They are wrapped by teak leaves or gunny bags to protect them from rains and fungi, moss and microorganisms. Women claim their methods of storing maize are far superior then other chemical treatment.

Women farmers store seeds of many vegetables. Except onion and potato, vegetables are allowed to fully riped on the field, then sun-dried and stored properly by appropriate methods depending on the type of the vegetable. Women also layer bamboo grain containers with dung and neem leaves to protect grains from pests. The indigenous methods avoid the use of chemicals and are easily replicable in similar environments.

Tribal women of Orissa have axpertise in collection and marketing of minor forest produce. But they could not get free access despite forming smaller organization, like Mandibisi Mahila Mandal and larger federation like Ama Sangathan. After long and persistent efforts, they obtained exclusive gave license for collection, processing and marketing of hill brooms,that helped to curb monopoly of local traders.

With the MFP collected, women processed and marketed hill brooms. The women federation processes yearly 300 quintals of hill brooms. Nearly 100 women are employed. The price of hill broom has gone up from Rs 2/- to 15 per kilogram in six years. Owing Women's persistent efforts helped registered members in panchayats toget rights over trading of MFP in the year 2000. Women practise innovative ways of preserving mahua flowers, a minor forest produce, Mahua flowers are kept in bags, while Mahua leaves are bundled and kept hanging in wall.

Agragamee organized women federations and mahila mandals for tribal women.

Four such women federations and 145 mahila mandals at block and village level are involved in watershed activities, implementation of projects and campaign for tribal rights. Agragamee has provided training and capacity building, record keeping and support for campaigns and communication materials. The support has far reaching impact on the women groups. Agragamee provided support to women federations of different regions. The first federations, With the success of the Ama Sangathan And Mandibisi Mahila Mandal, women in different regions formed federationssuch as Indravati Mahila Mahasangh in Kalahandi, Dasmantpur Anchalik Mahila Mahasangh in Koraput, and Phiringia Anchalik Mahila Mahasangh in Phulbani

Organic Framing

With initial apprehensions, many farmers switched to organic farming in Kashipur block. 1581 farming families have taken up organic vegetable cultivation. The methods of cultivation were green manuring crops, treating seedlings with bio fertilizers, using compost, vermi compost and soil treatment with bio fertilizers, The farmers used oil cakes specially neem based and bone meal, using trichodermavirdi and neem based pesticides. The women farmers are trained in nutritional organic farming and organic plant protection measures. They are trained in preparation of compost, vermi compost and humus. Organic farming activities like summer ploughing, adjustment of time of seed sowing, seed treatment, inter cultivation and weed control, mixed cropping, use of resistant varieties, removal of unwanted and diseased plants, crop rotation are regularly taken by women farmers.

Agragamee trained the farmers in use of organic pesticides such as Neem, Karanja, Turmeric, Hingu, Tobaco, Begunia, Basanga, Tulsi and Marrygold etc. Similarly use of organic manures for different crops like cereals, pulses, oilseeds, vegetables, spices etc were taken up. The farmers themselves are doing grading, preservation and marketing of crops raised from organic farming.

Commitment for Social Change

Before commencement of the project, Agragamee entered into eight points commitment with the community for social change. These commitments were:

1. Collective action for village development,
2. Total ban on brewing and consumption of alcohol,
3. Every child in school,

4. No free grazing of cattle,
5. Commitment to strengthen people's organization,
6. Protection and generation of tree cover,
7. Maintenance of community grain banks,
8. Total hygiene and sanitation in villages[1].

The commitments yielded successful results: mixed forest protection was taken up in 374.2 ha with 100 percent community participation, In 13 villages, forest protection has been targeted in earnest. Cashew plantation was taken up in 579.71 ha with 80 percent people's participation. 4000 ha of watershed were brought under community based forest management. Cattle grazing have been brought under control. Protective bunds and trenches were dug with 25 percent people's participation. In eight villages, people supported honorarium of part time teachers for night schools. In 62 villages, women have come together to form Mahila mandals.

Impact of Interventions Food Security: Women farmers have undertaken mixed and inter cropping in 240 ha (paddy, arhar, groundnut and oilseeds) and orchard development in 181 ha of land. Women organized 300-grain banks with storage capacity of 15 quintals each. Organic vegetable cultivation by 1581 farming families and training and capacity building of 1200 women farmers are indices of food security.

Water Security: Women have taken active role in creating water-harvesting structures, and providing irrigation facilities by which 1270 farmers in 536 ha of land were benefited. Now water is available in open wells even in peak summer.

Ecological Security: Nearly 1200 hectares of land were cultivated with forest species such as karanja, chakunda, neem, amla, bamboo and horticultural species such as mango, litchi, jackfruit, custard apple, guava and lemon. 415 compost pits in 50 villages of 10 gram panchayats were put in place. Thus 802 acres of forest in 17 villages of operational area were protected.

Social Cost Benefits

- By hard and persistent efforts of Ama Sangathan, the leading women federation obtained hill broom lease from state government, as observed earlier for collecting, processing and marketing of the product.
- Watersheds made available have increased upland production up to 60 percent during rainy season in addition to improved vegetable cultivation . The forest

coverage has increased nearly 20 percent in 40 villages. Poor families could buy assets including land, bullocks and other necessities due to improved economic gains.

However several issues of tribal population remain to be addressed by the Government:

1. Increasing displacement due to mining issues-affecting tribals habitat and livelihood
2. Issue of settling forestland and other wasteland in favour of tribals
3. Poor Implementation of Panchayat Extension to the Schedule Areas (PESA) Act 1996.
4. Distress migration - women are deserted risking their survival
5. Women trafficking for immoral purposes
6. Access, control and management of natural resources

Despite the efforts of non-governmental organizations, it is high time for Government to strengthen the impacts by their active involvement in providing women their due status in social structure and empower and enable people to access sustainable and secure livelihood.

12

Social benefits of gender-differentiated participation in Seed improvement, a pre requisite for Participatory Plant Breeding

Vanaja Ramprasad

Natural resource management has become a crucial aspect of sustainable development and requires the involvement of multiple stakeholders. Issues concerning successful management and conservation of natural resources are dependent upon active and meaningful participation of the key stakeholders both at the primary and secondary level. In this light the facilitating role of NGOs, local governments, grass roots groups and farmers' associations has become important. It has been recognized in the recent years that intervention in Natural resource management cannot be conceived of in isolation but has to be perceived in the backdrop of sociological aspects. This would require an understanding of how men and women living on marginal lands, marshy lands and other fragile ecosystems perceive their changing sociological and ecological environment. Traditionally communities have played a very nurturing role in conserving their natural resources.

Despite rapid urbanization and its influence Peoples conception of management emanates from their natural resources as source for their livelihoods. It is also conditioned by the complexity of societies, notions of gender (socially constructed roles and characteristics assigned to men and women in specific cultures) class, caste ethnicity and age that are integral to the understanding of social relations and decision making processes as also observed by Vernooy[1].Outside interventions also play a role.

Agriculture today attempts to use natural resources under human influence and at the same time, struggles to meet the needs for increased production using intensive inputs like irrigation, chemical pesticides and quality seeds. Over the past few decades, the latter led to gradual loss of natural resources including genetic diversity. In its way, the role of farmers and especially women, as conservers of diversity, and knowledge holders have also been marginalized. The efforts of outside interventions aiming to retrieve the lost diversity and the knowledge system have to be based on collective wisdom of people and capacity to organize community of farmers.

In this context, this paper discusses the following:

- the experience of intervention of NGOs to organize local level institutions like self help groups, community seed banks and federation of members from the community,
- the perceptions of men and women farmers on their involvement in spheres like seed production, resource management at agricultural and household level and gender-differentiated preferences for varietal selection, and
- integrated participation by intervening NGOs to enhance women's organizational skills and to bridge the gap between indigenous knowledge and scientific principles validating the former.

In that process, the application and validation of women's knowledge on seed selection, seed treatment and seed storage are evaluated. Drawing upon the lessons learnt, the importance of indigenous knowledge and gender-differentiated participation in enhancing the quality of seeds produced and their importance as a pre requisite to plant breeding, particularly maintenance of seed purity are emphasized.

Keywords: Women, indigenous knowledge, plant breeding, seed purification, gender participation.

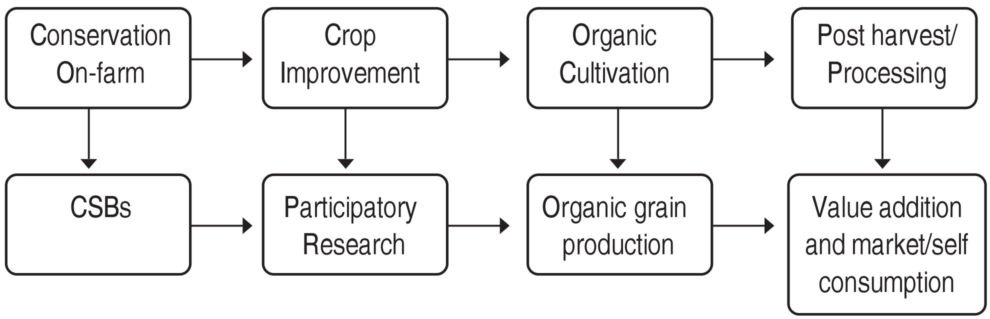
It has been established by disaggregated data in several studies that women are the managers who contribute to more than 60 percent of the work in different ways in agriculture. But their involvement in agriculture has been completely ignored. Their contribution to the household income is either not counted or under counted in national economy[2]. Male farmer has predominance and therefore, policies and programs ignore women's needs and concern as a farmer[3]. Their contributions are either unrecognized or undervalued[4]. Agriculture needs to recognize women's unpaid contribution. In the spectrum of agricultural activities, seed saving and seed selection have been recognized as womens' domain. New technologies have displaced and de recognized women's role in this sector. This lost space needs to be gained by involving women farmers in seed saving, developing their management skills, recognizing and utilizing their knowledge and technical expertise in conservation and activities like micro credit.

Women as seed Bank managers

The seed banks managed by women are a focal point of not only seed availability for a cluster of villages but also engaging women in value addition to the seed and the grain. Seed production through kitchen gardens has been a major income generation activity. Seed diversity in the seed banks is maintained by procuring the seeds in situ from various farmers. Women who manage seed banks take care of seed germination, seed storage and seed treatment before they are distributed to other farmers, thereby maintaining quality cultivation.

The transition in the role played by women and men is seen from one of subsistence to one of market economy. The need to increase income from farm and non-

Seed to Food: Ensuring Sustainability



farm activity is crucial since there is a necessity to lift up the lot of small and marginal farmers. Green Foundation focused on a project that not only gave importance to conservation of indigenous varieties but also gave attention to crop improvement to realize the potential of the local varieties. To enhance on-farm genetic diversity, farmers were involved in seed purification for crop improvement. To have an understanding of the role, men and women played in the changing agricultural scenario the perceptions of their role was elicited through participatory rural appraisals.

Perception of men and women

The perception of the role played by women and men was independently established through a participatory exercise. In most societies, women and men have differing responsibilities related to agriculture and households and they possess knowledge of different kind related to cultivation and consumption of food. A simple PRA was conducted in a village where on farm conservation activities were initiated. The results of the PRA generally showed (Table 12.1) that both men and women were engaged in a wide variety of activities related to farming, seed selection and preservation. It was observed that, unlike the assumption that men and women set aside special time for such activities, they integrate such activities optimally into their daily lives. It was established that

Table 12.1 **Gender participation in agricultural activities by men and women**

Sl. No	Activities	Percentage of time spent			
		Men		Women	
		M	W	M	W
1	Stubble Collection	15	85	-	100
2	Seed Selection - Main	100	-	73	27
	- Mixed	20	80	-	100
3	Land Preparation - Manure	30	70	40	60
	- Whole	100	-	100	-
4	Seed Treatment (Process)	15	85	-	100
5	Sowing	65	35	27	73
6	Top dressing & earthing up	90	10	80	20
7	Irrigation	90	10	53	47
8	Weeding	-	100	-	100
9	Inter cultivation	100	-	100	-
10	Plant protection	100	-	80	20
11	Ear head selection for seeds	20	80	-	100
12	Harvesting	85	15	67	33
13	Threshing & Cleaning	25	75	7	93
14	Transportation	100	-	73	27
15	Marketing	100	-	87	13
16	Seed Storage	85	15	100	-
17	Security (Water & Elephants ward)	100	-	100	-

Veeriahana doddi village, Kanak pura Taluka, Bangalore Rural District
Number of farmers who attended the PRA: Men 20 & Women 15 - Total: 35

seed selection and preservation were found to be complex processes involving cultural events, seed exchange between villages and other local settlements. The data established that there was interconnectivity between activities of women and men on issues of biodiversity management.

Some activities are usually done by men and some others by women.

For example, men take care of seeds/variety (main crop) selection, land preparation with implements, intrecultivation watch and ward, top dressing and earthing up, plant protection, harvesting, transportation, marketing and seed storage.

Women take charge of stubble collection, weeding, seed treatment, intercrop seed/ variety selection, manure application, ear head selection for seeds, threshing and cleaning, and support to all activities carried out by men.

Though women partake in almost all agricultural activities, their role in decision making is insignificant except some of the field oriented operations like stubble collection, intercrop seed/ variety selection and seed storage.

Men and women have different perceptions on their roles in household activities (Table 12.2). For instance, Women take major role in food preparation, house cleaning, washing clothes, decoration, childcare and maintenance and cleaning of grains.

Table 12.2 **Management of household activities as perceived by men and women**

Sl. No	House hold activities	Perception of Women			Perception of Men		
		M	W	mx	M	W	mx
1	Cattle management and small ruminants maintenance	-	-	100	10	-	90
2	Food preparation	-	100	-	-	95	5
3	House Cleaning and decoration	-	93	7	-	100	-
4	Cloth washing and Water collection	-	86	14	-	90	10
5	Provision purchases	7	7	86	10	-	18
6	Children care and maintenance	-	100	-	-	100	-
7	Flour making	-	27	73	30	15	55
8	Firewood collection for food preparation	20	-	80	20	35	45
9	Fodder collection	-	14	86	15	-	85
10	Cleaning of grains	-	100	-	-	100	-

Figure represent percentage of time spent; M- Men; W-Women; MX- both men and women

Men do not play any major role in managing household activities but they support in some activities like cattle management, purchase of provisions, flour making, firewood and fodder collection.

In addition, genera opinion prevails that

- men are born to do agricultural operations and women are born to do Cooking activities,
- men cannot do cooking properly,
- they lack cleanliness in cooking / household activity,
- men milk cross-bred cattle while women indigenous cattle, and
- men take care of bullocks and women cows.

A study of the gendered criteria in varietal selection (Table 12.3) brings out the following:

Table 12.3 **Gender differentiated data on varietal selection**

Sl.No	Criteria	Perception of Women			Perception of Men		
		M	W	mx	M	W	mx
1	Drought resistance	-	-	100	20	-	80
2	Lodging	-	-	100	65	-	35
3	High yield	67	33	-	15	-	85
4	Seed for the following year	-	100	-	30	45	25
5	Grain colour	-	-	100	55	-	45
6	Cooking quality	-	100	-	10	20	70
7	Plant shape	-	-	100	90	-	10
8	Intercropping	-	100	-	10	15	75
9	Low fertilizer rate	-	100	-	30	25	45
10	Maturing time	-	100	-	65	20	15
11	Plant height	-	-	100	80	-	20
12	Disease resistance	-	-	100	10	-	90
13	Pest resistance	-	-	100	5	-	95

Figures represent percentages; M-Men; W-Women; Mx-Both men and women

- Women usually look for good seeds for use in the next season, cooking quality, suitability for intercropping, low fertilizer rate and maturity. They imply that women value quality than quantity, and low cost of production.
- Men usually look for higher yield, drought resistance, pest and disease resistance, plant architecture and the like. This indicates men give more importance to high yields and associated income by marketing.
- Only men do intercultivation, top dressing, plant protection, transportation and marketing
- Only women do stubble collection, weeding and seed treatment.
- Both together do land preparation, seed selection, ear head selection, sowing, harvesting, irrigation, threshing, cleaning and storage
- Decisions are taken by men on seed selection, ear head selection and seed treatment and women on seed selection and purification.

The study of the results from the PRA point to three important areas for intervention:

- Involve both men and women in seeds purification and selecting for farmer preferred characteristics of a variety before increasing yields,
- Ensure active participation of both men and women farmers in understanding the indigenous knowledge on seed treatment to enhance the germination quality and contain seed borne diseases, and
- Evolve a participatory research strategy on seed storage based on indigenous knowledge of among women.

Traditional learning experience has led us to believe that we learn best by listening to experts. It has been found, however, that learning that results in increased self-awareness, changed behavior, and the acquisition of new skills must actively engage the individual in the learning process. In particular, adults have been found to learn more effectively by doing or experiencing.

David Kolb[5], has described this learning process as a four-phase cycle in which the learner does something concrete or has a specific experience which provides a basis for the learner's observation and reflection on the experience and their own response to it. These observations are then assimilated into a conceptual framework or related to other concepts in the learner's past experience and knowledge from which implications for action can be derived, and tested and applied in different situations.

It was based on this theory that the adult learning exercises were applied on different aspects of seed conservation. The premise was that farmers as adult learners assimilate useful information into their personal "experience bank" against which future learning events will be compared and to which new concepts will be related. Further it was based on the understanding that unless what is learned can be applied to actual work or life situations the learning will not be effective or long lasting. We illustrate these conceptions with an example of seed purification.

Experience with purification of a local variety of Finger Millet *(Eleusine coracana)*, Pichhakadi Ragi

Participatory research conducted by Green Foundation revealed that farmers knowledge is central to revitalize the cultivation of landraces. Collaborative research showed that for a typical crop of marginal and unpredictable environments such as finger millets and rainfed paddy, it is possible to exploit the specific adaptation to marginal environments under farmers' conditions and improve yields without additional external inputs.

Pichakaddi ragi, the local variety grows to a height of 80-100 cm erect, with 2–4 tillers/plant. The crop matures in 135–150 days and gives a grain yield in the range of 18-25 q/ha. Farmers prefer to grow this land race because of good straw liked by cattle yields. According to women farmers, one measure of Pichakaddi ragi flour is equal to two measures of improved variety ragi flour used in preparation of foodstuff (ragi balls, for example).

At the time when Green Foundation took up participatory improvement, it was confronted with poor crops with poor growth, single stem devoid of productive tillers, and a mixture of plants carried forward by people as Pichakaddi ragi. There were no morphological or seed markers either of this local race to the knowledge of farmers.

Therefore a scientific approach to purification of PK was designed on a participatory mode with a few farmers at their sites. The approach utilized the indigenous knowledge (IK)of farmers who were identified on the Foundation's experience during other initiatives in those areas. Participatory demonstration experiments made the farmers realize that scientific methods of cultivation followed by selection on a set of diagnostic morphological characters could purify and improve yields of this ragi landrace.

In 3 seasons of experiments, the ragi landrace got purified and could give yields considerably higher than those earlier realized by farmers.

Role of Women in seed Treatment

Farmers have long observed the efficiency of seed treatment based on IK some of which have become extinct. Green Foundation collected information on several of those treatments and facilitated crop responses to those treatments and identify those most suitable for wider dissemination. In these experiments, asafoetida and cows urine treatments produced healthy seedlings. These, along with seeds treated with salt water, were free from finger blast a pathogen responsible for great crop loss in finger millet.

Some implications for gender sensitive policy on seeds

- The example of finger millet describes initiatives to enhance seed quality and to empower women by the efforts of NGO. It is well known that women in rural areas around the world have low access to information, knowledge and training. A study by FAO (1997)[6] also shows that only 5 percent of agricultural extension services reach women. It is also true that development programmes generally do not consider social and gender factors. Our effort emphasizes that strengthening work with women as partners simultaneously building their capacities are pre- requisite to any research activity intended to enhance benefits to farmers.
- The concept of community seed banks can have a major policy implication to strengthen easy and good seed availability to farmers in time that would help in conservation and management of agrobiodiversity.
- Capacity building of women farmers in maintaining the purity of seeds, and improving seed germination using IK through proper seed treatment and seed storage practices is important for stably high production that would enable reduction in poverty.

Such interventions would recognize and channel the gendered nature of technological interventions optimally.

References

1. Ronnie (Vernooy), Social and Gender analysis in Natural Resource Management
2. Agarwal, B., (1985) "Work Participation of Rural Women in Third World: Some Data and Conceptual Biases" in *Economic and Political Weekly*, Vol. XX, No 51 and 52, Review of Agriculture, December 21-28, 1985.
3. ADB (Asian Development Bank) and UNIFEM (United Nations Development Fund for Women) (1990), Gender Issues in Agriculture, Papers and Proceedings of the

Regional Conference, Manila, Philippines, 5-6 December 1990.

4. Siason, I.M., E. Tech, Matics, K.I., Choo, P.S., Shariff, M., Heruwati, E.S., Susilowati, T., Miki, N, Shelly, A.B., Rajbharshi, K.G., Ranjit, R., Siriwardena, P.P.G.N., Nandeesha M.C., and Sunderarajan, M., (2001), "Women in Fisheries in Asia," in "Global Symposium on Women in Fisheries 6th Asian Fisheries Forum, 29 November 2001, Kaohsiung, Tiawan.

5. David, A. Kolb., Experiential Learning. New York: Prentice-Hall, 1984.

6. FAO 1997 Gender The key to sustainability and Food Security Rome

13

Aharam: Collective and value added marketing of farm produce as a community enterprise

V. C. Nadarajan, N. Muthu Velayudham, P.Saravanan, R. Rengarajan, and Utkarsh Ghate

Use of local resources and skills for strengthening rural livelihoods through the mode of Community Enterprise (CE) is the central focus of the work of the Covenant Centre for Development (CCD) in the areas of medicinal plants and traditional food crops. Earlier it provided technical support to communities to market medicinal plants. It helped women Self Help Groups (SHGs) to establishing the Gram Mooligai Company Ltd. that started in the year 2000 with 300 families selling medicinal plants to the tune of Rs.3.37 lakhs. It today involves 1382 families having a turnover of Rs. 54.01 lakhs. The company trades in 32 species of medicinal plants. The work involves sustainable use. Reduction in marketing expenses and a modest increase of 20 % in the procurement price are the community benefits. This success prompted CCD to adopt a similar approach to food crops produced by small scale farmers to local and external consumers through a producer company called Aharam Traditional Crop Producer Company Ltd. The company aims at providing assured markets at better prices for producer groups while ensuring food and nutritional security of the rural poor at affordable prices. Aharam markets about 50 essential products such as millets, pulses, oil and mangoes and some are value added like tamarind, rice, vegetable oils involving key partners – SHGs and their Federations. Some of the goods like honey, tea and spices are procured from like-minded NGOs elsewhere. The effort started with 300 families in the year 2004 presently extends to 2000 families, aiming to reach 10,000 families. Aharam also markets bulk commodities like Mango from small farmers to processors with definite price advantage to both parties. Aharam is now organizing these small holders into Mango Producer Clusters/Collectives that would help them in productivity improvement, provide them access to formal credit sources, assists in collective marketing. The efforts have some important insights to offer: Collective Marketing of products helps primary producers in receiving better prices for their produce, optimization of operational costs,

institutionalizing the operations in the form of producer collectives for better access to credit and other support services, including seeds.

Keywords: Farmers groups, collective trade, value addition, supply chain management

The Covenant Center for Development (CCD) was established in 1993 at Pulvakkarai, a village in Virdhunagar District, to work among rural school dropouts, youth and women. Initial work of the organization was focused on addressing the problem of rural out-migration by providing vocational training for school dropouts and mobilizing women into groups for social and economic up-liftment. A conscious effort was made to use local resources and traditional skills in the process. From a humble beginning, the organization now assists 4 federations of 620 women Self Help Groups (SHGs) with 9,000 women members from 150 villages spread over the districts of Madurai, Sivagangai, Virthunagar, Ramanathapuam and Dindigul.In addition, the work has spread into creation of networks for rural artisans, medicinal plant cultivators and collectors, fishing and farmers and their community based organizations (CBOs)[1] in the Tsunami affected coast.

The *Aharam* Model

The programme was established in the year 2003 with the goal of establishing a supply chain network for agricultural products of a locality and its hinterlands to promote a locally sustainable market that address self-reliance, fulfill nutrition and food security, at affordable costs.

The *Aharam* is modeled after the earlier experience of CCD with the *Gram Mooligai Company Limited* (GMCL)[2], owned and governed by community that procures, processes and markets medicinal plants from farmlands and wastelands. The *Aharam* Traditional Crop Producer Company Limited is a producer and governed company that procure, processes and markets agricultural products that are either produced or processed locally. The suppliers are producers of the *Kalasam* regions (operational area) and every household is a market. *Kalasams* are Women's Self Help Groups (SHGs) formed for the purpose of collective savings, which are circulated as credit among members of the group in times of need. Many such groups have now been formed into a federation known as *Mahakalasam*. The Kalasam participates in order mobilizing, issue of indent, collection and repacking of material and its eventual distribution to rural consumers. Ford Foundation has supported this initiative.

In 2002, the Aharam grocery chain initiated a basic market study by the students of Management from American College, Madurai in 48 villages in the Pulvakkarai Region of Virudhunagar district involving Kalasams to understand the consumption patterns in villages, purchase frequency, consumer behaviour and product/brand preference. Important findings of the study was that the average per capita spent on purchased grocery amounted to Rs.100/- , which is an indicator of the capacity of the population and that 47 stock keeping units (SKUs) were fast moving commodities.

The programme was started on a trial basis in 2004 with 2 distribution pathways:

- Essential Commodity Package System (Pulses, oil and spices totaling 25kg / family).
- Retail Outlet System

The services offered by the above systems included a credit card scheme and door delivery for grocery. Centralized procurement centers in Mahakalasam or Federation offices procured locally available grocery, in addition to a range of products from wholesale agents. Initially fifty essential products were supplied through the network, which was expanded to include raw and value added products from local community based organizations and similar networks elsewhere.

The Aharam Traditional Crop Producers Company Limited (Figure 13.1) was institutionalized in November 2005 under the Companies Act 1956. The board now consists of 5 CCD nominees and 5 community members. These promoters would eventually be reconstituted based on shareholders. To assure sustainability, the network was registered as a producer company, which has the benefits of a cooperative without its political interference and also provides scope for expanding commercial activity including inter-state exchange of goods and raw materials[3].

Source of material

There were 2 important aspects of procurement and supply. On the one end, there were several small holders who produced small quantities of a wide variety of agricultural goods. On the other end were consumers who required small quantities of grocery of assorted nature. In addition some of the producers were also consumers themselves, requiring assorted groceries. Good quality grocery items - pulses, oil and spices weighing 25 kg and worth Rs. 500/- per family are procured from farmers and urban traders at fair price, which is sometimes 10% lower than market.

Products such as pulses, chili, onion, coriander, groundnut, tamarind are procured from 100 farmers, associated with 600 women SHGs across 242 villages in 4 districts. Non-regional products such as mustard from Madhya Pradesh, pulses

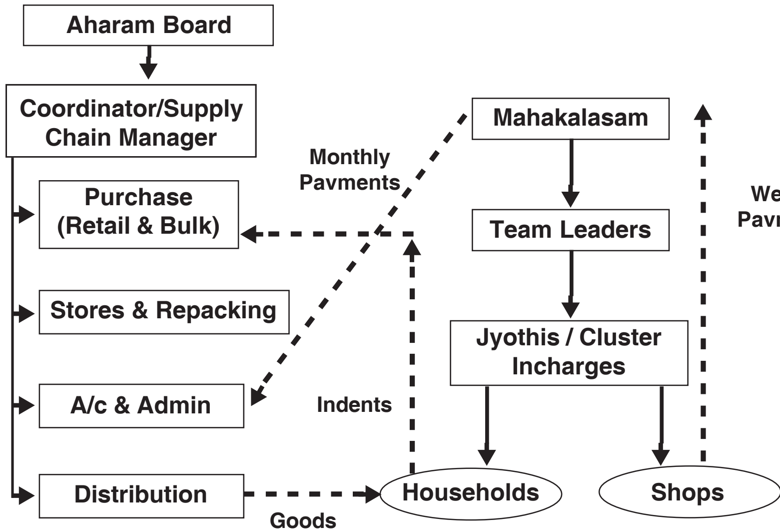


Figure 13.1 Aharam Traditional Crop Producers Company Limited – The Model

from Orissa, honey from Kerala at 30% of the market price are procured from partner NGOs. These SHGs and their federations are the fulcrum of the model and integrate forward and backward linkages of the supply chain. Existing offices of the women's Self Help Groups (SHG), 60 in number and 15 shops deliver goods in a packed form to 1,000 families, which are poor and landless. Aharam Business Development Services (BDS) includes technology training such as traditional recipes of nutritious millet malt, puffed rice, herbal juice powder, cooking oil etc. using Common Facility Centre (CFC) hosted with modern tools. Aharam engages 15 rural poor women at value addition facilities such as building and machinery for the storage, powdering, packing, and labeling at the back-end. At the front end lies a team of 50 part-time workers. In all 65 people are engaged to reach out to 1,000 families, the ratio being 1 seller: 9 consumers. BDS also trains farmers in generation and use of organic inputs. Green manure crops (pulses, hemp) are grown and mixed in soil as bio- fertilizer. Fermented solution of cow dung, cow urine, jaggery are sprayed as bio-tonic. Many of these reduce input cost and thereby raising income.

The federations in 3 geographically distinct regions close to Madurai are involved:

- Suranam (Coastal Region – South West of Madurai)

- Pulvakkarai (Dryland Plains – South of Madurai)
- Natham (Hilly Region – North West of Madurai)

Each of these location produced diversified crops and minor produce that could be potentially fed into the supply chain[4].

Apart from the products of these locations, some groceries and goods not produced locally was sourced from Madurai town or from likeminded NGOs e.g. honey, mustard.

Location	Products
Suranam	Traditional varieties of paddy, puffed rice, beaten rice, coriander, chillies, palmyrah jaggery
Pulavakkarai	Groundnut, Toor dal, Thattapayiru (a local variety of pulses), millets – Tinai, Samai, Ragi and Bajra
Natham	Tamarind, Coconut, Vegetables and Fruits

Supply chain and rural consumers

About 40 supply nodes were identified to which producer groups supply their products. Each federation, depending on its local conditions, have adopted different operational modes of reaching out to its members. The Suranam Mahakalasam Federation procures orders from individual households during the weekly SHG meetings, which is pooled at a Federation level and placed with the procurement and supply team. The federation operates a shop at Suranam, which supplies material ordered for, on credit for a period of two weeks. Special arrangements are made during festivals, domestic functions or wedding in the household.

The Pulvakkarai Federation integrates its operations with local shopkeepers. The Federation places an indent based on the requirements of its group members and local shopkeepers, which is passed onto the procurement and supply team. Indents are also collected from local shopkeepers, independently and passed onto the team. The distribution is through the local shops, who have been convinced to pass on the benefits of lower cost of products to consumers. Credit facilities to members of SHGs in the network are extended through credit cards honoured by the shopkeepers. This effort utilizes existing commercial network, thereby avoiding creation of yet another distribution channel and costs involved therein.

The Natham Federation collects individual indents during Kalasam meetings and pool them at federation level, which is placed with the procurement and supply team. Credit ratings are also maintained for each individual / group by the cluster In-charge based on the promptness and value of repayment. Packages are sent to each cluster, where individual members collect their provision. This effort reduces the need for storage space and hence reduced costs.

Door Delivery and Retail Outlets

CCD started a door delivery system for the Kalasam members. A central team was put together in Madurai, with the start-up loan from the organization. The package of goods had fifty items with a consolidated price of Rs. 500. In the first round of distribution, one thousand packs were delivered through the Kalasams in 2004. A Kalasam sponsored shop was set up at Pulvakkarai, with the central procurement warehouse being run by the Mahakalasam[4]. A sub dealership has been tied-up with an outlet. The retail outlet capital has been from the local Kalasam, and the Mahakalasam, with the CCD's Aharam is also giving select goods on credit (Table 13.1).

Table 13.1 **Retail outlets started by the Kalasam members**

Kalasam Name	Village Name	Amount (Rs)
Vinayagar Kalasam	Pulvakkarai	55,000
Annai Theresa Kalasam	Aviyur	25,000
Muthu Kalasam	Aviyur	30,000
Alagunatchi Kalasam	A. Mukkulam	25,000
Murugan Kalasam	Thimmapuram	15,000

Changes were made by the Aharam Door Delivery Scheme, based on its learnings:

- Scheme was made available only to Kalasam members, as the supply chain is largely built around the credit structure of the Mahakalasam, and follow-up with non-members proved difficult and cumbersome
- The value of the package was reduced from Rs. 500 to Rs. 300
- Region specific packages were made, as some of the grocery items were locally grown
- Packaging was decentralized in Pulvakkarai
- Select SHG products like Papad, palm jaggery, coriander and chillies were included
- Products from other NGOs and CBOs included

Credit Care Scheme

The Mahakalasm entered into supply agreements with grocery shops and introduced the credit care scheme for the consumers in its operational area. The Kalasam members paid the monthly fee for being included in the scheme. For instance, to be given a credit of Rs. 500, the member paid an annual service fee of Rs. 100, and for a credit of Rs. 300, the member paid a fee a Rs. 50. The member was not charged any interest the first month, and thereafter was charged a monthly interest of 18%. Different kinds of supply packages at different rates, like individual packages, festival package, essential commodity package etc. were also attempted under this scheme during Deepavali in 2004[4].

The Economics of the Aharam Model

Saving expenses on advertisement through word of mouth, and reducing overhead costs by using existing SHG office and staff, are the key to provide goods at low cost to buyers. SHGs save 5% in storage and handling which supports 15 SHG cluster coordinators (at Rs. 1,560/- pm). Every month, groceries weighing 25 kgs, costing Rs. 500/- are home delivered to 500 families on no interest credit for a period of three months. 300 families purchase the same from 15 shops that also sell these to another 200 non-members. It is estimated that in the coming year 15 staff and 45 SHG cluster coordinators will reach 5,000 homes, besides 50 shops would cater to and additional 5,000 families. The transactions would fetch the Aharam central team Rs. 300,000/- per month as commission. In addition, three coordinators for procuring, processing and distributing groceries would charge Rs. 30,000/-. The staff would cost 3.3 % of the turnover, while 5% may be the profit.

Lessons learnt

a. Aharam innovation lies in integrating SHGs as producers and consumers into single entity, which reduces the length of the supply chain and delivery cost anywhere between 30 - 50%. SHGs as a Community based organization (CBO) are good vehicles for production and marketing. Identifying a viable, niche product segment – grocery segment and use of local resources and traditional skills (LRTS) as an Unique Selling Proposition (USP), are also innovations.

b. Each federation is able to mobilize members anywhere between 300-500 whose weekly indents range between Rs.45, 000-Rs.75, 000. During the festival season, the amount of off-take increase upto Rs.100, 000.

c. Unless prices of goods of the Aharam network are competitive, local shopkeepers do not admit to stock products.

d. Some shopkeepers have rejected Aharam goods as being expensive for consumers or too lowly priced for the shopkeeper.

e. In some federations, staff members are involved in receiving and redistribution of goods, which is a hidden, cost borne by the project, and may not be sustainable in the long run.

f. The transport costs involved for delivering products to each cluster is another hidden cost to the project.

g. The process of catering to individual households by the Federation office has its limitations.

h. A comprehensive local language software application is being developed that would handle the entire process of order securing, processing, indent generation procurement, distribution and ultimately cash collection.

i. It is also proposed that through the Aharam network, special packages will be made available for the local festivals, marriage halls, hostels, hospitals, restaurants and other commercial establishment in the locality.

Prospects of the model

a. Low cost and locally sustainable processing techniques have been identified which can further add value to the produce.

b. Credit cards will be issued to all the members of the Kalasam. Though these they can purchase all their domestic requirements from the Aharam supply chain. The amount will be automatically credited to their pending payments and they can later on at the cluster level.

c. Ways and means are being explored to network farmers' associations in peninsular and central Indian states to leverage on each others' strength and derive better market access and benefit through such networking. Inter-state partnership will be crucial in future to seek low cost, good quality crop produce. Here, farmers community based organizations (CBOs) would provide the material and initially neighboring NGOs such as CCD would engage the CBOs. Aharam plans to reach 50,000 families over a period of 3 years, with the help of 6 NGO & CBO partners across 6 states across India: Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Orissa, and Madhya Pradesh. A feasibility study for the 6 states is completed with the funding from the Tata

Trust who may support this venture. It would trade in goods worth Rs. 20 Million /yr (15,000 ton). Though 12% of the project costs may be grant supported, a business margin of 10% would be possible after reaching 5,000 families, due to "economy of scale" principle.

d. Evolve a common labeling standard which most farmer groups can easily follow and which would provide the consumer with safe and minimum chemical (if not chemical free) food. These could possibly include three categories of products that are apart from certified organic:

   In-conversion Organic Products – Farmers who want their produce to be certified 'organic' should adhere to actual guidelines of 'organic' for three consecutive years. During the transition they are not permitted to label their products and lose the advantage of accessing premium markets, inspite of the fact that their products are organically produced.

   Non-Pesticide Management (NPM) Products – are those are produced without using any chemical pesticides or GMOs but could be using chemical fertilizers, mostly due to non-availability of organic nutrient inputs.

   Default Organic but uncertified products – a large percentage of produce from dryland farming in many areas are by default organic, but do not opt for certification due to high certification costs and very low volumes of production from individual farms.

References

1. http://www.ccd.org.in
2. http://www.villageherbs.com
3. Aharam Traditional Crop Producer Company Limited. Not dated. Proposal for conducting Aharam supply Chain feasibility Study submitted to the Sri Dorabji Tata Trust.
4. Anonymous. 2005. The Covenant Centre for Development Programmes. Aharam-Rural Supply Chain Enterprise.

Acknowledgement

The authors express their gratitude to Dr. V. Arivudai Nambi of M.S. Swaminathan Research Foundation, Chennai for offering a number of suggestions and also modifying the paper.

14

High Yielding Rice Varieties Developed Using Landraces of Palakkad for Kerala

P. Chandrasekharan

In rice, crosses were done between dwarf varieties and landrace, Thavalakkannan from Thiruvilvamala (TKTM) identified as possessing maximum grain number of 430 in addition to similar one, Chenkazhama from Ottappalam. Selections were made from filial generation of those crosses based on height (80-120 cm), productive tillers, long panicles, high grain number and *matta* (bold grain, red rice). Those selected were given PC numbers. PC1 was identified in F_6, PC2 in F_7 and both were released in February 2003. Four more short duration varieties have been identified: PC5 in F_9; PC3, PC4 and PC6 in F_{10}. Evaluated in yield trials in the second crop of 2004-05 and in the first crop of 2005 –06, the superiority of their performance was confirmed. PC3 (Sivam) and PC 6 (Sundaram) were varieties incorporating genes for high grain number (exceeding 400) from TKTM. During the last four seasons PC1 and PC2 have spread to more than 500 acres in almost all districts of Kerala. Production and supply of quality seeds were channeled in farmer participatory mode, and three progressive farmers took charge of these activities from the year 2000.

Keywords: Rice-landraces –Transfer of genes- participatory research-participatory plant breeding

Palakkad district, the "Rice-Bowl" of Kerala used to grow about 50 traditional rice varieties (Land races – *Oryza sativa* var. *Indica*) before the introduction of dwarf high yielding varieties. Thavalakkannan was then a popular variety because of its good palatability, high recovery percent (> 60%) and the ability of cooked rice to preserve in cold water for 12 hours, without losing its hardness and taste, qualities that farmers of Palakkad desire. It is a coarse variety called *matta* in Malayalam to mean 'bold-grain, red rice'. Further the quality of starch is such that it is most suitable for all culinary preparations of Kerala like '*idli, dosa, puttu, appam and gruel*'. Excessive height and consequent lodging decreased yields upto 50% producing only 2500 to 3000 kg/ha.

Introduction of dwarf and high yielding variety (HYV) like IR8 boosted yields up to three times in a 135-days crop; but its quality was not suitable for kerala rice preparations, its straw was low in quantity and was unfit for thatching roofs as desired by local peoples. The dwarf varieties bred by rice research station, Pattambi in Kerala like PTB38, PTB45 and PTB51 were improved both in respect of quality and straw but their yields were comparatively lower than HYVs. Further HYVs grown as second crop in Kerala (Sept - Jan planting) did not do well and a survey by Kerala Agricultural University showed that only 28% of second crop area was covered by HYVs. Despite irrigation facilities, average yield of paddy in Kerala state was only 2300 kg/ha. Palakkad district is a rain deficit area with temperature ranging from 17-40^{o}c.

It was then decided to explore the possibilities of incorporating high yield components into traditional varieties and develop derivatives meeting the requirements of local people. This paper describes the participatory development with farmers of pure line derivatives, incorporating the palatability of dwarf varieties from Thavalakkannan and Chenkazhama and ensuring a broad genetic base.

Material and Methods

With the objective of incorporating palatability components into dwarf varieties, seeds of the landrace Thavalakkannan (TKTM) were collected from a farmer in Thiruvilvamala; it showed good yield components, particular spikelet number (~ 400). Chenkazhama (CHNK), an equally good traditional variety was collected from another farmer in Ottappalam. Seeds of IR8, IR36, PTB 8,9,26 were obtained from Pattambi Rice Research Station, and the other varieties, *matta* Thriveni (MTTV) and Athira (ATHR) from local farmers.

Thavalakkannan and Chenkazhma are phenotypically similar possessing reddish purple (referred by farmers as violet colour) leaf-sheath, leaf junction and leaf margins. The dwarf varieties generally had green sheath and the hybrids were identified easily using the dominant purple pigmentation. Five crosses (Table 1) were made: 1. IR36 x TKTM; 2. ATHR x CHNK; 3. TKTM x ATHR; 4. TKTM x MTTV; 5. TKTM x IR8. Hybrids with TKTM as female parent were identified on semi sterility. True hybrids were identified and in further generations selections were made based on height (medium dwarf) productive tillers, long panicles, high grain number and *matta* (bold grain, red rice) which farmers of Kerala prefer. *Matta* rice fetches the farmer a premium of Rs. 300 for 500 kg of paddy. Farmers do not grow TKTM and CHNK as second crop due to poor yields.

However, derivatives that are bred had to perform well in both the crop seasons.

Thus selections were made in F_2 generation in Mannapra village of Palakkad district. From F_3 onwards, the material was grown and further selections made in the fields of three farmers in a participatory mode. Selection made on the 5 traits mentioned earlier was continued until plants attained homogeneity for the traits. The maturity period of the homogenized lines was recorded. Thus PC1 identified in F_6 and PC2 in F_7 were ready for release during 2003.

This participatory breeding being the personal venture of the author, a new method of communicating the availability of new varieties became essential. An account of the varieties was published as news item by “Karashaka Sree”, a monthly journal in Malayalam by Malayala Manorama devoted to Kerala farmers. This was followed later by Malayala Manorama daily in all the five editions giving the address of the author and phone number with an account of the varieties ready for release. This enabled farmers to contact the author for seeds. They were directed to buy seeds from the participating farmers. Paddy seeds were sold at Government support price which was half the price permitted for certified seeds of varieties released by Kerala Agricultural University. Farmers came forward to buy seeds of PC1 and PC2 since their quality and taste were superior with high yields and matched farmers’ preferences. In the same way, PC3 to PC6 were evolved.

Mathrubhoomi, another popular Malayalam daily of Kerala brought the news to the attention of farmers by publishing an account of 4 short duration varieties (100-115 days) during March 2006. This was followed by an account in “Karshaka Sree” and Malayala Manorama daily. This process was very successful in helping spread of the new varieties to large areas in Palakkad district.

Results and Conclusions

The performance of parental varieties and derived lines, new varieties, PC1 to PC6 (Table 14.1) clearly showed that the developed varieties had reduced height with increased tiller number in some cases. But the performance in the second crop was uniformly good.

Short Duration Varieties from TKTM

Short duration varieties could be developed from crosses with TKTM as maternal parent. While the cross TKTM x ATHR gave two short duration varieties, PC3 and PC6, the cross TKTM x MTTV led to the variety, PC4 and TKTM x IR8 to the variety, PC5 (Table 14.2).The value of a traditional race, TKTM in producing a series of dwarf derivatives is thus evident. The performance of the derived varieties,

Table 14.1 **Improvement in yield component in derivatives compared to parents**

	TKTM		CHNK		MTTV		ATHR		IR8		IR36	
	I	II	I	II	I	II	I	II	I	II	I	II
HT	182	161	193	81	90	73	109	76	95.7	71	97	70
TL	3	12	3	7	5	5	5	4	5	13	5	5
LP	31	24.2	28.4	20.5	27.5	23	24.5	23	24	22.5	24.5	23
SL	430	160	213	70	184	107	214	135	169	159	211	134
DM	135	-	128	-	105	100	130	125	125	120	125	120
	* PC1		PC2		PC3		PC4		PC5		PC6	
	I	II	I	II	I	II	I	II	I	II	I	II
HT	101	90	120	98	122	75	88	84	105	82	107	80
TL	6	17	8	17	6	10	7	17	6	15	5	4
LP	25	28	29	26.5	30.5	23	25.5	25.5	32	23	27.5	22
SL	211	272	401	305	413	216	237	266	299	230	435	181
DM	135	128	120	115	117	110	115	110	115	110	105	100

*TKTM: Thavalakkannan from Thiruvilvamala; CHNK: Chenkazhama from Ottappalam; MTTV: Matta Thriveni (PTB 45); ATHR: Athira (PTB51)HT: Plant height (cm); TL: No.of productive tillers; LP: Length of Panicle (cm); SL: No.of spikelets; DM: Days to mature, I: First crop (May sowing) II: Second crop (September sowing) *Pedigree of varieties as in Table 14.2.*

particularly in grain number, suggest that TKTM as a female parent and Athira as a male parent could provide excellent cross combinations for producing new varieties answering farmers' preference in terms of quality, taste, cooking properties in addition to good yield. The past experience with HYVs was not completely satisfactory as they do not do well in second crop and they do not fit into the climatic condition prevalent in Palakkad.

The significance of the landrace, TKTM

Palakkad district is considered 'Rice-Bowl' of Kerala. Almost all varieties cultivated here are grown throughout Kerala. Krishnaswamy and Chandrasekharan (1957) reported a naturally occurring tetraploid species of *Oryza, O. malampuzhaensis* from Emurbhagavathy hills of Malampuzha region of Palakkad. Although the diploid of the species, *O. officinalis* occurred naturally in Assam, its tetraploid occurred here. The land race like Thavalakkannan (TK) has many varied forms, TK matta (PT8), TK White rice (PTB9) TKTM mentioned in the present study are all genetically different and show great diversity though phenotypically similar to

Chenkazhama (PTB 26) and CHNK of the present study. Reddish purple colour is a dominant trait found in these varieties. Sterile glumes of PTB8 as well as tip of glumes show extended colour. The maximum grain numbers of all these varieties do not exceed 250. Therefore the variety, TKTM which possessed 430 grains on the main panicle is an exceptionally superior variety.

Another aspect is the length of panicle. While many of IRRI varieties show panicle length of about 24 cm, landraces like TK and Chenkazhama show more frequently, panicles of about 30 cm indicating that ancient breeders, had preferred longer panicles and higher grain number associated with those varieties. This study has demonstrated that desirable traits from them could be transferred to the dwarf varieties, as shown by the performance of PC1 to PC5 (Table 14.2).

Table 14.2 **Performance of the developed varieties**

Variety	Derived from	Grain yield(q/ha.)	1000 grainWeight (g)
TKTM	Landrace of Palakkad	25	27
CHNK	Landrace of Palakkad	25	27
PC1	IR36 X TKTM	60	28
PC2	ATHR X CHNK	56	26
PC3 (Sivam)*	TKTM X ATHR	64	27
PC4 (Sathyam)*	TKTM X MTTV	60	25
PC5 (Santham)*	TKTM X IR8	61	30
PC6 (Sundaram)*	TKTM X ATHR	56	24

** Popular names given to the developed varieties*

All the varieties have long grains (8 – 9 mm) and breadth ranging from 3.0 – 3.6 mm

When the excessive height of landrace TKTM was corrected in derivatives, improved yields appear to be certain. Therefore in Kerala, one should increasingly make use of premier landraces of specific regions to produce superior varieties.Grain number combined with increased productive tillers and “matta” (bold grain, red rice) contributed by TKTM provide a cost-effective pathway for sustained development of new varieties suitable to Palakkad region of Kerala.

Reference

Krishnaswamy, N and Chandrasekharan, P., 1957. Note on a naturally occurring tetraploid species of *Oryza*. Sci. and Cult. 23: 307 - 310

15

Characterization and utilization of the ancient scented rice cultivar, Kalanamak

U.S. Singh, Neelam Singh, N.W. Zaidi, H.N. Singh, S.C. Mani, and R.K. Singh

Kalanamak, popularly known as scented black pearl of Eastern Uttar Pradesh, derives its name from black husk (*kala* = black). It is in cultivation since Buddha period (563 BC). Kalanamak is famous for its taste, palatability and aroma. It surpasses Basmati rice in all quality traits except grain length. Kalanamak fetches higher price than Basmati rice in local market. Until 15 years ago Kalanamak was grown widely in *Tarai* belt of eastern Uttar Pradesh comprising of districts Siddharthanagar, Sant Kabir Nagar, Maharajganj, Basti, Gonda and Gorakhpur. It covered more than 10 % of total area under rice in district Siddharthanagar (U.P.). However, acreage under this variety in this district declined to less than 0.5 percent of total rice area during 2002 and has almost vanished from other areas. Major reasons were (i) panicle blast epidemics during two consecutive years, 1998 and 1999, (ii) poor yield, (iii) tall stature causing lodging, (iv) long duration, (v) decline in grain quality particularly loss of aroma and taste, (vi) non-availability of quality seeds and (vii) total lack of any research support. Seed admixture and total absence of any seed purification or production programme were mainly responsible for decline in yield and quality. Farmers are using their own seed since ages.

During the present investigation 41 lines of Kalanamak were collected from eastern Uttar Pradesh (U.P.) & Bihar, purified by single plant selection and characterized for morpho-physiological, agronomic, grain quality and molecular traits in addition to reaction to biotic (diseases and insect pests) and abiotic (salinity and alkalinity) stresses. High quality, high yielding blast resistant and/or alkalinity tolerant lines were evaluated at farmers' fields both in normal and Usar soils and also in the All India Coordination Rice Improvement Project (AICRIP) trials. High quality blast resistant lines were distributed to farmers in district Siddharthanagar and their performance recorded during the years 2002 to 2005.

Wide variation was found in different Kalanamak lines for morpho-physiological, agronomic and grain quality traits, and biotic (diseases and pests) and abiotic stresses (pH and salt). RAPD markers showed high degree of genomic similarity in 38 lines of Kalanamak (including one line of Kala Joha) suggesting that Kalanamak lines used in the present study did not evolve independently but possible from one ancestral population. Participatory evaluation of a few selections in farmers' fields identified highly promising lines. For example, the selection, Kalanamak 3131 occupied an area around 10000 acres in the district Siddharthanagar during 2005 that spread to >30000 acres in 2006.Kalanamak 3327 performed very well in a multi-location tests yielding in some test locations around 6 t/ha. Likewise, a salt tolerant selection, Kalanamak 3119 performed well in alkaline, coastal saline and inland saline soils. This paper gives an account of the process of development of Kalanamak selections and in the process, its revival.

Key words: Ancient rice, Natural variation, Kalanamak, Scented rice, Usar soil

Kalanamak, (*kala* = black) is one of the finest quality scented rices of India. It derives its name from its black husk. It is known for its taste, palatability, deliciousness and aroma and surpasses Basmati rice, known internationally as a finest quality rice, in almost all quality traits except grain length. In local market Kalanamak fetches higher price than Basmati rice[1]. Cooked rice is fluffy, soft, non-sticky, sweet and easily digestible with a strong aroma and relatively longer shelf-life.

Kalanamak has been cultivated for a long time past dating back to Buddha period (563 BC). Its carbonized grains were found from excavation of Aligarhwa (district Siddharthanagar, Uttar Pradesh, India), located at Nepal border[2]. Kalanamak was grown widely in *Tarai* belt of Uttar Pradesh, India including districts Siddharthanagar, Sant Kabir Nagar, Maharajganj, Basti, Gonda and Gorakhpur. Until 1990, it occupied more than 10 % of total area under rice in district Siddharthanagar (U.P.), India. However, acreage under this variety in this district declined to less than 0.5 percent of total rice area during 2002 and almost vanished from other areas principally due to (i) poor yield, (ii) tall stature causing lodging, (iii) long duration, (iv) decline in grain quality (loss of aroma and taste), (v) high incidence of panicle blast, and (vi) non-availability of quality seeds and research support. In the context of farmers using their own seed for decades, seed admixture and lack of seed purification and production programme are major factors for decline in yield and quality of this historic scented rice cultivar [2].This paper reports work at improving this black husked scented rice, Kalanamak with a view to saving it from extinction.

Seventy-six lines of Kalanamak were collected from eastern Uttar Pradesh (U.P) and Bihar. They were characterized for morphophysiological traits and purified by single plant selection. . After discarding duplicates, 41 lines were finally selected. They were further characterized for morphophysiological, agronomic, grain quality and molecular traits and reaction to biotic (diseases and insect pests) and abiotic (salinity and alkalinity) stresses. High quality, high yielding blast resistant and/or alkalinity tolerant lines were evaluated at farmers' fields both in normal and *Usar* (saline) soils in district Siddharthanagar (normal soil) and Barabanki (*Usar* soil), in addition to evaluating them in multilocation through All India Coordinated Rice Improvement Programme (AICRIP). Promising lines were distributed to farmers in district Siddharthanagar and their performance and suitability evaluated during the years 2002 to 2005.

The morphophysiological and agronomic traits, number of tillers, flowering time, plant height, crop duration, panicle length, number of grains per panicle, yield, and 1000-grain weight were recorded [3]. Grain quality character (paddy/ kernel), like length (L), breadth (B), L:B ratio of grains, kernel elongation after cooking, elongation ratio, gelatinization temperature, amylose content, gel consistency and aroma were estimated following the methods described by Dela Cruz and Khush[4] and Sood and Siddiq[5].

Susceptibility of different lines of Kalanamak to diseases and insect pests was recorded under natural infection condition except for bacterial leaf blight (BLB), which does not occur in Kalanamak under natural condition of Nagina (Bijnore, UP) or Siddharthanagar (UP). Susceptibility of different lines of Kalanamak to BLB was evaluated by artificial inoculation in field. Methods of assessment of the above traits are published by IRRI[3].

A subset of 31 lines of Kalanamak was scored for salinity and alkalinity stresses on *Usar* soils of 8.5-9.0 pH and electrical conductivity (EC) 0.24 - 0.32 dSm^{-1} and 9.0-9.5 pH having EC 0.29-0.46 dSm^{-1} at the Centre for Research and Development of Waste and Marginal Lands, Barabanki (U.P.). Both pH and EC of soils were measured in 1:2 soil-water suspensions[6]. At this Centre, field blocks with different pH range are available. Initially different lines were planted in five rows (each row 4 m long) only, without replication, in each pH block. Two lines (3119 and 3131) showing better performance and high grain quality were evaluated in a replicated (three) trial at two different pH (8.5 - 9.0 and 9.0 - 9.5) in a large plots (40 m^2 area per replication). 38 lines were evaluated with 58 RAPD markers under PCR amplification for polymorphism. Using the Jaccard[7] similarity matrices, cluster analysis was performed and corresponding dendrogram generated using UPMGA[8] and NTSYS-pc (Numerical Taxonomy and Multivariate Analysis System for personal computers) package[9].

Results And Discussion

Morpho-physiological, agronomic and grain quality characteristics

All the 41 Kalanamak lines had the same brown-black coloured of husk with varied intensity. They were near equal in crop duration (177 to 183 d), gel consistency (soft to medium) and amylose content (intermediate to high-intermediate); they varied for all other traits.

Susceptibility to diseases and insect pests

Kalanamak is, in general, susceptible to diseases and insect pests like panicle blast (caused by *Magnaporthe grisea* (Hebart) Barr), brown spot (*Cochliobolus miyabeanus* (Ito & Kuribayashi) Drechsler ex Dastur), sheath blight (*Thanatephorus cucumeris* (Frank) Donk), sheath rot (*Sarocladium* or*yzae* (Sawada) W. Gams & Hawksw), stem rot (*Magnaporthe salvini* (Cke.) Tak. (1896) and yellow stem borer (*Scirpophaga incertulas* Walker 1963). For example, panicle blast appeared in epidemic form during 1998 and 1999 that resulted in sharp decline in cultivated area of Kalanamak.

We have evaluated Kalanamak lines against diseases and pests at two locations in two consecutive years. Under natural conditions, different lines showed wide diversity in their reaction towards panicle blast, sheath rot, stem rot, brown spot and stem borer. All lines were susceptible (S) or moderately susceptible (MS) against sheath blight. Only the line, 3220 showed moderate resistance (MR). But against panicle (or neck) blast as many as 10 lines (3114, 3121, 3128, 3130, 3131, 3213, 3216, 3220, 3259 and 3320) exhibited high degree of resistance when disease incidence was total in susceptible checks, while twelve lines showed moderate degree of resistance. Most of the Kalanamak lines, except 3081, 3125, 3129, 3214, 3229, 3256, 3266, 3278 and 3329 exhibited moderate to high degree of resistance against sheath rot. However, against stem rot only 9 lines (3122, 3124, 3129, 3168, 3213, 3220, 3222, 3320 and 3327) were resistant or moderately resistant. Ten lines (3089, 3120, 3124, 3126, 3131, 3212, 3215, 3257, 3266 and 3329) exhibited resistance towards brown spot. None exhibited resistance to yellow stem borer, causing dead heart and white head symptoms, and the most important insect of Kalanamak: though eight lines (3113, 3117, 3126, 3128, 3219, 3222, 3257 and 3319) showed less than 10% incidence. From the listed lines above, some could be located to show moderate to high resistance against multiple diseases and insect pests. Natural incidence of bacterial blight is rare in Kalanamak But under artificial inoculation, all were susceptible.

Performance in Usar soil

The word *namak* in Kalanamak means salt. However, the use of this suffix is not very clear as Kalanamak was never recommended for cultivation in salt conditions. Nevertheless Kalanamak was once widely cultivated in Himalayan *Tarai* of eastern Uttar Pradesh, where *Usar* soils are widespread. Performance of 31 lines of Kalanamak was evaluated in the field on alkaline *Usar* soil at two different pH ranges, i.e. 8.5 - 9.0 and 9.0 - 9.5. Two rice cultivars Sarju 52 and Pokkali, recommended for inland saline-alkaline and coastal saline soils, respectively, were used as controls. All Kalanamak lines performed quite well at pH 8.5 - 9.0. However, at a higher pH (9.0 - 9.5), there was reduction in yield in all the lines. However, lines 3119, 3131-1 and 3266 showed less decline in yield at higher pH. Further, the performance of these three lines on *Usar* soil was more consistent than control.

Two Kalanamak lines 3119 and 3131 showing high grain quality, resistance to panicle blast and reasonably high yield in *Usar* soil, were selected for large scale evaluation in *Usar* soil. Both these lines gave excellent yield performance in *Usar* soil, and yielded equally well or better than the coarse grain rice cultivar, Narendra Usar-2 released for cultivation in *Usar* soil. Kalanamak 3119 and 3131 yielded as high as 33.3 and 23.5q/ha at pH 9.0 to 9.5 in test plots (Table 15.1). The yields are exceptionally good considering the market rate of Kalanamak that is approx. 4 to 5 times higher than coarse grain varieties, like Pokkali or Narendra Usar-2[10]. Kalanamak 3119 when evaluated on saline-alkaline soils at 10 different locations

Table 15.1 **Yields of Kalanamak selections in *Usar* soil of two different pH ranges at CWAML, Kurshi, Barabanki (U.P.).**

Kalanamak lines	Yield (q / ha)	
	Soil pH 8.5 to 9.0	Soil pH 9.0 to 9.5
3119	60.00	33.30
3131	46.60	23.50
Narendra Usar-2	56.60	24.40
CD at p = 0.05	4.63	3.28

Plot size: 40 m^2; replications: 3

through AICRIP, yielded quite well in alkaline (~ 23.4 q/ha), coastal saline (~ 29.1 q/ha) and inland saline soils (~27.1 q/ha) (Table 15.2).

Table 15.2 **Performance of Kalanamak 3119 at 8 locations in saline-alkaline soil and 2 locations in normal soil***

Location (State)	Soil pH	Soil EC (dSm^{-1})	Yield ($q.ha^{-1}$)
Alkaline			
Kumarganj (Uttar Pradesh)	9.7	2.2 – 3.4	25.45
Navsari (Gujrat)	8.7–9.2	0.9 – 3.2	13.68
Kanpur (Uttar Pradesh)	9.8	-	31.00
Coastal Saline			
Cuttack (Orissa)	4.7 - 7.0	5.0 – 5.6	44.00
Canning (West Bengal)	5.0 – 8.0	6.2 – 6.5	27.22
Vyttila (Kerala)	5.6 – 6.2	5.0 – 5.4	16.00
Inland Saline			
Machilipatnam (Andhra Pradesh)	7.5 – 8.5	5.3 – 6.6	25.71
Gangavati (Karnataka)	6.3	8.1	28.49
Normal soil			
Gosaba (West Bengal)	6.3	1.5	14.60
Karaikal (Pondicheri)	8.0	0.9	55.70

**See References [11]*

Evaluation at farmers' Fields

Seven of the resistant or moderately resistant lines (3114, 3119, 3120, 3130, 3131, 3216 and 3327) to panicle blast were also better in yield and grain quality (Table 15.3 and 15.4). These selections were distributed to the farmers in district Siddharthanagar, the native area of cultivation of Kalanamak. Performance of these lines was much better than traditional Kalanamak during both the years. Their average yield varied between 3.5 to 4.5 t ha^{-1} against average yield of 1.2 to 1.5 t ha^{-1} at farmers' fields of traditional Kalanamak (Table 15.4), that enthused farmers to cultivate those lines preferentially. Thus in the district, Siddharthanagar in 2005 Kalanamak 3131 covered more than 10,000 acres area at farmers' fields.

Table 15.3 **Quality characteristics improved selections of Kalanamak**

Kalanamak selections	Paddy		Kernel			Cooked kernel		ER	GT	GC	AC	Reaction to panicle blast*	Aroma
	L	B	L	B	L/B	L	B						
3114	7.0	2.1	4.7	1.9	2.5	10.6	2.4	2.3	H-I	Soft	21.7	R	Moderate
3119	7.3	2.2	5.5	1.54	3.7	9.7	2.6	1.8	L	Medium	24.3	MR	Strong
3120	8	2.2	5.6	2.1	2.7	10.0	2.6	1.8	I	Soft	25.9	MR	Strong
3130	7.4	2.2	5	2.1	2.4	10.6	2.6	2.1	H-I	Soft	25.6	MR	Moderate
3131	7.3	2.4	4.6	1.8	2.6	10.2	2.4	2.2	I	Soft	23.5	R	Strong
3216	7.4	2.2	4.8	1.8	2.7	10.6	2.4	2.2	I	Medium	24.8	R	Strong
3327	7.2	2.2	4.8	2.0	2.4	9.4	2.7	2.0	H-I	Soft	23.9	MR	Strong

*ER-elongation ratio; GT-gelatinization temperature; GC-gel consistency; AC-amylose content; L-length; B-breadth; H-high; I-intermediate; L-low; R-resistant; MR-moderately resistant. *Based on reactions at two locations*

Table 15.4 **Performance of selected lines of Kalanamak at farmers fields in district Siddharthanagar during 2002 and 2003.**

Kalanamak selections	Yield (t ha^{-1})		
	2002	2003	Average
3114	3.867	4.060	3.964
3119	3.667	3.370	3.519
3120	5.120	3.950	4.535
3130	3.733	3.913	38.23
3131	3.840	4.720	4.280
3216	3.980	4.150	4.065
3327	3.345	3.260	3.302
Kalanamak Traditional	1.250	1.470	1.360

During current *kharif* 2006 it has spread over to more than 20,000 acres area in district Siddharthanagar and another 10,000 acres in adjoining district, Sant Kabir Nagar. This variety also showed good performance when tested under ASGON (Aromatic Short Grain Observation Nursery) of AICRIP during *kharif* 2005. Kalanamak 3131 has since been given to Uttar Pradesh government to consider its release for cultivation in eastern Uttar Pradesh.

Likewise, Kalanamak 3327 and other Kalanamak lines 3119, 3131 and 3216, selected from initial variation of Kalanamak offer great promise for reviving cultivation of this ancient cultivars.

Molecular characterization

The PCR amplification, with 58 RAPD markers showed high degree of genomic similarity. The Jaccard[7] similarity coefficient among the test genotypes ranged from 0.82 between most distant (dissimilar) lines to 0.98 between the closest (similar) lines (Figure 15.1). Thirty-three out of 38 lines exhibited greater than 90 % genetic similarity. It included Kala Joha, a black husk aromatic rice cultivar from Assam indicating the possibility that probably this cultivar originated from Kalanamak. Five lines, which exhibited less than 90 % genomic similarity from other lines were 3119-2, 3266, 3256, 3257 and 3089. These may be out groups due to gene flow generated over time (Figure 15.1).

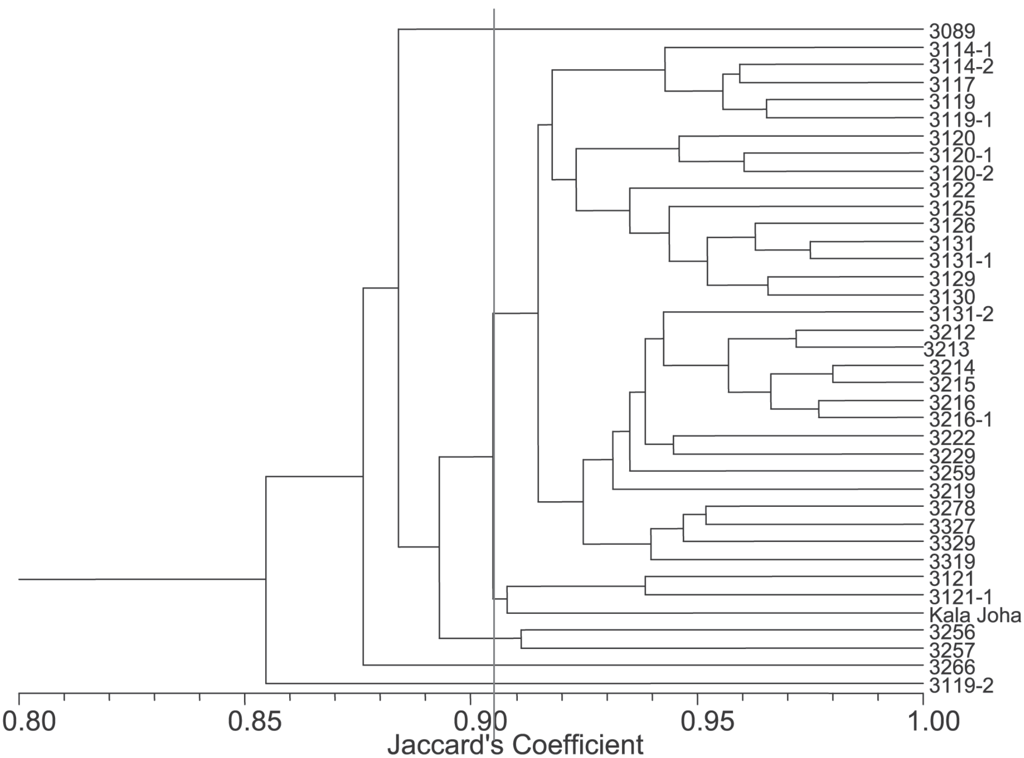


Figure 15.1 **Genomic relatedness among 38 Kalanamak rice collections on the basis of molecular markers (RAPD) (Cophenetic correlation coefficient (r) = 0.87)**

The high genetic similarity observed among Kalanamak lines is strong evidence suggesting that the different lines of Kalanamak did not evolve independently from each other and therefore, likely to be part of the same ancestral population.

This observation gains further ground by the three different analysis, clustering dendrogram, and principal coordinate analysis and cophenetic coefficient.

Because Kalanamak is an ancient cultivar, farmers have been using their own seed for the cultivation since hundreds of the years. There was never any organized seed purification, production and distribution system for this cultivar. So whatever variability cropped in either due to mutation or limited out crossing is retained in the population in the form of small genetic diversity but relatively wider variability in their morphological, agronomic and grain quality traits and also susceptibility towards diseases and pests. This variability has resulted in decline of both productivity and quality but at the same time it has probably helped in survival of the cultivar in its native area of cultivation. Mixed seed lot behaves as a multi-line under natural condition. Probably because of this variability Kalanamak suffers less from different diseases and pests in its native area of cultivation as compared to evolved varieties in same area [2].

The present study could therefore select for high yielding variants and in further generations fix them to provide sustainable yield levels.

References

1. Singh, U.S., Singh, Neelam, Singh, H.N., Singh, O.P. and Singh, R.K., Rediscovering scented rice cultivar Kalanamak, *Asian Agri-History*, 2005, **9**, 211-219.

2. Singh, R.K., U.S. Singh, Neelam Singh, H.N. Singh, and Singh, G., Kalanamak: A scented Black pearl of Eastern Uttar Pradesh, In *A Treatise on the Scented Rices of India* (eds. Singh, R.K. and Singh, U.S.), Kalyani Publishers, New Delhi, 2003, pp. 421-431.

3. IRRI., 1996, *Standard Evaluation System for Rice*, INGER, International Rice Research Institute (IRRI), Los Banos, Laguna, Philippines, 1996, **30** p.

4. Dela Cruz, N. and Khush, G.S., Rice grain quality evaluation procedures, In *Aromatic Rices* (eds. Singh, R.K., Singh, U.S. and Khush, G.S.), Oxford & IBH Publishing Co., New Delhi, India, 2000, pp. 15-28.

5. Sood, B.C. and Siddiq, E.A., A rapid technique for scent determinations in rice, *Indian J. Genet. Plant Breed*., 1978, **38,** 2268-2271.

6. Abrol, I. P., Yadav, J. S. P. and Massoud. F. I., *Salt-Affected Soils and their Management,* Food and Agriculture Organization of the United Nations, Rome, Italy, 1988.

7. Jaccard, P., Nouvelles recherches sur la distribution florate, *Bull. Soc. Vaud. Sci. Nat*., 1908, **44,** 223-270.

8. Sneath, P.H.A. and Sokal, R.R., *Numerical Taxonomy*, Freeman ,W.H. and Co., USA, 1973.

9. Rohlf, F.J., 2000, *NTSYS-pc Numerical Taxonomy and Multivariate Analysis System* Version 2.1, Exeter Software, Setauket, New York, USA, 2000.

10. Singh, U.S., Singh, N., Singh, H.N., Singh, R.K. and Singh, M.P., Biodiversity in Kalanamak: Estimation and utilization, In *Aromatic Rices of Uttar Pradesh and Uttaranchal* (eds. Singh, R.K. and Singh, U.S.), Kalyani Publishers, New Delhi, 2005, pp. 33-41.

11. Anonymous., *Progress Report 2005. Varietal Improvement*. Vol. 1, All India Coordinated Rice Improvement Programme, Directorate of Rice Research, Rajendranagar, Hyderabad, India, 2006.

16

Participatory plant breeding: linking capacity building and farmers' rights

Bert Visser and Niels Louwaars

Participatory plant breeding (PPB) should allow farmers to be the central actors and encompass the entire breeding cycle. For such PPB efforts to be effective, capacity building forms a necessary prerequisite. Taking into account the importance of on-farm maintenance of plant genetic resources, capacity building needs a wider interpretation in the international debate, and should not be restricted to public sector institutions but include farmer communities. Sufficient evidence shows that farmers can be breeders, that new farmers' varieties are developed continuously, whether in the context of PPB projects or autonomously, and that some of farmers' varieties can be very successful in terms of adoption rates and market shares. Capacity building also follows from the farmers' rights agenda. Farmers' rights should not simply entail a counterpart of breeder's rights but also address all socio-cultural and economic aspects allowing the persistence of farming systems that can successfully maintain their own genetic resources. Such a concept will also recognize the rights of farmers on access to appropriate germplasm.

Keywords: participatory plant breeding, capacity building, farmer's rights and policies

A brief history of concepts

The term "participatory plant breeding" (PPB) became established in the 1990s, as several projects were undertaken under this banner [1]. At the same time it became clear that quite different approaches were captured under this term. In some projects the term participatory was used to indicate that farmers evaluated in their own farms finished and stable (candidate) varieties developed in public sector plant breeding institutes, thus enabling a more reliable prediction of the adaptation range, and the potential adoption rates of new varieties. Other projects took the term participatory to indicate that farmers were to be included in priority setting processes for breeding objectives (through rural appraisal techniques) or, alternatively, that farmers needed support from the formal sector to undertake and strengthen their own crossing and selection activities. Under these divergent interpretations, project decision and responsibilities have thus been distributed quite differently over the major stakeholders. A useful characterization of project types has been provided by Sperling et al.[2]

The generic term "capacity building" has of course a long history. Beyond the meaning in the narrow sense of building individual capacities through education and training, capacity building includes support for institutional development and institutional learning, and empowerment in accessing knowledge and information. In the context of this study, references to capacity building are made in the context of Convention on Biological Diversity (CBD; 1992), Global Plan of Action (GPA; 1996) and International Treaty on Plant Genetic Resources for Food and Agriculture (IT-PGRFA; 2001). In these agreements, capacity building is primarily a responsibility of donor countries, implicitly or explicitly included as a component of benefit sharing. Little reference is made to the institutions that are involved therein. This can be considered a logical outcome of the principle of national sovereignty according to which it is left to the state how implementation of international agreements is given form.

As a result, many stakeholders associate the public sector rather than farmer communities or community based organizations (CBOs) as the principal beneficiaries of capacity building activities [3, 4]. This interpretation is only further strengthened by a focus on programmes for scientific and technical education and training, developing and strengthening facilities, and carrying out scientific research in the three international agreements referred to above. The Global Plan of Action, however, specifically recognizes the role of communities and NGOs in capacity building activities (e.g. in paragraphs 220 and 313).

The most debated and politically sensitive term is "farmers' rights", a term that - in 1985 - was originally coined to juxtapose the contributions of farmers to the development of crop varieties with those of formal sector plant breeders, who could protect their varieties by breeder's rights [5]. From the start, widely different interpretations were given to the term. The FAO Conference of 1989 defined farmers' rights as the "rights arising from the past, present and future contributions of farmers in conserving, improving and making available plant genetic resources, particularly those in the centres of origin/diversity." The purpose of these rights is stated to be "ensuring full benefits to farmers and supporting the continuation of their contributions". A "non-monopolistic" *sui generis* system of farmers' rights was later proposed whereby no registration would be necessary and all communities' knowledge may be protected against misappropriation by nonlegitimate means [6] .In the Charter of Farmers' Rights (1993), declared by farmers' organizations, these rights were described as the right to land; the right to conserve, reproduce, and modify seed and plant material; the right to feed and save the country; the right to just agricultural prices and public support for sustainable agriculture; the right to information; the right to participatory research; the right to natural resources; and the right to safety and health. The IT PGRFA codified "Farmers' Rights" to specifically include rights on the protection of traditional knowledge, on benefit-sharing and on participation in decision making, in addition to generic rights that farmers have to save, use, exchange and sell farm-saved seed. Whereas these rights are to be implemented at the national level, only some countries have taken steps to include components of these rights in their national law.

On the nature of farmers' varieties and their relation to PPB

Current farmers' breeding goes beyond selection in landraces, and includes development and maintenance of major new farmers' varieties that are increasingly uniform. Evidence is found in South-East Asia and South Asia [7,8], but the practice is most likely prevailing in other regions also. In some countries (Nepal, Vietnam), farmer-bred varieties are even formally registered in the national variety list, creating recognition for the originators or maintainers, and contributing to a potentially widespread use of the varieties.

Traditionally, only landraces would serve as the source of diversity in farmer breeding. Modern varieties developed in the formal sector have partly replaced landraces, but have not abolished farmers' breeding practices, whether or not in the context of PPB, nor their seed-saving practices. Farmers'varieties, whether traditional landraces or advanced varieties selected or developed by farmers, constitute a major share in crop production.

In an increasing number of countries, plant varieties developed by the private and public sectors can be protected by plant breeder's rights. Granting of such rights creates a commercial opportunity for the breeder, while at the same time keeping the protected variety available for further research and breeding, although the breedre's exemption and farmers' privilege have been limited in the last UPOV Act (1991). Recognition of the contribution of farmers' varieties to agricultural development and as a source for further breeding advancements, and the protection of their cultural identity, are only specifically regulated in a small number of countries. (India has enacted the Protection of Plant Varieties and Farmer's Right Act (2001)[9], and the Organization of African Unity published in 1998 a draft

Model Law on "Community Rights and on the Control of Access to Biological Resources").Proper interpretation of current international agreements impacting on plant genetic resources may help address these gaps. In this context, ensuring recognition of collective innovation, allowing access to relevant germplasm sources for farmers' breeding activities, keeping the products of farmer breeding freely available, and arranging for effective benefit-sharing, all form major challenges.

1. Plant breeder's rights are based on the concept of the individual (rights are granted to an individual person or company), and whereas CBD and IT-PGRFA recognize the collective contribution to plant genetic resources by farmer communities, no internationally accepted legal system yet exists that recognizes the products of collective innovation [10,11].
2. More importantly, access by farmers to germplasm that is appropriate for further breeding, whether parent lines with major traits or segregating populations from breeding stations, or farmers' varieties of other regions or countries from genebanks is by no means guaranteed. Some breeders and genebank curators do not consider farmers as serious stakeholders and are not able to respond to their needs and requests (pers. comm.; 2005). A paradigm shift is required to allow these professionals to recognize the complementary contribution that breeders and farmers can make to the development of varieties optimally adapted to local conditions and preferences.
3. Breeder's materials are increasingly protected by patents, plant breeder's rights or institutional secrecy policies, preventing their distribution to farmers or limiting their use by farmers and institutions working for them.

Sharing of benefits generated by third parties based on germplasm and information made available by farmers' varieties has not been effectively arranged for yet. At the international level, the CBD has only provided a framework for benefit sharing and the access and benefit-sharing system of the IT-PGRFA has only recently come into operation by the adoption of the standard Material Transfer Agreement. No international policies have come into operation regulating the transfer of benefits down to farmer communities, and few national regulatory frameworks that intend to do so have become effective so far. Whereas it is still largely unclear if, how and when benefits generated may reach farmer communities [12,13], some examples exist. India has provided benefit-sharing to farmers for the use of the medicinal plant arogya pacha (Trichopus zeylanicus L.) in the medicine known as 'Jeevani'. In addition, the South African Council for Scientific and Industrial Research will pay the local San community a share of payments received from Phytopharm, its UK-based licencee for a potential anti-obesity drug.

Capacity building and farmers' rights: a direct linkage

Whereas the IT PGRFA provides a fairly narrow description of Farmers' Rights, this description may still act as a starting point for analyzing the role and components of capacity building in relation to PPB.

For example, the right to protection of traditional knowledge relevant to plant genetic resources for food and agriculture (Article 9.2a of the IT PGRFA) can be implemented best by the maintenance of this traditional knowledge through use. This logically translates in strategies to maintain and upgrade farmers' varieties through PPB, which requires the development of the capacities detailed below. In addition, the right to equitably participate in sharing the benefits arising from the utilization of PGRFA may lead to monetary or non-monetary benefit-sharing. The IT PGRFA identifies capacity building, information exchange and technology transfer among the non-monetary benefits. Capacity building in participatory plant breeding may be considered a valid form of benefit-sharing by which formal sector partners share their knowledge and materials with farmers. In return, farmers share their knowledge and materials with the formal sector partners and thus contribute to the development of their capacities as well.

Finally, the right to participate in making decisions, at the national level, on matters related to the conservation and sustainable use of PGRFA is directly linked to capacity building, since farmers will not be able to participate in decision-making if they are not knowledgeable of the issues at hand. Thus, they have to develop their capacity to participate effectively, and may have to be supported in developing such qualities.

Capacity building is thus an important component of any type of Farmers' Rights, either as a mechanism to implement the rights or as a necessary prerequisite.

Capacities needed for participatory plant breeding

In various projects (e.g. CGIAR System-Wide Programme on Participatory Research and Gender Analysis; the Community Biodiversity Development and Conservation programme) participatory plant breeding requires substantial efforts by farmers, who are regarded as the central actors. Not all these efforts belong to farmers' normal practices. In particular in farmer-centered PPB approaches, farmers are supposed to set their own objectives, to select and access potentially useful germplasm, to learn how to make crosses, how to select from segregating populations, how to document their breeding work, how to market their own new products and how to relate to authorities in doing so[8]. Such activities are not familiar to the great majority of farmers, so farmers have to build capacity in order to successfully undertake these activities. This capacity building requires training in these different fields and also access to useful plant material and information. In other words, capacity building in the framework of PPB does not only depend on the efforts of farmers themselves but also on the contributions by other stakeholders, such as germplasm holders (genebanks, breeding institutions), extension services, experts from breeding stations, local and national authorities, and supportive organizations (NGOs, CBOs, universities).

In particular, perceptions by these stakeholders on the value of farmers' knowledge and materials and on the empowerment of farmers determine whether, how and to what extent PPB initiatives can be successful. Relevant questions include whether farmers' varieties (or landraces) are regarded as old-fashioned and deemed to be replaced or to be reckoned as viable, persistent varieties that can complement formal sector varieties, whether farmers are recognized as breeders in their own right or only as marginal contributors to formal sector plant breeding, and whether or not the quality of their products can compete with the breeding products of professional plant breeders.

Seed legislation often contains implicit views on such issues. As a consequence, any PPB initiative by definition not only entails strong capacity building components but will also sooner or later in project implementation be confronted with the need to deal with policy issues. Such policy issues dealing with farmers' capacity to manage their own germplasm can be considered part of the farmers' rights issue.

Capacities that are required in participatory plant breeding can thus be summarized as follows:

- knowledge of plant breeding (both scientific and local knowledge) and of the needs of farmers in their own farming systems.
- access to genetic materials, both the farmers' varieties that form the starting point for breeding efforts, and formal sector materials that may provide particular genetic traits or high quality breeding material in general.
- capability to generate conducive policies that allow PPB and the spread of its results, notably in the form of seed laws and regulations that protect the farmers' rights and avoid misappropriation.

Operationalizing capacity building for PPB: process and conditions

Function and scope of necessary expertise

Capacity building in PPB should contribute to alleviating poverty and improving food security and food sovereignty of farmer communities, and contribute to greater community autonomy and less dependence on external inputs. Therefore, capacity building should not be limited to those components of plant breeding for which farmers have some advantage over professional breeders because of their agro-ecological environments, their practices, or relatively low costs. On the contrary, capacity building should encompass the full process of plant breeding as well as address all facilitating processes, in order to empower farming communities to master their own food production and their own lives. For such capacity building farmers may need major external support. Professionals contributing to participatory plant breeding can directly address several issues distinguished in the Charter of Farmers' Rights, such as the right to conserve, reproduce, and modify seed and plant material; the right to information; the right to participatory research; and the right to natural resources [15.]

In offering support to farmer groups, it is important to realize that some capabilities will be useful for all farmers in a community, whereas for the mastering of other capabilities only few farmers in a community may suffice. Hence, not all farmers in the community need the same knowledge and skills.

Various stakeholders can provide expertise, support or materials for PPB to farming communities, including social scientists, plant breeders, and market economists. In many cases, staff of extension services and NGOs can be trained alongside key farmers, and often they are more able to guide farmers over prolonged periods of time than public sector breeders. Even if it seems not feasible to formally involve plant breeding institutes in PPB initiatives because of lack of recognition for farmers' contributions to crop development, it is sometimes possible to identify allies amongst the breeders in such institutes that with institutional consent may provide services at an individual basis. In general, model farmers form the most important, effective and cost-efficient trainers and mediators of information.

Securing access to appropriate germplasm

Access to proper germplasm should be regarded as a basic element of farmers' rights. Farmers' own practices often involve accessing novel germplasm not yet cultivated in the community either by buying small seed lots on the market or by exchange with family relations or other acquaintances, monitoring the germplasm in the field, and allowing it to cross with local varieties if interesting traits are found in the novel germplasm [7,8]. Such practice can also be integrated in capacity building programmes, whereas the scope of access can be substantially widened to include germplasm from breeding institutes or genebanks, either in the form of finished varieties or breeding materials. In addition, farmers may be provided with segregating populations from breeding programmes, both early (F2) and later (F6) stages, from which they can select their own preferred genotypes. In other words, support for farmers' breeding work can be offered through widening access to public institutions, as well as to breeding materials normally not available to farmers.

In accessing useful germplasm from genebanks or breeding institutes, conditions to the use of such material may be posed. However, since the free exchange of germplasm is a deep-rooted practice of farmer communities, restricting or even tracking the spread of germplasm either in its original form or in the form of a product derived from the original germplasm, is practically not possible. Farming communities and formal sector participants in PPB should develop clear policies on which types of restrictions to access to genetic resources are acceptable.

One of the major advantages of farmers' seed systems is the free availability of farmers' varieties. Farmers all over the world have always exchanged seed amongst themselves, rooted in the recognition that free exchange is in the ultimate interest of farmers. Free exchange allows them to cope with seed shortages and with new pest and disease challenges, and allows them to continuously adapt their own local varieties by introgressing new interesting traits.

Intellectual property rights systems, and in particular patents on crop varieties and traits, have severely challenged this free exchange principle. In order for participatory plant breeding approaches to be effective in the long run, it has been argued to be essential that farmers' varieties stay in the public domain and that access by farmers is not limited either by intellectual property rights such as plant breeder's rights, or by new interpretations of the concept of farmers' rights [11, 14].

Rights and policies

National seed laws may impose registration criteria on farmers' varieties that are difficult to fulfill. Such conditions regard not only distinctness, but also uniformity levels that are often not met by farmers' variety, which are deliberately kept more versatile. The tests determining the Value for Cultivation and Use under these release systems furthermore imply that only varieties that do well on average in multi-locational testing are accepted rather than varieties that do exceptionally well in a specific environment, as is commonly the case in PPB. Furthermore, some local authorities and phytosanitary services have questionned the level of resistances to important pestst and diseases in farmers' varieties.

All such conditions limit farmers' options in exploiting the results of their breeding work in the PPB context. Addressing these limitations timely is essential for the success of participatory plant breeding projects. Such policy work requires specific expertise, and may be offered by supportive NGO's as well as other stakeholders.

Having said all this, seed laws may also be useful since they may offer recognition to the originators, as they register the name of the variety. When the name of the community or the region features in the official variety name, any user will be able to understand its origin.

The question may be raised if farmers need a legal system providing them with rights similar to those of plant breeders in the public and private sectors, or that a farmers' rights concept is needed that offers recognition for the breeding work and protection against misappropriation of germplasm without direct monetary compensation. Such recognition may instead result in farm-focused community support programmes of various nature.

It can be argued that in searching for alternative protective measures current concepts of intellectual property rights are not suitable. Alternative rights systems that do not focus on property, but rather on recognition and protection may be needed that may be composed of multiple measures. Both the principle of declaration of origin and farmers' registers may be part of such systems, whereas current seed legislation may need adaptations to make the system operational.

Whereas in most cases farmers may not wish to take out property rights in the form of plant breeder's rights, others including public and private breeding companies may start using the new farmers' varieties or even submit the same material for granting property rights under their name without any option for seeking legal recourse by farmers. Farmers' registers may offer a way out by making the properties of a new variety public knowledge, thus preventing the granting of a property right to third parties. Adoption of the concept of declaration of origin would neither monetize genetic resources nor discourage farmers to share these resources, but recognize their contributions as developers. Alternatively, plant breeder's rights may also be used as a defensive protection system, i.e. to make sure that others cannot monopolise the products of farmers' work. Whereas the advantage is that also varieties that have undergone subsequent minor changes by third parties cannot be monopolized without the consent of the community (so-called essentially derived varieties), this type of ownership remains alien to farmers, and can be quite expensive. Therefore, taking out breeder's rights may not be a desirable and viable option to farmer communities. In any case, partners in PPB projects have to be very clear about their intentions regarding the products of their jointly undertaken work.

The use of existing legislation covering an alternative intellectual property rights system, geographical indications, may also be considered. It protects a product in the market which is produced in a certain locality, and it may be linked to a certain production method and/or genetic resource use. This may further strengthen the cultural component (the ability to create new and typical diversity) in addition to a physical component (the place of origin). Such policy related issues require specific capacities. This expertise may be provided by supportive NGO's as well as other stakeholders.

Conclusions

Revisiting capacity building in the context of farmers' rights

In summary, farmers' rights can be seen as a legal complement of breeder's rights (the latter now enacted in many countries), balancing rights of farmers and breeders, but alternatively farmers' rights may be interpreted as a socio-cultural and economic concept referring to the recognition of farmers' role in maintaining genetic resources and biodiversity. In further developing the concept of farmers' rights it is important to realize that only a handful of countries have adopted legislation referring to farmers' rights, whereas at the same time the international legally binding agreements impacting on farmers' rights (CBD and IT PGRFA) postulate that the implementation of the concept of farmers' rights is a national responsibility. Therefore, farmers need community-based organizations that can lobby in favor of their interests at the national level, and allies in the policy environment who understand their practices, recognize their role in maintaining PGRFA and support their positions.

If farmers' rights are not understood in a narrow sense, forming the complement of breeder's rights, but in contrast are interpreted as to involve the recognition and protection of farmers' practices contributing to the maintenance and development of plant genetic resources, then capacity building forms a major constituent of farmers' rights. The IT PGRFA with its references to farmers as major beneficiaries of benefit-sharing and to the need for capacity building as part of benefit-sharing certainly provides a basis for such interpretation.

In providing support to farmers' communities, the notion that farmer breeding is not a practice of the past but still vivid and contributing to the further development of plant genetic resources should be taken as guidance. Support should focus on the training of farmers in the context of participatory plant breeding, on the availability of appropriate germplasm to which farmers have normally no access, to finding new market outlets. Whereas such measures recognize the importance of farmer breeding to food production and food security, other measures are needed to secure access to appropriate germplasm and hence to protect the farmer breeding system in order for it to operate effectively. These measures include the rights of farmers to use and further distribute germplasm and market its products, and the prevention of misappropriation of farmers' products.

This farmers' rights agenda is not a narrow legal agenda, but a wider socio-cultural and economic agenda and a major challenge to the world's plant genetic resources community.

This agenda also links the work in the field to the policy arena, realizing that policy issues regarding PGRFA are here to stay, and need to be addressed in order for participatory plant breeding and on-farm plant genetic resources development to be successful.

References

1. Vernooy, R., 2003. In_Focus: Seeds that give. Participatory plant breeding. International Development and Research Council, Ottawa, Canada.
2. Sperling, L., Ashby, J.A., Smith, M.E., Weltzien, E. and McGuire, S., 2001. A framework for analyzing participatory plant breeidng aopporaches and results. Euphytica **122**, 439 – 450.
3. Guimarães, E.P., Kueneman, E. and Carena, M.J., 2006. Assessment of national plant breeding capacities in Africa and recommendation for further capacity building. HortScience **41**, 50 – 52.
4. http://www.fao.org/docrep/008/af081e/af081e01.htm#TopOfPage
5. Andersen, R., 2005. The history of farmers'rights. FNI Report 8/2005. The Fridtjof Nansen Institute, Lysaker. Norway.
6. Correa, C., 2000. Integrating public health concern into patent legislation in developing countries. South Centre, Geneva, Switzerland.
7. Ramanna, A. and Smale, M., 2004. Rights and access to plant genetic resources under India's new law. Developm. Policy Rev. **22**, 423 – 442.

8. Salazar, R., Louwaars, N.P. and Visser, B., 2006. Protecting farmers' new varieties: new approaches to rights on collective innovations in plant genetic resources. World Developm., in press.

9. Swaminathan M.S. 2006. http://www.geneconserve.pro.br/artigo_3.htm.

10. Srinivasan,, C.S., 2003. Exploring the feasibility of farmers' rights. Developm. Policy Rev. **21**, 419 – 447.

11. Overwalle, G., Protecting and sharing biodiversity and traditional knowledge: holder and user tools. Ecol. Econ. **53**, 585 – 607.

12. Grain., 2005. The FAO Seed Treaty. Seedling October 2005. Grain, Barcelona, Spain.

13. Mendelsohn, R., 2000. The market value of farmers' rights. In: Agriculture and intellectual property rights (eds. Santaniello, V., Evenson, R.E., Zilberman D. and Carlson, G.A.,) CAB International, London, UK.

14. Brush, Stephen B., (1994): *Providing Farmers' Rights through* In Situ *Conservation of Crop Genetic Resources*, CPGR Background Study Paper No.3 (Rome: FAO).

15. Smolders, H., (ed.). 2006. Field guide for participatory plant breeding in farmer field schools. Centre for Genetic Resources, Wageningen, the Netherlands.

Abstracts Only

17

Alternative paddy cultivation practice to mitigate global warming

H.E. Shashidhar

Agriculture, as we know it today, is tuned to maximize productivity at all costs. The ecological costs of each agricultural practice are seldom the major concern. In spite of this, the profitability and productivity of crops, especially major cereals are waning. The country is resorting to importing food to meet its demand! A clear manifestation of the ecological damage through product quality is discernable in the high levels of contamination of our water bodies, degradation of large extant of land, contamination of vegetables and food grains due to excessive use of plant protection chemicals etc.

Alternative agricultural practices need to be evolved urgently so as to meet the needs of the present and future generations, lest we make this earth uninhabitable. Each new research program, and products developed thereof, needs to be evaluated for ecological impact, at this point in time and possible implication in future. Bio-safety assessment need not be the concern of biotechnologists who move genes, promoters, modifiers and regulators, around flora and fauna.

One of the effects of agricultural technology has been its contribution to global warming. Global warming (climate change) is a catastrophe inflicted on this earth by human beings. The thin line between human need and greed is fading fast.

Anticipatory breeding programs with active involvement of farmers and consumers in the developmental process seem the right way to go ahead. Breeding for problems faced by the farmers, and consumers, currently and those projected based on past trends, as revealed by historical records, needs to be discovered, perfected and popularized urgently.

Today's Paddy

Paddy is a cereal that drives the country forward. Paddy produced through impounding water in the fields, through the cropping season, has been shown to contribute immensely to global warming. India with the vast area under paddy contributes about 2.14 Terra-grams of methane per year, next only to China at 3.73 terra grams. Each molecule of methane has a life of 12.2 years and a global warming potential of 21 per molecule. Added to this, the amount of nitrous oxide that runs off the paddy fields and contaminates the water bodies is also huge. Each molecule of nitrous oxide has a global warming potential of 310 and atmospheric life of 120 years.

Alternative Paddy

Direct seeding of paddy was (and is) in vogue in some parts of India. It is still practiced in low-input cultivation systems or in uplands where chronic water shortage and low productivity are common. The traditional varieties that are well adapted to this practice are endowed with many good traits but not high yield. Borrowing a leaf from this system, we have developed high yielding genetic material that is amenable for direct seeding. These paddies can be irrigated akin to maize or sorghum and still produce the save yield levels. This would be an ideal substitute to irrigated paddies where water is impounded through the cropping season.

Applying the concept of deficit irrigation, we need to work out the appropriate levels of irrigation, fertilization and profitability.

Our concern for the environment should never take the backseat at lease with the selfish interests of each or our children, children of our relatives, children of our friends, and the coming generation. We will be doing a service to all life forms on earth, if we could make our agricultural practices eco-friendly.

18

Novel Genetic Combinations for Facilitating Breeding for Crop Improvement

Ajay Parida

Historically, plant breeding has the major aim of genetic enhancement of crop plants through the application of principles of Mendelian Genetics and modern tools and techniques of cell and molecular biology. Many breeding programs also include induced mutations with either or both physical and chemical mutagens and focus on the improvement of traits such as high yield, multiple resistance to major disease, insect pests and tolerance to abiotic stresses and improved quality. The improved varieties more often than not fit into the crop cultivation systems of different eco-agricultural regions for the production of feed, fiber, food, and industrial products. The value of new plant varieties in increasing food production has been demonstrated time and again.

Recent advances in molecular genetics and crop biotechnology have opened new opportunities to speed up the process of plant breeding. Molecular markers have become important tools in the hands of plant breeders for enhancing the selection efficiency and quantifying and identifying plant genetic resources for various agronomic traits. Assessment of genetic diversity of elite germplasm resources have been utilized for a variety of reasons – species identification, genetic relationships, parent selection, germplasm management and sampling and germplasm protection, among others. It has been established that DNA markers provide superior discriminatory power related to protein and morphological markers with few exceptions. The availability of a repertoire of methods for detecting DNA polymorphism suggest that they could be advantageous for a species, which have wide gene pools.

Plant breeding has in fact entered in an era of genomics and the later has immense implications for facilitating breeding genotypes for improved characteristics. The isolation, cloning and moving of genes from diverse biological sources into plant genomes holds promise to broaden the gene pool of crops and tailor plant varieties for specific traits that determine yield, quality and resistance to biotic and abiotic stresses.

The ongoing work at MSSRF through utiliazing the advanced molecular tools and technologies has enabled generation of novel genetic combinations for developing location specific crop varities with tolerance/ resistance to abiotic stresses and improved nutrition quality.

Novel Genetic Combinations for Salinity Stress

With a view to identify and isolate novel genetic combinations offering resistance to coastal salinity, MSSRF had initiated work on mangrove species. Mangroves are salt tolerant plant communities occupying the coastal estuarine regions of the tropics. They serve as a vital link between terrestrial and aquatic ecosystems and provide livelihood and ecological security for the coastal communities.

Identification and isolation of novel genetic combinations with implications to abiotic stress were undertaken from the widely distributed mangrove species, *Avicennia marina* and the wild rice *Porteresia coarctata*. Enriched gene libraries constructed from these two species are used for identification and isolation of stress tolerant genes. Many novel genetic combinations have been identified, sequenced and characterised from these libraries. Efforts for identification of unique genes in mangroves have also been undertaken using large-scale genome sequencing and differential expression analysis. Some of the isolated genes from mangroves were characterised and analyzed for their expression levels in varying saline conditions.

Methodologies for construction of vectors for transformation and transformation systems have been established in Tobacco, Rice, Blackgram and Mustard. An integrated approach to gene isolation to development of transgenics in locally adapted cultivars and integration of pre-breeding with participatory breeding is the focus of the ongoing work that underlines the basic principle of ensuring diversity with efficiency.

Novel Genetic Combinations for Drought Stress

Drought is an increasingly important constraint to crop productivity and yield stability worldwide and is one of the major environmental stress in agriculture. In some parts of the world, particularly the semi-arid tropics and other locations drought is endemic and even the most productive agricultural regions experience short periods of drought almost every year and occasionally, with severe drought.

Drought stress induces diverse physiological and molecular responses in plants. These include changes in gene expression and metabolism, osmotic adjustment, induction of repair systems and chaperones. These processes influence plant distribution, survival, and crop yields worldwide. Hence, the responses of plants to various stress have for decades been the focus of physiological studies and more recently, of molecular and reverse genetic studies and transgenic experimentation. The use of model plant systems to investigate different facets of a given abiotic stress has been the major thrust area in recent years.

Prosopis juliflora a leguminous a phreatophytic perennial deciduous thorny small tree, is now the dominant woody plant found in about 48 million ha of grazing lands worldwide from sea level to 1500 m. It grows in very hot and dry regions with temperatures as high as 48°C and annual precipitation of 150-750 mm. It grows in a variety of areas including saline, alkaline, sandy and rocky soils. An introduced species in India, it has subsequently spread aggressively across the country. *P. juliflora* can withstand high leaf-to-air vapour pressure deficit (VPD) by reducing metabolic activity and by effective adjustments in the partitioning of electron flow between assimilation and non-assimilation processes. *P. juliflora* is also heavy metal tolerant. The plant, therefore, is an ideal candidate for mining genes for abiotic stress tolerance including drought.

As a first step towards the characterization of genes that contribute to combating abiotic stress, construction and analysis of a cDNA library of *Prosopis juliflora* genes is reported here. Random expressed sequence tag (EST) sequencing of 1750 clones produced 1,467 quality reads. These clones were classified into functional categories and BLAST comparisons revealed that 114 clones were homologous to genes implicated in stress response(s) and include heat shock proteins, metallothioneins, lipid transfer proteins and late embryogenesis abundant proteins. Of the ESTs analyzed, 26% showed homology to previously uncharacterized genes in the databases. 52 clones from this category were selected for reverse Northern analysis: 21 were shown to be up-regulated and 16 down regulated. The results obtained by reverse Northern analysis were confirmed by Northern analysis. Clustering of the 1,467 ESTs produced a total of 295 contigs encompassing 790 ESTs, resulting in a 54.2% redundancy. Two of the abundant genes coding for a non-specific lipid transfer protein and late embryogenesis abundant protein were sequenced completely. Northern analysis (PEG stress) for the two genes was carried out.

One of the genes from the *P. juliflora* library, Glutathione-S-Transferase (PjGST), was chosen for further study. Northern experiments were done for PjGST for

PEG, salt, mannitol, cadmium, heat stresses, water withdrawal and 2,4 D, GSH, methyl viologen, H_2O_2 application. PjGST was transformed into tobacco (Wisconsin 38) and the presence of the integrated gene was confirmed by PCR Southern. Transformed tobacco plantlets were tested for survival under stress conditions. PjGST transformed plants were found to survive better under conditions of 150mM NaCl, 100mM mannitol, 25 mM cadmium or 10% PEG. PjGST was also transformed into indica rice variety ADT 43 and the presence of the transgene in the T_2 generation was confirmed with PCR southern. Stress tolerance studies (ability to germinate in medium containing 150mM NaCl, 100mM mannitol or 25mM cadmium) was carried out with the transgenic rice plants and they showed faster germination as compared to control (untransformed) plants.

Novel Genetic combination for Nutritional Enhancement

Billions of people in developing countries suffer from micronutrient malnutrition. Even mild levels of micronutrient malnutrition may damage cognitive development, lower disease resistance in children, and reduce the likelihood that mothers survive childbirth. The costs of these deficiencies in terms of lives lost and poor quality of life are staggering. Deficiencies of three micronutrients - vitamin A, iron, and iodine – are widespread in India.

More than 2 billion people worldwide are iron-deficient. Iron deficiency anemia is by far the most common micronutrient deficiency in the world. Iron deficiency during childhood and adolescence impairs physical growth, mental development, and learning capacity. In adults, iron deficiency anemia reduces the capacity to do physical labor. Iron deficiency increases the risk of women dying during delivery or in the postpartum period.

Ferritin is an iron storage protein, found in plants, animals and bacteria. The basic function of the ferritin is to take up the iron, to store it in non-toxic form, and release it for metabolic functions strictly on need bases. The iron stored in ferritin is complete bioavilable. It has a capacity to store/sequester 4500 Fe atoms in the central cavity as in a safe form. Ferritin has several advantages over other candidate genes such as better bioavailability of stored Fe. It has been demonstrated that the bioavailability of the external ferritin was almost similar to that of $FeSO_4$ in dietary iron deficient anemic rats. Since it forms a single subunit no need to introduce more than one gene for getting the function to produce the translated protein.

We have isolated ferritin gene from mangrove plant *Avicennia marina* by random EST sequencing analysis and further full-length gene was isolated by TAIL PCR method. The ferritin cDNAs from *Glycine max* L. cv and *A. marina* were used for transformation in rice. The ferritin gene driven by rice endosperm specific promoter GluB I was cloned in plant transformation vector CAMBIA 1301. In addition, concerned with the environmental safety issues, there is a nessecity to develop marker free transgenic system. Therefore, the plant selectable marker hygromycin was removed from the binary vector and transformation was done by cotransformation method. It involves the prefacing of two separate T-DNAs into the same plant cell, one of this vector holding the gene of interest and the other has selectable marker. Unlinked integrations of these two T-DNAs to the segregation of marker gene from the gene of interest at T1 generation. The transformation was done by both agrobacterium and particle bombardment mediated method in *indica* rice verities Pusa Basmathi and ADT 43.

Six independent ferritin transgenic plants were obtained. Integration of the transgene in rice genome was confirmed by Southern blot analysis. Western analysis was performed to study the expression ferritin gene in rice seed. In all the transgenic southern positive plants (seeds), a 28-kDa-ferritin protein was detected confirming that ferritin protein accumulates in rice seeds. Further, iron specific histochemical analysis (Perl's Prussian blue technique) was done for localization iron rice. Perl's Prussian blue staining of ferritin transgenic rice grain sections showed the distribution of iron accumulation (blue colored ferric ferrocyanide compound through out the alureone and sub aleurone layers and also in the central region of starchy endosperm and it was not observed in the un-transformed control rice grains especially in endosperm and sub aleurone layer. This corroborates the higher accumulation of iron in transgenic *indica* rice.

These above three examples highlight the appropriate use of advanced molecular biology tools those have been able to generate pre-breeding material for facilitating crop improvement. These materials with desired characteristics will be of significance in broadening the genetic base of the rice crop plant with integration of conventional breeding methods for introgression into local rice varieties.

19

Transitions in Science of Plant Breeding

M. Maheswaran

Plant Breeding, the art and science of improving genetic make up of crop species, has a long history and is categorized into Participatory Plant Breeding (PPB), Institutional Plant Breeding, Corporate Plant Breeding, and Molecular Breeding. The evolution of science of plant breeding was influenced by the changing situations of the end users and the individuals those who are practicing the plant breeding. Whatever may be the category, the success of plant breeding depends on collaboration between breeders and farmers, marketers, processors, consumers, and policy makers. The success endures food security, health and nutrition and employment in the society. In the context of plant breeding, in the recent past PPB that involves close farmer-researcher collaboration to bring about plant genetic improvement within a species is gaining momentum in the developing countries. However, molecular breeding played a very limited role in satisfying the needs of resource poor farmers. There are claims that the tools of novel approach can significantly improve the impact of research for poor farmers especially in the areas of assessing crop genetic diversity, promoting recombination, enhancing germplasm and delivering improved genetic materials. But so far there are relevant products through this approach only to suit the needs of resource rich farmers those who are having direct access to either institutional or corporate plant breeding. These tools of biotechnology which include both plant molecular biology techniques and tissue culture techniques are still cosmetic and patchy to PPB without replicated success. The cost involved, technicalities associated and biosafety issues are some of the impediments in exploiting the modern biotechnological tools in PPB.

Whatever may be the outcome of all the above mentioned selective breeding methods, all these methods failed to accommodate the role of peasant farmers in expanding crop genetic diversity. Many landraces every crop have been lost. They also overlook the science of selective breeding framers have developed, as well as ignore the multitude of traditional framing techniques that are eco-friendly and sustainable. This paper addresses successes and issues associated with PPB in the context of using modern biotechnological tools

20

Participatory Management of Natural Resources to Enhance Livelihood Options and Conservation: Opportunities and Challenges.

Kamal Bawa, Gladwin Joseph and Siddappa Setty

Natural capital in the form of biodiversity, water and soils is fast eroding in many parts of the world. Yet this capital is necessary to alleviate rural poverty in developing countries and to sustain human societies. Despite decades of efforts in development and conservation, success in meeting the twin goals of livelihoods security and conservation has been limited. New models and approaches to build human and social capital as well as institutions to confront sustainability challenges are needed. We outline some of these models and approaches in participatory management of natural resources to enhance livelihood options and to promote conservation in two biodiversity hotspots of India. We share experiences in participatory resource management and institution building at multiple scales. Interdisciplinarity, participatory processes, and networking among nested institutions are key elements of the models and approaches that we are pursuing. In spite of initial successes, major constraints and challenges remain. We discuss ways to overcome these limitations, and offer general comments on the type of institutions that we would eventually need to make progress.

21

Enhancing Livelihood and Food Security through Agrobiodiversity Conservation

K. Vijayalakshmi and S. Arumugasamy

In the early 1990s Centre for Indian Knowledge Systems had started a small but ambitious project to revive traditional organic agriculture in Tamil Nadu. To do this, they needed a vital element namely the seeds of traditional crop varieties. After one year and a trail of many hundred miles that took them to different states of South India eight varieties of rice were found. Some were a handful of seeds and others a mere few grains. These precious seeds had to be propagated and the rice varieties had to be revived. CIKS believed that the best approach was to entrust the seeds with interested farmers who could cultivate them year after year. The belief was that if the farmers could be taught to use locally available resources to achieve this, they could not only gain a livelihood but also enjoy food security for a lifetime. In the process, they would conserve India's precious crop diversity. The paper describes in detail the story of a project that changed the lives of many South Indian farmers.

More than 100 rice varieties and 50 vegetable varieties are conserved by a network of 3000 farmers spread in four districts of Tamil Nadu under this project. It describes the formation and functioning of organic farmers sangams through which the project is implemented. Capacity building measures in the form of short-term trainings and trainers trainings that are provided by CIKS are discussed. The functioning of the community seed banks, field based biopesticide units are also dealt with in detail. The continuous monitoring and onfarm support provided by CIKS has been a major component for the success of this programme. This has also been discussed. Marketing efforts undertaken by CIKS and efforts to expand this programme are also explained.

22

Participatory Plant Breeding for Drought Tolerance in Rice; A Case Study

H.E. Shashidhar, R. Venuprasad, Naveen Sharma, M. Toorchi, M.S.Vinod, K. Manjunatha, Hima Bindu, Adnan Kanbar, Tejasvi, Erpin Sudheer, M. janmatiit, T.M. Gireesha, T. Raghu, T. Vidya, K.K. Manohar, M. Vasundhara, S. Mane, G.S. Hemamalini and Lakshmipathi

Participation of farmers during the selection process, as the filial generations were being advanced, has immensely contributed towards success in development of drought tolerant paddy varieties. This helped preempt chances of errors in terms of inappropriate or inadequate product quality, non adaptive germplasm or other unforeseen (by scientists) factors determining consumer preference and aspirations. Farmer's criticisms have been considered in shaping the technology. Successive crops were raised in the farmer's fields itself, ensuring complete participation throughout the program. Hundreds of farmers and scientists participated in the selection program, each season, when the crop attained maturity.

Conventional paddy cultivation is almost synonymous with abundant water availability. With cost of production skyrocketing, paddy cultivation is an unattractive proposition. Technologies to make paddy consume less water and labour, but still yield the same levels, have been developed at UAS, Bangalore

That rice is a water-loving crop has been ingrained in the psyche of farmers, policy makers, and the general public for centuries. The gene pool of *Oryza* encompasses a vast array of versatile and dynamic ecotypes that could establish, grow, survive and yield grains under a wide range of edaphic, climatic, topographic and hydrological environs. For example, while upland rice completes its life cycle without any 'impounded water', submerged paddy yields grain floating in lakes and rivers, while actively responding to the rise and fall in water level. The range of variation in the genus offers immense opportunities to re-engineer rice to grow and produce grains with very low water input, without compromising yield levels and quality standards expected of rice.

Cultivating irrigated paddy involves intensive land preparation, which entails repeated ploughing, leveling, puddling, and management of bunds throughout the season. Further, nursery raised separately and maintained for 21-30 days consumes labour, money and water. Rice could now be grown akin to arable crops like maize, Sorghum or any millet. The land needs to be ploughed to let seed germinate without being smothered by clods or surface hardpan."Eco-friendly Aerobic paddy" could be sown by broadcasting, in lines behind plough furrows or using a 'seed drill'. Fertilizers could be applied alongside. Paddy could now be rotated with other crops in a cropping system where in each crop could benefit from the crop residue of the other and the build up of pests and pathogens could also be less.

Aerobic rice lines incorporate high levels of drought tolerance and productivity. Molecular markers associated with quantitative trait loci and monogenic traits with roots, osmotic adjustment and grain yield have been used to facilitate this task. Six new rice genotypes identified through a MAS program have undergone extensive multi-location field trials across Karnataka and some sites (six) in the country. The results obtained so far are very promising. While the yield under severe stress ranges from 1.2 – 1.9 tones per ha., under non stress the lines yield 5 – 6.5 tones per ha. The quality of the grains ranges from long slender to short bold with all gradations in between. The quality of rice does not depend on the quantity of water supplied.

The aerobic rice technology package adopts the technology of 'deficit irrigation'. It is possible that paddy can be cultivated in areas where irrigated rice is currently being cultivated. Water saved this way, could be utilized to cultivate other crops, which might ensure equitable distribution of rain, under-ground or surface irrigation water. This is a rainwater harvesting technology too, as the rain that is received in a submerged irrigated rice field is 'a waste' as it is already full of water. If aerobic rice could be adopted to this areas, rain water received here would be captured within the plot and possibly used by the crop. Irrigations could be skipped should there be good rains.

23

Strengthening Traditional Agriculture and Enhancement of Livelihood Security among Soligas at Biligiri Rangaswamy Temple Wildlife Sanctuary

Siddappa Setty, Gladwin Joseph, Madegowda and Raghunandhan

Most of the agricultural practices followed by Soliga farmers are adapted from the shifting-agriculture systems that they practiced for centuries before 1972. Soliga farmers in the BR Hills own or lease 1-4 acres of land per household. They grow a diversity of crops such as finger millet, maize, red gram, mustard, amaranthus, field beans and other vegetable plants. Forty percent of the farmers grow shade-coffee under residual forest trees. Agriculture is adapted to the subsistence needs of the farm families. Current agriculture practices are low in input and subsequent low in yield. Yields are also probably low because of low soil fertility due to high degree of soil erosion from sloping farmlands.

Under these circumstances, which are probably common to millions of farmers in forest-fringe areas in the tropics, we are working with these farm families to introduce simple 'organic' technologies to increase yields, diversify the farms, and conserve soil and water. Introducing these technologies depends on a strategy of using on-farm trials for low-risk interventions and field-station trials for high-risk interventions. Low-risk interventions include the use of contour row-sowing rather than broadcast sowing, improved access to traditional varieties of seeds, and composting practices. The relatively high-risk interventions are to incorporate locally grafted high-yielding amla and related fruit trees, and selecting high-yielding local crop varieties, and crop rotation. All interventions aim to strengthen on-farm capacities, improve sustainable traditional technologies and enhancement of livelihood security.

On-farm trials using row cropping showed 30% increase in yields to broadcast sowing in 21 farms. However, the variation in yields using either method was high from field to field and ranged from 100-1250 kg/acre. This indicates a high degree of variation in soil productivity and suggests that there is potential to improve yields considerably by improving practices and building soils. Traditional varieties of seeds were sourced and systems put in place to store and distribute them. Sixteen tree species preferred by Soliga farmers were grown by a few selected farmers and distributed for planting along farm bunds. Nursery technologies to improve quality of seedlings are experimentally evaluated at the field station before it is operationalized.

We are building on-farm capacity to improve composting systems. Rather than introduce high-yielding grafted trees from non-local sources, we are experimenting with grafting locally available plus-tree scions and rootstocks for select species with medicinal and nutritive value. Using local individuals reduces the risk of disease/pest introduction and uncertain impacts of gene flow from introduced individuals. Small farm-size reduces the space available for trees so it is critical that farmers have access to early and high yielding grafted trees.

24

Farmers' Rights: Its Role and Relevance in Global Agriculture

S. Bala Ravi

Generations of farmers, world over, particularly from those regions considered to be the centers of origin and diversity of crop plants, through their continuous selection of plant varieties to suit to the different agro-climatic and edaphic conditions, biotic and abiotic pressures and specific consumption needs and their diligent conservation have contributed the extant genetic diversity in several economically important traits in each crop. The socio-economic benefits being accrued by the world from this intelligent value addition in each component of this genetic diversity along with associated knowledge system is so immense. Free sharing and exchange of these genetic resources and knowledge, *sans* the concept of ownership rights up on them has enormously benefited global agriculture, national food security and livelihood security of millions of farming families, particularly from the economically disadvantaged countries.

A break from this long practice was signaled with the establishment of patent right on plant varieties in the United States of America in 1930 and with plant breeder's right under the International Convention on the Protection of New Varieties of Plants (UPOV) in Europe in 1961. These institutional changes sought to establish private ownership on plant varieties on the ground that derivation of new plant varieties involved intellectual property rights, while denying such rights to farmers who provide the genetic diversity for the so-called 'innovative' re-shuffling process. These new rights, in addition, deprived the farmers their traditional rights on the seeds by imposing restrictions on saving the seed from their crop, re-using, sharing, exchanging or selling saved seeds.

Farmers' Rights on seeds as an entitlement to the past, present and future contributions of farmers in conserving, improving and making available plant genetic resources was first introduced in 1983 by the International Undertaking on Plant Genetic Resources of the Food and Agriculture Organization. The recently concluded FAO International Treaty on Plant Genetic Resources for Food and Agriculture defined two important rights under the Farmers' Rights. First is the right to save, use, exchange and sell farm-saved seeds and other propagating material. Second is the right to participate in decision making regarding and in the fair and equitable sharing of the benefits arising from, the use of plant genetic resources. This Treaty requires each Contracting Party, to evolve its national legislation and thereby take appropriate measures to protect and promote farmers' rights.

India, in compliance with its commitment to the Trade Related aspects of Intellectual Property Rights (TRIPS) enacted a *sui generis* legislation to provide protection to plant varieties. While doing this, the law seeks to safeguard and promote the traditional roles and rights of farmers in creation and conservation of plant genetic resources. This paper discusses, in the context of the International Treaty, some of the important features of Indian legislation, the Protection of Plant Varieties and Farmers' Rights Act with focus on the farmers' rights.

25

The Revival of Agrobiodiversity through Protection of the Farmer

Yeshwanth Shenoy

The muted debate on the conservation of agrobiodiversity in the larger debate of conserving biodiversity is now showing signs of resuscitation. The larger community is realizing the importance of agrobiodiversity in ensuring food security for the future rather than seeing at agriculture as a threat to biodiversity. Agrobiodiversity Conservation ensures the availability of the genetic resources which are the foundation blocks upon which agriculture and world food security rests. The FAO had identified the spread of modern commercial agriculture and intensive high-input production systems as a major factor that drives the loss of native varieties and breeds. Certain new factors like the intellectual property regime, the advancement of technology like the genetic Use Restriction Technology has further added to the problem of loss of native varieties in the agricultural sector and this development have reached threatening propositions. However, the silver lining is the increasing awareness among the policy makers of the threat that loss of agrobiodiversity has posed. Their increased interaction with the scientific and legal community to stem the loss of biodiversity has propelled the enactment of legislations to encourage the protection of agrobiodiversity. The TRIPS agreement required every member of the WTO to ensure some kind of protection that should be made available to protect plant varieties and many countries have formulated *sui generis* legislations to protect their interests rather than provide for patent protection for plant varieties. India also enacted a *sui generis* legislation called the Protection of Plant Varieties and Farmers Rights Act, 2001 (hereinafter the Act). The government claims that the Act is the *sui generis* legislation that takes care of India's obligations under the TRIPS Agreement. The Act has a lot of similarities with the UPOV 1978 and sometimes the claims of the *sui generis* nature of legislation come to be questioned. Has the Act taken into account the diversity seen across India or the socio-economic situation of the class that it seeks to protect, taken care off or is it the adoption of the UPOV 1978? How does the Act protect the Traditional Varieties? Does the Landraces qualify for Protection under the Act? Do the farmers or the breeders of these varieties stand to gain any benefit out of this Act? Does legislation alone help our country to ensure agricultural development and stop it from derailing from the fast tracks set up by the Green Revolution? Is there a need to look holistically in to the Agricultural Policy? Does Farmer Suicides ring the bell? This paper will analyse these aspects and will try to identify some immediate solutions including legal protection and capacity building options. If "action speaks louder than words", we need to seriously debate the Seeds Bill, which in its current form can nullify the entire PPVFR Act. This Paper will put some light on the implications of the Seeds Bill in the Agricultural Sector and the implications on the Farmers.

Contributors

Contributors

Arunachalam, V.[1], Naik, S.[2], Prasad, K[2] and Ramprasad, Vanaja[2]
[1]M.S. Swaminathan Research Foundation
Chennai 600 113, India
[2]Green Foundation
570/1,Padmashri Nilaya, P.O 7651, 3rd Main, 4th Cross
Bangalore, India
For correspondence: **varunachalam@mssrf.res.in**

Chandrasekharan, P.
Kothaneth House, CRD Menon Colony
Kalleully P.O, Palakkad 678 005,India
☎ **0491-2527015**

Ceccarelli, Salvatore and Grando, Stefania
ICARDA
P.O. Box 5466 Aleppo (Syria)
For correspondence: **s.ceccarelli@cgiar.org**

Das, Vidya and Das, Binod
Agragamee
P.O.Kashipur 765 015
Orissa, India
For correspondence: **agragamee@satyam.net.in**

Leena Kumary, S.
Rice Research Station
Moncompu, Thekkekkara, Alleppey District
Kerala 688 503, India
For correspondence: **leenakumarys@rediffmail.com**

Nadarajan, V. C., Muthu Velayudham, N., Saravanan, P., Rengarajan, R and Ghate, Utkarsh
The Covenant Centre for Development (CCD)
18C/1,Kennet Cross Road
Ellis Nagar, Madurai 625 010, India
For correspondence: **info@ccd.org.in**

222

Paris, T.[1], Singh, A. [2], Singh, V.N[2] and Ram, P.C.[2]
[1]IRRI
DAPO 7777, Metro Manila
The Philippines
[2]Narendra Deva Agricultural Technology (NDUAT)
Kumarganj, Faizabad, Easatern Uttar Pradesh, India
For correspondence: **t.paris@cgiar.org**

Peroni, N., Kageyama, P.Y and Begossi, A.
Natural History Museum Biology Institute
University of Campinas
Rua Coronel Quirino 1636, Campinas, S.P, Brazil 13025-002
For correspondence: **nivaldo@unicamp.br**

Ramprasad, Vanaja
Green Foundation
570/1,Padmashri Nilaya, P.O 7651,3rd Main, 4th Cross
Bangalore, India
For correspondence: **van@vsnl.com**

Rengalakshmi, R., Mishra, S., Chaudhury, S.S., Israel Oliver King, E.D and Ray, T.
M.S. Swaminathan Research Foundation, Chennai, India
For correspondence: **rengalakshmi@mssrf.res.in**

Sie, M., Hema, D., Ouedraogo, M., Sanon, M.J., Traore, S., Bado, L., Sanou, A., Ouattara, Z and Ogunbayo, S.A.
Africa Rice Centre (WARDA)
01 B.P. 2031 Cotonou, Benin,West Africa
For correspondence: **m.sie@cgiar.org**

Singh, U. S.[1], Singh, N.[1], Zaidi, N. W.[1], Singh, H.N.[1], Mani, S. C[1] and Singh, R. K.[2]
[1]G. B. Pant University of Agriculture & Technology
Pantnagar 263 145, Uttaranchal, India
[2]National Academy of Agricultural Sciences
NARS Complex, Dev Prakash Shastri Marg, New Delhi 110 012, India
For correspondence: **ussingh3@rediffmail.com**

Sreekanth, A.[1], Ilangantileke, S[2] and Rath, Subrat K.[3]
[1]International Potato Centre (CIP-SWCA)
CIP-Liaison Office, RCCTCRI
P O Dumuduma HBC, Bhubaneswar 751 019, Orissa, India
[2] International Potato Centre (CIP-SWCA)
IARI Campus,Pusa ,New Delhi 110 012, India

[3]Watersheds (OWDM)
Government Of Orissa
Nuapada, Orissa, India
For correspondence: **s.attaluri@cgiar.org**

Visser, Bert and Louwaars, Niels
Centre for Genetic Resources
The Netherlands (CGN), Plant Research International
P.O. Box 16, 6700 AA Wageningen, The Netherlands
For correspondence: **Bert.Visser@wur.nl**

Yadavendra, J. P[1] and Witcombe, J. R.[2]
[1]Gramin Vikas Trust,
Kanchan Kunj, Anand Bhawan Compound
Chakaliya Road, Dahod 389 151,Gujarat, India
[2]CAZS Natural Resources
University of WalesGwynedd, LL57 2UW Bangor, UK
For correspondence: **jpykmw77@yahoo.com**

Participants

Participants

Anil Kumar, N.
Programme Director (Biodiversity)
M.S. Swaminathan Research Foundation, Chennai, India
anil@mssrf.res.in

Arivudai Nambi, A.
Project Director (SDC V&A)
M.S. Swaminathan Research Foundation, Chennai, India
anambi@mssrf.res.in

Arivudai Nambi, V.
Project Coordinator (SDC)
M.S. Swaminathan Research Foundation, Chennai, India
nambi@mssrf.res.in

Arunachalam, V.
Technical Programme Advisor (SDC)
M.S. Swaminathan Research Foundation, Chennai, India
varunachalam@mssrf.res.in

Athreya, V.B.
Consultant
M.S. Swaminathan Research Foundation, Chennai, India
venkatesh.athreya@gmail.com

Bala Ravi, S.
Advisor (Biodiversity)
M.S. Swaminathan Research Foundation, Chennai, India
sbala@mssrf.res.in

Bawa, Kamal
Distinguished Professor
Department of Biology, University of Massachusetts, Boston
100 Morrissey Blvd. Boston, MA 02125 U.S.A
Kamal.bawa@umb.edu

Bhanumathy, K.
Co-coordinator (THMRC)
M.S. Swaminathan Research Foundation, Chennai, India
bhanumathykm@gmail.com

Bhavani, R.V.
Project Director
B. V. Rao Centre
M.S. Swaminathan Research Foundation, Chennai, India
bhavani@mssrf.res.in

Ceccarelli, Salvatore
Barley Breeder
ICARDA
P.O. Box 5466 Aleppo (Syria)
s.ceccarelli@cgiar.org

Chandrasekharan, P.
Former Dean (TNAU)
Kothaneth House, CRD Menon Colony
Kalleully P.O, Palakkad 678 005, India
☎: 0491-2527015

Chaudhury, Susanta Sekhar
Senior Scientist (SDC)
M.S. Swaminathan Research Foundation
Biju Patnaik Medicinal Plants Garden and Research Centre
Makkaput, Jeypore 764 002, India
sushantasekhar@rediffmail.com

Das, Binod
Socio Economic Analyst
Agragamee
P.O.Kashipur 765 015
Orissa, India
agragamee@satyam.net.in

Das, P.
Project Director
M.S. Swaminathan Research Foundation
Biju Patnaik Medicinal Plants Garden and Research Centre
Makkaput, Jeypore 764 002, India
profpdas@yahoo.co.uk

Eganathan, P.
Senior Scientist (DBT)
M.S. Swaminathan Research Foundation, Chennai, India
eganathan@mssrf.res.in

Girigan, G.
Senior Scientist (SDC)
M.S. Swaminathan Research Foundation (CAbC)
Site Office: Puthoorvoyal P.O. Kalpetta 673 121
Wayanad, Kerala, India
girigangopi@yahoo.co.uk

Gopinath, R.
Project Associate (WFP-TRC)
M.S. Swaminathan Research Foundation, Chennai, India
gopinath@mssrf.res.in

Gowda, C.L.L.
Global Theme leader (Crop improvement)
ICRISAT
Hyderabad 502 324, India
c.gowda@cgiar.org

Hazra, C.R.
Vice-Chancellor
Indira Gandhi Agricultural University
Krishak Nagar, Raipur 492 006, Chattisgarh, India
hazracr@yahoo.co.in

Israel Oliver King, E.D.
Senior Scientist (SDC)
M.S. Swaminathan Research Foundation
Site office: 42 B2, President Vekat Rao Street
Gandhi Nagar, Mohanur Road, Namakkal
ediok151173@yahoo.com

Jithesh, M.N.
Research Associate (SRF DAE)
M.S.Swaminathan Research Foundation, Chennai, India
narayanan.jithesh@gmail.com

Kadirvel, P.
Research Coordinator
Barwale Foundation, 8-2-703,A.G.Heights
Road No.12, Banjara Hills, Hyderabad 500034, India
kadirvelp@yahoo.com

Kannaiyan, P.
Chairman
National Biodiversity Authority
475,9th South Cross Street
Kapaleeswar Nagar, Neelankarai, Chennai, India
nba_India@vsnl.net

Kumaran, Senthil
Programme Director (NVA TATA)
M.S. Swaminathan Research Foundation, Chennai, India
senthil@mssrf.res.in

Leena Kumary, S.
Associate Professor
Rice Research Station
Moncompu, Thekkekkara, Alleppey Dt, Kerala 688 503, India
leenakumarys@rediffmail.com

Mahapatra Siba, S.
Senior Scientist (SDC)
M.S. Swaminathan Research Foundation
Biju Patnaik Medicinal Plants Garden and Research Centre
Makkaput, Jeypore 764 002, India
sibamahapatra@yahoo.co.in

Maheswaran, M.
Professor
Department of Plant Breeding and Genetics
Tamil Nadu Agricultural University
Coimbatore 641 003,India
mahes@tnau.ac.in

Mani, S. C.
Professor
Department of Genetics and Plant Breeding
G. B.Pant University of Agriculture & Technology
Pantnagar 263 145, Uttaranchal, India
scmani@gmail.com

Mishra, Smita
Training, Extension and Networking Coordinator (SDC)
M.S. Swaminathan Research Foundation, Chennai, India
smita@mssrf.res.in

Muthu Velayudham, N.
The Covenant Centre for Development (CCD)
18C/1,Kennet Cross Road
Ellis Nagar, Madurai 625 010, India
mdu_ccd@sancharnet.in

Nadarajan, V. C.
The Covenant Centre for Development (CCD)
18C/1,Kennet Cross Road
Ellis Nagar, Madurai 625 010, India
info@ccd.org.in

Nair, Sudha
Programme Director (JRD Centre)
M.S. Swaminathan Research Foundation, Chennai, India
sudhanair@mssrf.res.in

Nampoothiri, K.U.K.
Project Director (CAbC)
M.S. Swaminathan Research Foundation
Site Office: Puthoorvoyal P.O, Kalpetta 673 121
Wayanad, Kerala, India
cabcmssrf@eth.net

Nayak, Tushar Ranjan
Project Associate (SDC)
M.S. Swaminathan Research Foundation
Biju Patnaik Medicinal Plants Garden and Research Centre
Makkaput, Jeypore 764 002, India
nayaktusar71@rediffmail.com

Panda, Akshaya Kumar
Project Associate
M.S. Swaminathan Research Foundation
Biju Patnaik Medicinal Plants Garden and Research Centre
Makkaput, Jeypore 764 002, India
Koraput, Orissa, India
akshaya74@rediffmail.com

Parida, Ajay
Programme Director (DBT)
M.S. Swaminathan Research Foundation, Chennai, India
ajay@mssrf.res.in

Parida, Prasanta Kumar
Scientist (SDC)
M.S. Swaminathan Research Foundation
Biju Patnaik Medicinal Plants Garden and Research Centre
Makkaput, Jeypore 764 002, India
prashantparida@rediffmail.com

Paris, Thelma
Senior Scientist (Socio-Economist-Gender Specialist)
Social Sciences Division
IRRI
DAPO 7777, Metro Manila, The Philippines
t.paris@cgiar.org

Peroni, Nivaldo
Natural History Museum Biology Institute
University of Campinas
Rua Coronel Quirino 1636, Campinas, S.P, Brazil 13025 002
nivaldo@unicamp.br

Peter, K.V.
Ex-Vice-Chancellor
Kerala Agricultural University
Vellanikara, Trichur 680 656, Kerala, India
kvptr@yahoo.com

Prasad, M.K.
Chairman (NCCNR)
62.Giri Nagar, Cochin-682 020, India
mk_prasad@hotmail.com

Ramprasad, Vanaja
Director
Green Foundation
570/1,Padmashri Nilaya, P.O 7651,3rd Main, 4th Cross
Bangalore, India
van@vsnl.com

Rani, Geetha
Manager
Gene Bank (SDC)
M.S. Swaminathan Research Foundation, Chennai, India
genebank@mssrf.res.in

Raveendran, T.S.
Director
Centre for Plant Breeding and Genetics
Tamilnadu Agricultural University
Coimbatore 641 003, India
directorcpbg@tnau.ac.in

Ray, Trilochana
Project Associate (SDC)
M.S. Swaminathan Research Foundation
Biju Patnaik Medicinal Plants Garden and Research Centre
Makkaput, Jeypore 764 002, India
ray_trilochana@yahoo.com

Rekha, R.
Programme Associate (THMRC)
M.S. Swaminathan Research Foundation, Chennai, India
rekha_172002@yahoo.co.in

Rengalakshmi, R.
Subject Matter Specialist (Water Shed) TATA
M.S. Swaminathan Research Foundation, Chennai, India
rengalakshmi@mssrf.res.in

Rengarajan, R.
The Covenant Centre for Development (CCD)
18C/1,Kennet Cross Road
Ellis Nagar, Madurai 625 010, India
info@ccd.org.in

Setty, Siddappa
Outreach Co-coordinator
ATREE
659 5th A Main,
Hebbal 560 024
Bangalore, India
siddappa@atree.org

Shashidhar, H. E.
Professor
Department of Genetics and Plant Breeding
University of Agricultural Sciences, Bangalore 560 065, India
heshashidhar@rediffmail.com

Shenoy, Yeshwanth
Advocate
Priyadarshini, Veekshnam Road, Ernakulam 682 018, India
yshenoy@gmail.com

Sie, Moussa
Rice Breeder
Africa Rice Centre (WARDA)
01 B.P. 2031, Cotonou, Benin Republic
West Africa
m.sie@cgiar.org

Singh, D.N.
Chief Scientist
Dryland Agriculture
Birsa Agricultural University
Ranchi 834 006, India
dnsingh_bau@rediffmail.com

Sreekanth, Attaluri
International Potato Centre (CIP-SWCA)
CIP-Liaison Office, RCCTCRI
P O Dumuduma HBC, Bhubaneswar 751 019, Orissa, India
s.attaluri@cgiar.org

Subbiah, Vijay R.
Scientist (JRD)
M.S. Swaminathan Research Foundation, Chennai, India
vijaysubbiah@mssrf.res.in

Swaminathan, M.S.
Chairman
M.S. Swaminathan Research Foundation, Chennai, India

Swaminathan, Mina
Advisor (Education, Communication and Gender)
M.S. Swaminathan Research Foundation, Chennai, India
karma@mssrf.res.in

Thamizoli, P.
Coordinator (JRD Tata Centre)
M.S. Swaminathan Research Foundation, Chennai, India
thamizoli@hotmail.com

Varma, Deepa
Project Associate (Food Security)
M.S. Swaminathan Research Foundation, Chennai, India
deepavarma@mssrf.res.in

Velayutham, M.
Executive Director
M.S. Swaminathan Research Foundation, Chennai, India
executivedirector@mssrf.res.in

Venkataraman, K.
Member Secretary
National Biodiversity Authority
475,9th South Cross Street, Kapaleeswar Nagar
Neelankarai, Chennai, India
nba_India@vsnl.net

Vijayalakshmi, K.
Research Director
Centre for Indian Knowledge Systems
30, Gandhi Mandapam Road, Kotturpuram, Chennai, India
info@ciks.org

Visser, Bert
Director
Centre for Genetic Resources
The Netherlands (CGN), Plant Research International
P.O. Box 16, 6700 AA Wageningen, The Netherlands
Bert.Visser@wur.nl

Yadavendra, J. P.
Research Co-ordinator
Gramin Vikas Trust
Kanchan Kunj, Anand Bhawan Compound
Chakaliya Road, Dahod 389 151,Gujarat, India
jpykmw77@yahoo.com

Symposium Program

International Symposium on "Participatory Plant Breeding and Knowledge Management for strengthening Rural Livelihoods"

17-19 July 2006

Venue: M.S. Swaminathan Research Foundation,
Taramani Institutional Area,
Third Cross Street, Chennai 600113
INDIA

17 July 2006

Inaugural Session — **09.30 - 11.30**

Tea — **11.30 - 12.00**

SESSION A: Participatory Research for Livelihood Security – I: Participatory plant breeding and Livelihood options

Chair: M.S.Swaminathan — **Rapporteur: V. Arivudai Nambi** — **12.00 - 13.30**

Ceccarelli, Salvatore, ICARDA, Syria
A Model of Decentralized-Participatory Plant Breeding

Moussa Sie, WARDA, Africa
Participatory rice varietal selection in rainfed lowland in West Africa with special reference to Burkina Faso

H. E. Shashidhar, Bangalore
Alternative paddy cultivation practices to mitigate global warming

Discussion

Lunch — **13.30 - 14.30**

Participatory Research for Livelihood Security – II: Anticipatory Breeding

Chair: H.E. Shashidhar — **Rapporteur: M.N. Jithesh** — **14.30 - 15.40**

Ajay Parida, MSSRF, Chennai
Novel Genetic Combination for Facilitating Breeding for Crop Improvement

M. Maheswaran, TNAU, Coimbatore
Transitions in Science of Plant Breeding

Discussion

236

Tea	**15.40 - 16.10**

SESSION B: Participatory Research for Livelihood Security – Livelihood options

Chair: K.V. Peter **Rapporteur: R. Rengalakshmi** **16.10 - 17.40**

S. Leena Kumary, Moncompu, Kerala
Conservation to commercialization – Sustaining Kerala's rural livelihoods through utilization of the medicinal rice diversity

Sreekanth Attaluri and Sarath Ilangantileke, CIP, Bhubaneswar, India
On – farm participatory selection of Orange- fleshed Sweet potato (Ipomoea batatas L., Lam) for nutrition improvement in Nuapada district of Western Orissa, India

J.P. Yadavendra and J.R.Witcombe, Bhopal
The impact of new maize and rice varieties on the livelihoods of poor farmers in marginal agriculture areas of western India

Discussion

18 July 2006

SESSION C: Integrating Traditional Knowledge with Improvement options for enhanced livelihood security of the poor

Chair: C.R. Hazra **Rapporteur: P. Tamilozhi** **09.30 - 11.00**

Kamal Bawa, Gladwin Joseph and Siddappa Setty, Boston
Partcipatory Management of Natural resources to Enhance Livelihood Options and Conservation: Opportunities and Challenges.

Nivaldo Peroni, Brazil
Traditional knowledge and enhancement of genetic diversity: the case of Cassava diversity in Brazil

V. Arunachalam, Shankar Naik, Krishna Prasad and Vanaja Ramprasad
Indigenous Technical Knowledge driven crop improvement

Discussion

Tea	**11.00 - 11.30**

Session D: Social Benefits from Participatory Improvement and Gender Issues

Chair: Mina Swaminathan **Rapporteur: R. Gopinath** **11.30 - 13.30**

Paris, Thelma R., Abha Singh, V.N. Singh and P.C. Ram
Mainstreaming social and gender concerns in participatory rice varietal improvement program for rainfed environments in eastern Uttar Pradesh, India

R. Rengalakshmi , Smita Mishra , Susanta S. Choudhury , Israel Oliver King and Trilochana Ray
Gendered Knowledge and Gender Relations: Case studies in Two Agro-biodiversity-rich Locations

Vidya Das and Binod Kumar Das, Agragamee, Orissa
Benefits of Tribal Women's Activities in Watershed Areas: Agragamee's Experience in Orissa

Vanaja Ramprasad
The Social benefits of gender-differentiated participation in seed banking-a pre requisite for Participatory Plant Breeding

Discussion

Lunch **13.30 - 14.30**

Session E: Case histories that demonstrate enhanced livelihood security of the poor

Chair: M.K. Prasad **Rapporteur: Vijay Subbaiah** **14.30 - 17.30**

K. Vijayalakshmi and S. Arumugaswamy, CIKS, Chennai
Enhancing Livelihood and Food Security through Agrobiodiversity Conservation

V.C. Nadarajan, N.Muthu Velayudham, P. Saravanan, R Rengarajan and U. V. Ghate, CCD, Madurai
Aharam: Collective and value added marketing of farm produce as a community enterprise

H. E. Shashidhar , Venuprasad.R , Naveen Sharma , Toorchi.M , Vinod.M.S. , Manjunatha.K , Hima Bindu , Adnan Kanbar , Tejasvi , Erpin Sudheer , Janmatiit.M , Gireesha.T.M., Raghu.T, Vidya.T , Manohar.K.K , Vasundhara.M
Mane.S , Hemamalini.G.S and lakshmipathi.
Participatory Plant Breeding for Drought Resistance in Rice – a case study

---

Tea **15.30 - 16.00**

P. Chandrasekharan, Kerala
High Yielding Rice Varieties Developed Using Landraces of Palakkad for Kerala

U. S. Singh, H.N. Singh, Neelam Singh, N. W. Zaidi, S. C. Mani and R. K. Singh
Characterization and utilization of the ancient scented rice cultivar, Kalanamak

Siddappa Setty,Gladwin Joseph , Madegowda and Raghunandhan, ATREE, Bangalore
Strengthening Traditional Agriculture and Enhancement of Livelihood Security among Soligas at Biligiri Rangaswamy Temple Wildlife Sanctuary.

Discussion

Symposium Dinner 20.00

19 July 2006

Session F: Capacity building, Training institutions, knowledge management and Farmers' Rights

Chair: K. Venkataraman **Rapporteur: N. Anil Kumar** **09.30 - 11.00**

Visser, Bert, The Netherlands
Participatory plant breeding: linking capacity building and farmers' rights

Bala Ravi, MSSRF, Chennai
Farmers' Rights: Its Role and Relevance in Global Agriculture

Yeshwant Shenoy, Ernakulam
The Revival of Agrobiodiversity through protection of the farmer

Discussion

Tea 11.00 - 11.30

Valedictory Session and the Way Forward 11.30 - 13.00

Farewell Lunch