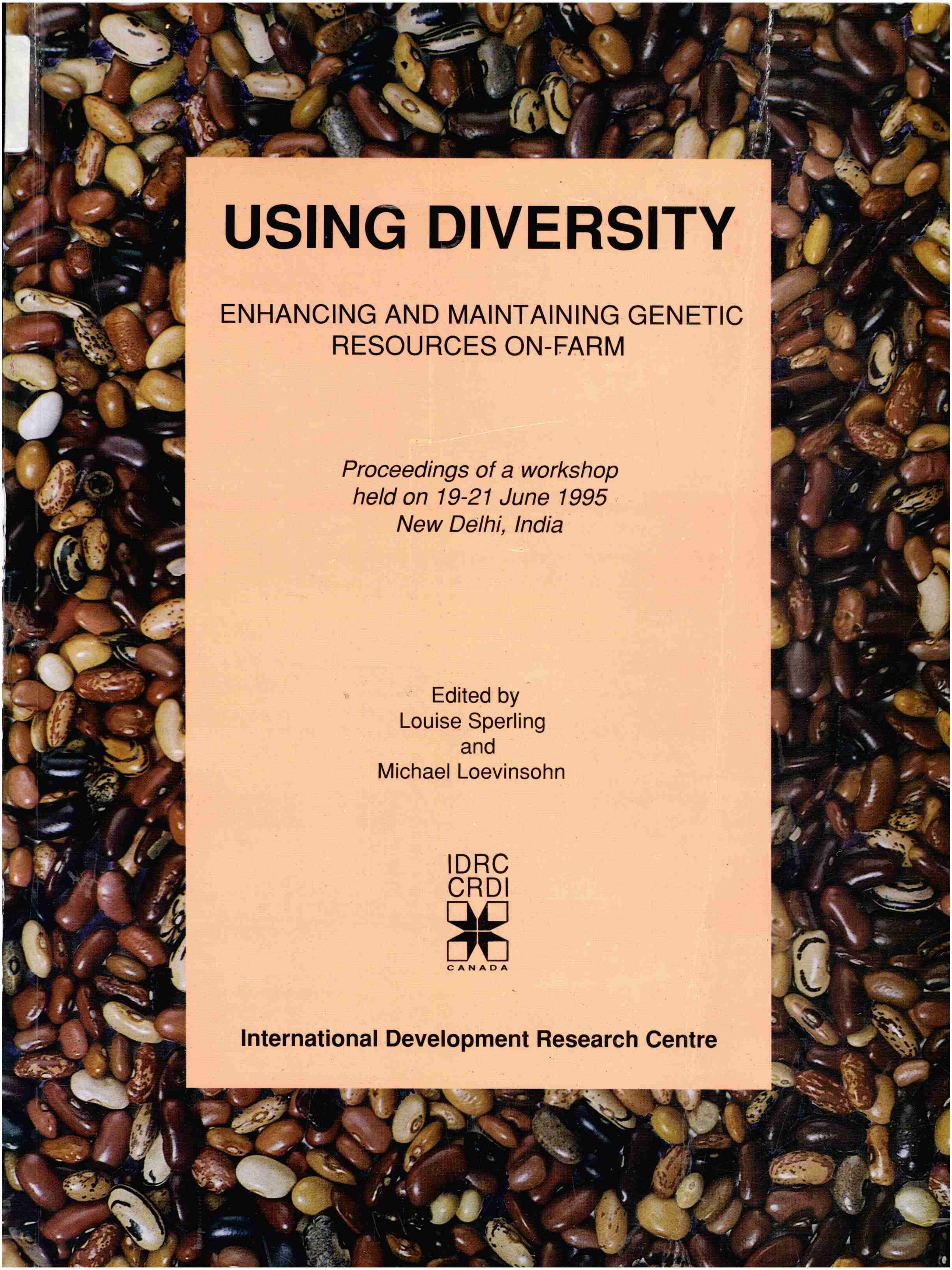

USING DIVERSITY

ENHANCING AND MAINTAINING GENETIC RESOURCES ON-FARM

Proceedings of a workshop
held on 19-21 June 1995
New Delhi, India

Edited by
Louise Sperling
and
Michael Loevinsohn

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PREFACE

A productive and stable agriculture requires genetic diversity, on-farm. Diverse varieties enable farmers to fit their cropping systems to varied and difficult conditions, to enhance the food security of their households and to exploit a range of plant products. But recent decades have witnessed first the erosion of that diversity in many areas with the spread of intensive, commercially-oriented production, then a growing realization, both in farming communities and in key institutions, that a resource of tremendous value is at risk of being lost. It is also increasingly realized that genebanks, far from the fields, can only imperfectly preserve that resource.

From 19 to 21 June 1995, the **Using Diversity** workshop explored the scope for maintaining and enhancing plant genetic resources in farmers' fields by better meeting their needs for diversity, particularly in South Asia. Sponsored and organized by the International Development Research Centre, the workshop brought together three groups that, in principle, share a common interest in diversity and farmers' use of it: breeders employing participatory approaches to crop improvement; grassroots organizations working with farming communities on the conservation and diffusion of local varieties; and scientists trying to understand the dynamics of diversity and the forces that drive it. These groups, however, do not often meet. The workshop provided a unique opportunity, therefore, to exchange varied experiences from the field and to explore possibilities for convergence among the different perspectives and collaboration among those working in different organizations.

Forty-five people, from Bangladesh, India and Nepal participated in the workshop, along with resource persons from Norway, the Philippines, and Zimbabwe. In editing the papers and discussions, we have tried to respect participants' characteristic styles and vocabularies, intervening only in the interest of clarity.

We would like to extend our warm thanks to Mrs. Jayanthi Balakrishnan who took charge of the logistic arrangements, to Mr. S.N. Singh for his tireless help with communications, and to Drs. Aung Gyi, Joachim Voss and other colleagues in IDRC's Delhi and Ottawa offices for their support and encouragement. But in particular, we thank the workshop participants who, with tolerance and good humor, gave life to the meeting's objectives and made the experience, as many said, both stimulating and revealing.

A special note is necessary regarding the use of the word "tribal". While the term may carry negative connotations in many parts of the world, it is used in India to describe the 54 million people who are classed as "indigenous" and who fall outside the caste system.

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Louise Sperling **Michael Loevinsohn**

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PROSPECTS AND ISSUES

M. Loevinsohn and L. Sperling

ABSTRACT

The erosion of South Asia's rich heritage of landraces has been paralleled by the erosion of farmer skills and community processes which created that diversity in the first place. This workshop brings together different groups with a shared, practical concern with the loss of both genetic resources and local control, with a view to exploring the common ground. Presentations cluster around three themes:

(i) Diagnosis of varietal diversity. Key here are understanding, in particular situations, the forces that create and degrade diversity; differences among individuals and groups in knowledge and skills; and the efficacy of farmer-to-farmer and other seed diffusion channels. Diagnosis aims at identifying opportunities for useful interventions, primarily in the following areas.

(ii) Decentralized breeding and selection. Methods that involve farmers in the early decisions of what to retain or discard are being used to develop varieties of several crops that are adapted to local conditions, meet diverse preferences and that, as a set, are often more productive than what emerges from conventional processes. Farmers' selections should, in principle, enhance diversity on-farm, but evidence on this important point is still scarce.

(iii) Seedbanking and seed supply. In various South Asian environments, community-based initiatives are attempting to provide farmers continued and secure access to diverse seeds. On-farm testing of varieties is frequently a feature, as is small-scale seed multiplication that enlarges livelihood options, particularly for women. Initiatives also frequently aim at enhancing farmers' skills in managing genetic and other resources.

A number of opportunities are evident for increasing the scope and impact of field-based initiatives. Many of these will require collaboration between groups and institutions that, up to now, have not worked together. These include: making farmer-bred varieties from similar agroecosystems over a wider area available to farmers' selection; where feasible, genetically improving local landraces to overcome specific deficiencies; and creating functional links between local seed and formal genebanks to enhance seed security and improve the banks' efficiency.

INTRODUCTION

The Using Diversity meeting brings together people with different perspectives on the use of and prospects for the diverse crop genetic resources of South Asia. Three principal viewpoints can be distinguished. First, there are those who are working to stem the erosion of landraces from the region's farms. Others seek to enhance and improve varieties so as to better meet farmers' productive needs. Finally, there are researchers who are attempting to understand the processes and trends of agricultural change, of which genetic erosion has been a principal component.

To a large extent in the world outside, and even more sharply at this meeting, these perspectives are segregated by institution. Distinct camps have emerged around on-farm conservation and genetic improvement and enhancement, in which different issues are given priority and different vocabularies favored. In the sessions that follow over the next three days, it is striking that only one non-governmental organization (NGO) representative will speak on breeding and selection, while no scientist from national agricultural research institutes is scheduled to present in the sessions on seedbanking and supply.

Can common ground be found? We believe it can, though how large is one of the issues this meeting may help illuminate. Common ground, we contend, lies in joining a dynamic and responsive conception of on-farm conservation, one that seeks to secure for the mass of small farmers continued access to the seed of varieties they value, to a decentralized, participatory process of genetic enhancement aimed at better meeting the diverse needs and preferences of those same farmers. Conservation and enhancement must be centered on farmers' own systems of use and production; both must be based on a deeper understanding of the uses to which people put diversity and of the forces that shape it. Among the key issues that presentations will highlight are:

WHAT SHOULD WE SEEK TO CONSERVE?

Particular landraces, or the processes by which genetic and varietal diversity are generated, maintained and spread? Different positions can be imagined and will be presented over the next few days. Greater clarity may emerge from the debate when it is recognized that varietal diversity on-farm is the outcome of an on-going evolutionary process, managed by farmers and shaped by the heterogeneity of environmental and social conditions with which they contend. In consequence, the landraces that are the object of conservation concern are neither uniform in space nor static over time. This theme is taken up and elaborated in several presentations, notably M. Bellon's. "Diversity maintained by farmers is not just the set of varieties they keep, but also the management processes these varieties are subject to and the knowledge that guides these processes. In fact, the specific varieties in the set may change through time." It follows from this that seeking to preserve particular products of agricultural evolution by paying or in some other way inducing farmers to grow what they might otherwise abandon is not what is most needed. A dynamic conception of on-farm conservation and a decentralized form of genetic enhancement would enlarge the varietal choices available to farmers and sustain the processes that create that choice.

Several of the presentations during the next three days will describe the erosion of farming communities' <u>control</u> over the processes of crop evolution, which has paralleled the erosion of varietal diversity itself. A number of forces are at work, but all have the effect of limiting the choices available to farmers and skewing decisions among them. For example, P.V. Sateesh will describe the devaluation of locally-adapted varieties of small millets and sorghum in rainfed villages of Andhra Pradesh and the promotion of rice and wheat by a range of government programs, including the Public Distribution System. S. van Oosterhoot recounts how, in Zimbabwe, public policy constrained farmers' options, first pushing them out of the market in the colonial period, then into it after Independence. Waves of genetic loss have been associated with the changes of regime, adding to the effects of drought, and threatening household food security. In the lowland rice-farming communities of Mindanao, Philippines, with which F. Magnifico's CONSERVE project is working, credit and extension programs have for many years promoted modern varieties at the expense of local cultivars.

WHICH DIVERSITY: VARIETAL OR GENETIC?

The two terms, varietal and genetic diversity, are often used interchangably. However, they are not necessarily the same and the priority given to conserving the one or the other depends on one's perspective. A smaller number of varieties would be needed to meet breeders' concerns for a representative sample of an area's gene pool than to satisfy farmers' needs for adapted and co-adapted varieties with the specific combinations of traits they require. Different institutions have emerged to serve the needs of the two groups: centrally-managed genebanks cater principally to breeders, while locally-managed seedbanks seek to ensure farmers' access to particular varieties.

In principle, there is ample scope for collaboration between the two. Seedbanks require dependable back-up for security and to maintain varieties that are not immediately in demand but that may be in future. Genebanks would benefit from links with the growers of landraces who could identify material of potentially wide interest that easily escapes collectors' attention, and, at least as importantly, information concerning its traits. In practice, however, relationships between the two sorts of banks are at best embryonic. As brought out by several participants, among them F. Mazhar and R. Khedkar, considerable mistrust exists and issues of rights in and access to material and information must be overcome. We return to this issue later.

DIAGNOSING CHANGE

Understanding the forces that create as well as degrade diversity is vital in planning supportive interventions. In many instances it is women who play the major role in selecting, shaping and maintaining varieties to meet different production and consumption needs. R. Tiwari and A. Das find this to be so in their study in the Himalayan foothills of Almora, though men there play a major role with crops, like soybean, grown mainly for the market. Unravelling who knows what about which crops, who shares knowledge and seed with whom and so on is not a simple matter: women are often overshadowed by men in mixed groups and become animated only when speaking among themselves, to female interviewers, and with seed samples in front of them. Patient work revealed that seed exchange is at best slow among different castes and between villages only 3 km apart. (This pattern of limited diffusion of seed and information comes out in several of the presentations.) In contrast, differences in wealth are found to be more important in Kerala, where, as V. Santhakumar shows, attitudes towards on-farm biodiversity differ markedly among marginal farmers, mixed subsistence/cash farmers and plantation owners. K. Riley's presentation goes some way to joining the social and genetic aspects of diagnosis. He makes the important point that genetic diversity exists at different levels, within the landrace that one farmer grows, among the landraces maintained in her village, and among the landraces of the region. Understanding the pattern in particular crops and particular environments, and how natural and farmers' active selection interact to shape it, will be crucial in deciding on appropriate interventions.

Farmers are likely to participate in a diagnosis if they can see a prospect of something useful emerging. Diagnostic methods must meet both researchers' need to understand and measure the dynamics of diversity and the very practical concerns of farming communities. Participants will describe their practical experiences in two principal realms: alternative breeding/selection approaches, and community-based seedbanking and multiplication initiatives.

DECENTRALIZING BREEDING AND SELECTION

The largest number of presentations will describe programs that have involved farmers in the early stages of selecting either among 'finished' varieties or among segregating material from crosses [which J. Witcombe and A. Joshi distinguish as Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB), respectively]. Rice has been the focus of many of the efforts. Aside from the KRIBHCO work in adjacent districts of Rajasthan, Gujarat and Madhya Pradesh, D.M. Maurya describes varietal selection with farmers in rainfed systems in eastern Uttar Pradesh, while K.D. Joshi and B. Sthapit summarize their experiences with participatory selection in the mid-hills and with breeding in the high altitude zones of Nepal. Other crops are also represented: E. Weltzien and colleagues and M.K. Choudhary describe, in two papers, farmer selection of pearl millet populations in arid areas of Rajasthan, while L. Sperling recounts lessons learned in a program on *Phaseolus* beans in Rwanda.

A few points bear emphasizing. Firstly, decentralized breeding and selection will tend to produce varieties adapted to specific natural environments. It has long been argued that, as a set, these varieties should be more productive than the one or a few, selected for broad adaptation, that typically emerge from conventional procedures. The papers presented here lend welcome empirical support to the argument and show that by associating farmers when there is still meaningful variation to choose from, varieties can be developed or identified that satisfy a range of needs and preferences, including but going beyond grain yield. Further follow-up is needed to confirm that these selections are indeed more appreciated and retained by farmers, both those who participated in the initial selection and their neighbors. Evaluation of these programs has been limited and what there is has seldom been 'at arm's length'.

Secondly, beyond improved performance, decentralized selection and breeding should, in principle, result in greater varietal diversity on-farm than do conventional approaches. However, as J. Witcombe and A. Joshi show, there is as yet little field evidence on this score. They point to one case where participatory selection identified a variety that proved popular over a wide area and that may, in fact, have reduced diversity. Nonetheless, they remain confident that when farmers have more varieties to choose from, more will be chosen. Much will depend on the quality of what farmers have to work with and on the care with which parents are chosen in the case of breeding, or varieties assembled, in the case of selection. Over the longer term, the impact of participatory approaches will also depend on the response of downstream structures, notably seed multiplication enterprises, and their ability to assure farmers' continued access to diverse varieties. The response of policy makers will also be crucial, for example in reviewing varietal release procedures.

Finally, breeders working in some of the most difficult environments, where stresses occur in complex patterns, see a clear need for greater decentralization and participation in selection, but have yet to attempt it. These include B. Mishra, who has worked for many years selecting cereals tolerant of problem soils and J.L. Dwivedi, a deepwater rice breeder in eastern Uttar Pradesh. The latter describes scientists' meager success in developing varieties that survive the myriad combinations of flooding depth, duration and time of onset that farmers must contend with, sometimes within the same field. Instead, Dwivedi intends to give farmers a 'genetic soup', i.e. variable, early generation populations from crosses of local varieties. Farmers will add their own selection criteria to those the natural environment imposes and he will monitor and further refine what results. This is essentially the 'evolutionary breeding' approach which T. Berg points out was first proposed for stress breeding 40 years ago, but which Berg believes can be made more efficient in meeting farmers' needs by drawing them into the selection process. Novel and potentially fruitful approaches like this demand a new 'division of labor' between farmers and scientists.

MAKING 'HIDDEN' DIVERSITY VISIBLE

The decentralized breeding and selection programs that will be described have generally employed either material resulting from crosses or officially released varieties. An exception is the Rwandan program that L. Sperling describes. Here, alongside exotic material from Latin America and lines derived from recent crosses, farmers were able to evaluate and select from a number of farmer-bred bean varieties that had been collected by scientists from across the country. Growers will normally see only a fraction of this diversity because it is effectively 'hidden' by slow and uneven farmer-to-farmer diffusion. There is reason to believe, however, that certain varieties will prove attractive to farmers living even some distance from where they are now grown. In Rwanda, of the ten most popular released bush bean varieties, six originated in farmers' fields. Making such 'hidden' diversity more accessible to farmers' selection may be one very practical way in which groups from the genetic enhancement and on-farm conservation camps can find common ground.

J. Witcombe and A. Joshi describe another form of diversity which may be hidden from farmers. In India, more than 500 rice varieties have been released in recent years, but most are not widely available, primarily because public seed enterprises concentrate on only a few, typically ones released more than 10 years ago. The situation is similar for other major crops. Slow and uneven diffusion, through either the formal or informal sectors, effectively limits farmers' choices, but also provides new opportunities for useful and effective interventions.

SEEDBANKING AND SEED SUPPLY

Initiatives seeking to assure continued and secure access to diverse seeds will be described in two sessions. Among the different approaches being tried in various environments:

> R. Khedkar's Academy of Development Sciences (ADS) has collected more than 300 rices from the Konkan region of Maharashtra and is distributing 1 kg samples of some 60 of these to farmers in several districts. After testing, farmers return 2 kg, either to ADS or to their neighbors.
>
> In Bangladesh, F. Mazhar of UBINIG describes how women of the *Nayakrishi Andolon* dislike the idea of a centralized 'bank', and are instead developing community 'seed wealth centers' where farmers can obtain and exchange seed samples at no cost. *Gram karmis* or village workers also grow nurseries from which larger quantities of seed are sold, thus helping to sustain their own efforts and the initiative as a whole.
>
> The farmer volunteers of V. Jardhari's *Beej Bachao Andolan* ('Save the Seeds Movement') are screening more than a hundred local varieties each of rice and common beans, as well as varieties of other hill crops, such as amaranth, that have

generally received little attention from formal research. Those found promising are multiplied and made available to neighboring farmers.

The *sanghams* (organizations of mostly lower caste women) with which the Deccan Development Society (DDS) is working in Zaheerabad, Andhra Pradesh, are rehabilitating patches of degraded land owned by these women and turning them into small but productive seed farms. As P.V. Satheesh explains, these are expected to form the basis of a distribution network for the seed of increasingly rare local varieties, at the same time expanding the livelihood options that are open to *sangham* women.

F. Magnifico describes the efforts of the Community Based Native Seeds Research Center (CONSERVE) to select, bank, and disseminate seed of traditional rice and maize germplasm in S. Cotabato, Philippines, an area where farmers have long experience of Green Revolution technology. CONSERVE puts strong emphasis on safeguarding local knowledge of crop varieties as well as the germplasm itself.

These different efforts share a number of features. Most are working on varietal erosion as one facet of a wider process of agricultural change and aim to influence more than just varietal diversity. DDS, for example, also works on reclaiming 'wastelands' and reestablishing a place in agriculture for coarse grains that are crucial for food security in poor households; UBINIG is concerned with a range of consequences of intensive rice cultivation, such as pesticide pollution and groundwater depletion. All groups appear to be working to empower farmers by enhancing their skills: ADS, for example, in hybridization, DDS in small enterprise management. Increased community control over agricultural production and innovation is the wider goal towards which most groups appear to be striving.

The programs are in each case quite young, some still embryonic. In all but one or two cases, it is too early to expect an evaluation of their reach, the extent to which they have touched different social and economic groups and the cost-effectiveness of their interventions. However, a number of concerns deserve further consideration. Firstly, the links among these local initiatives and between them and institutions that might provide useful support appear to be poorly developed. The issues of seed storage and longer-term security have been alluded to above. It is unlikely to prove very efficient for communities themselves to maintain large numbers of varieties that are not in current use. Economies of scale will accrue to centralized genebanks or regional ones, such as that being developed by the M.S. Swaminathan Research Foundation in Madras. However, rights of access and control must first be worked out, which requires a foundation of mutual trust that is not yet evident. The genebanks have historically taken in 'deposits' of landrace collections, but 'withdrawals' by the communities that bred them have been much less frequent and indeed are difficult to accomodate within their operational designs. The emergence of community-based conservation initiatives requires new thinking in this area and a wider role for the formal sector banks in supporting local level 'seed security'.

A second area where broader institutional linkages may be of use is in helping these initiatives enlarge the varietal options available to farmers, making conservation more dynamic. This might take the form of access to a wider range of genetic material, which could extend to collaboration on enhancing local varieties through breeding. The need for such support is recognized by several of those directing the seed initiatives. R. Khedkar, for example, points out that the local rice varieties ADS is making available to farmers in the Konkan area are highly susceptible to the yellow stemborer, an insect pest that has apparently increased in severity in recent years.

IS EROSION INEVITABLE?

Regardless of what is said at this workshop, there remains a widespread sense within the dominant institutions concerned with agricultural development in South Asia that diversity is yesterday's flavor. Many, probably most administrators and senior scientists in the region, believe that, in the long run, diversity on-farm can only be maintained by subsidy, that as intensive and commercially-oriented agriculture expands, farmers, left to themselves, will inevitably opt for uniformity.

The experience in areas where Green Revolution technologies have been taken up generally supports such pessimism. The adoption of packages that include irrigation, agrochemicals and 'improved' varieties has typically left in its wake a reduced number of cultivars, often closely related genetically. The outcome is unsurprising: as T. Berg points out, external inputs are intended to reduce environmental heterogeneity that people had earlier coped with by means of varietal diversity. But recent years have seen evidence of the limits of the intensive strategy. Real farm incomes have stagnated or declined in major cereal producing regions as crop prices have fallen relative to those of inputs and as environmental consequences from groundwater pumping and pesticide use have made themselves felt. In response, lowland farmers in several areas, such as those CONSERVE works with in the Philippines and UBINIG in Bangladesh, are gradually moving towards more diversified farming systems that rely less on purchased inputs, in which a larger number of more locally-adapted varieties are likely to find a place.

Whether renewed diversity in varieties and farm enterprises plays a part in increasing agricultural production or whether it serves mainly to reduce farmers' costs and secure their subsistence needs will depend on a number of factors, including the response of research and extension to these trends. But there are clearly grounds to believe that it is not only in the economically and socially marginal areas where Green Revolution approaches have made little headway that diversity-based crop development strategies have a future.

Conventional wisdom also has it that, alongside the pressures from intensive cultivation practices, market forces will lead farmers to favor a narrower range of cultivars as they gradually move away from subsistence production. But there is inconclusive evidence on this score, in particular, evidence that would help to distinguish where these forces originate. One study from Colombia (Janssen *et al.*, 1991) suggests that consumer preferences in terms of bean types may be broader than those of merchants', and that it is the latter who are constraining choice further along the commercial chain. Merchants will, at least eventually, respond to demand for diversity when it is expressed by wealthier consumers, as is indicated by the growth of 'organic' outlets in industrialized and some developing country urban centers. However, other strategies, through or around the market, may be required when, as in the Colombian case, the demand for diverse varieties originates from poorer consumers.

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UNDERSTANDING FARMER SEED AND VARIETY SYSTEMS

ON-FARM CONSERVATION AS A PROCESS: AN ANALYSIS OF ITS COMPONENTS

M. R. Bellon

ABSTRACT

On-farm conservation of plant genetic resources can be defined as the continued cultivation and management of a diverse set of crop populations by farmers in the agroecosystems where a crop has evolved. This set may include weedy and wild relatives of the crop, that though not purposely cultivated, may be present together with it, and in many instances tolerated. On-farm conservation is dynamic and is aimed at maintaining the evolutionary processes that continue to shape this diversity. This paper examines and discusses some of these processes that are common to several major crops, such as maize, rice, potatoes and beans. These are: (1) seed flows; (2) variety selection; (3) variety adaptation; and (4) seed selection and storage. It presents some of the methods and variables that can be used to elicit, describe and measure them.

INTRODUCTION

There is a worldwide concern over the loss of the diversity of plant genetic resources. A particular worry is the substitution of a diverse set of genetically variable crop landraces by a few genetically uniform modern varieties (Brush, 1991; Harlan, 1992; Hawkes, 1983; National Research Council, 1993; Plucknett *et al.*, 1987). The need to conserve this diversity has been recognized as important for many decades. It has translated into the creation of genebanks around the world, i.e., *ex situ* conservation (Hawkes, 1983; Plucknett *et al.*, 1987). Lately, on-farm conservation has been advocated as a complementary method to *ex situ* conservation (Altieri and Merrick, 1987; Brush, 1991; International Plant Genetic Resource Institute, 1993; Oldfield and Alcorn, 1987).

On-farm conservation of plant genetic resources can be defined as the continued cultivation and management of a diverse set of crop populations by farmers in the agroecosystems where a crop has evolved. This set may include the weedy and wild relatives of the crop that may be present together with it, and in many instances tolerated. It is dynamic and is aimed at maintaining the evolutionary processes that continue to shape this diversity. It is based on the recognition that, historically, farmers have developed and nurtured crop genetic diversity and that this process still continues among many farmers in spite of socioeconomic and technological changes. It emphasizes the role of farmers for two reasons: (1) crops are not only the result of natural factors, such as mutation and natural selection, but also and particularly, of human selection and management; and (2) in the last instance, farmers' decisions define whether these populations are maintained or disappear.

In spite of the increasing interest in on-farm conservation, we have a very limited knowledge and understanding of it. There have been only a few studies aimed at studying the conservation and management of crop genetic resources among small farmers, e.g., potatoes (Brush, 1992; Brush *et al.*, 1981; Brush *et al.*, 1992; Quiros *et al.*, 1990, 1992; Zimmerer and Douches, 1991), maize (Bellon, 1991; Bellon and Brush, 1994; Brush *et al.*, 1988; Louette, 1994), and in rice (Dennis, 1987; Lambert, 1985; Lando and Mak, 1994; Richards, 1986). Table 1 shows some examples of the numbers of varieties maintained for different crops in several parts of the world.

Table 1: Examples of number of varieties maintained by farmers in different crops and countries

Study	Bellon, 1991	Brush, 1991	Brush, 1991	Dennis, 1987	Lambert, 1985
Crop	Maize, Mexico	Potatoes, Peru	Potatoes, Peru	Rice, Thailand	Rice Malaysia
No. of varieties/ villages	15	no data	no data	9.9	32
No. of varieties/ household	2.5	9.6	10.3	1.7	3-4

On-farm conservation is carried out by farmers who are interested and willing to do so. It cannot be imposed on them. Therefore the basis of on-farm conservation should be the farmers that maintain crop intra-specific diversity. This requires a solid understanding of what they do, how they do it and why they do it. Therefore, outside agents, such as scientists, development workers, activists, research institutions, government and non-governmental organizations do not carry out on-farm conservation per se, but can identify opportunities and assist farmers in continuing their efforts at conserving crop diversity.

The purpose of this paper is to address what the farmers do. I argue that the diversity maintained by farmers is not just the set of varieties that they keep, but also the management processes these varieties are subject to and the knowledge that guides these processes. In fact, the specific varieties in the set may change through time. Hence farmers' diversity is a process rather than a state. This process can be referred to as 'farmers' management of diversity'. Below I define this term and its components, and present the methods that I used to measure some of these components in a case study among small maize farmers in Mexico.

FARMERS' DIVERSITY MANAGEMENT

Farmers' management of diversity refers to the cultivation of a diverse set of more or less specialized crop populations. These populations are named and recognized as units by the farmers: they are "farmers' varieties" as opposed to the improved varieties. The usually are segregated in space, time and/or use. The set of varieties is formed though a constant process of experimentation, evaluation and selection of existing and new varieties. There are two levels of selection: (a) choosing the varieties to be maintained; and then (b) for each one, choosing the seed stock that will be planted the next season. The selection process is dynamic and is influenced by the supply of populations from other farmers, villages, regions or even countries. This supply may involve new populations, as well as existing ones that a particular farmer may have lost and want to replant. Four components of farmers' management of diversity can be identified: (1) seed flows; (2) variety selection; (3) variety adaptation; and (4) seed selection and storage.

Seed flows

The exchange and transport of germplasm are a common historical pattern all over the world, that currently continues, particularly with the introduction of modern varieties. Several studies have documented the flow of seed of different varieties among small farmers (Cromwell, 1990; Dennis, 1987; Louette, 1994; Sperling and Loevinsohn, 1993). These flows can happen within a village, a region, a country or even among countries. These flows may happen as farmers exchange or market seed among themselves, purchase seed from commercial or government outlets, receive seed as a gift, or collect it from other farmers while traveling. The increasing importance of migration as an economic activity for may farmers may foster these flows. These flows include both traditional and modern varieties.

The collection of landraces and their use for the development of modern varieties, as well as the introduction of these varieties in the farming systems of many farmers has expanded the scope of these flows. Modern varieties incorporate germplasm originating in many different countries. It is common to observe modern and traditional varieties being grown by the same farmers (Bellon, 1991; Brush *et al.*, 1992). Provided that a diverse array of crop populations is maintained, the incorporation of modern varieties in a farming system can increase substantially the diversity present in it (Dennis, 1987).

These flows are important to understanding the diversity present in a location because they are the basis for incorporating new varieties and obtaining materials that have been lost but are desirable. It is not uncommon that a farmer may lose a desired variety by accident, or even if purposely discarded may want to recuperate it (Dennis, 1987; Sperling and Loevinsohn, 1993). Furthermore, these flows may have important genetic implications. They may be an important mechanism for the migration of genes. They may counter genetic drift in small populations, for example, for varieties planted in very small areas (Louette, 1994). In a study of 542 potato tubers collected in 18 markets in Peru, isozyme analysis showed that all genotypes belonged to a single large gene pool with considerable gene flow between cultivars of different groups. The transportation and local commercialization of potatoes in the market served to pool together varieties from different regions (Quiros *et al.*, 1992). In rice, Dennis (1987) has documented for Northern Thailand an active exchange of rice germplasm among Thai farmers across village, district, and provincial lines. This meant that a variety need not stay in the same village to persist successfully within a region. In theory, a network of seed exchange coupled with a rigorous and consistent seed selection method that produces high quality seed, may allow farmers to abandon poorer lines whenever there is access to better ones, with the eventual cumulative effect of generating and maintaining highly adapted and productive cultivars (Lambert, 1985).

Variety selection

The process of variety selection can be seen as the farmer's decision to maintain, incorporate or discard a variety to be planted in a particular growing season. The diversity of varieties present in the farmer's fields is the outcome of this decision. Diversity should increase, if the number of varieties incorporated and maintained is larger than the ones discarded, and *vice versa*. The varieties maintained or incorporated are either kept from the previous agricultural cycle or obtained through exchange or purchase.

Farmers continually evaluate each variety they have. This process has two components. One is to find out how a variety performs with respect to each concern or selection criterion, such as its performance under drought or flood conditions. The second is to rank the performance of the varieties in terms of each of the different selection criterion, i.e., which has the best drought resistance and which the worst. Farmers are in a constant process of trying to match their crop populations or varieties to their concerns, which in turn reflect the conditions under which they farm and their goals. In describing the management of traditional rice varieties in Pesagi, a Malay village, Lambert (1985) observed that farmers constantly experiment with rice cultivars. Even with well-known cultivars, individual households test one variety against another, a process of matching varietal performance to small but significant differences in localized habitats.

The fact that farmers have multiple criteria to select what varieties to plant, as well as where, when and how to do it, has been well established and reflect their concerns (e.g., Bellon, 1991; Brush *et al.*, 1981; Brush, 1992; Lando and Mak, 1994; Lambert, 1985; Sperling *et al.*, 1993). These concerns can be grouped into three major types (Bellon, 1991): (a) agroecological, which refers to the performance of a variety with respect to agroecological conditions, such as rainfall, temperature, soil quality, topography, etc.: (b) use, which refers to the performance of a variety with respect to the destination and uses of the output, such as production for subsistence or for the market, production of straw for fodder, taste, texture, yield, etc.; (c) technological, which refers to the performance of a variety with respect to management and inputs, such as the amount of fertilizer applied, delays in weedings, fitting with other crops, etc.. Table 2 provides examples of different selection concerns for several crops.

Table 2: Examples of farmers' selection criteria

Study	Lando and Mak, 1994	Bellon, 1991	Sperling, Loevinsohn, & Ntabomvura, 1993
Crop and Country	Rice, Cambodia	Maize, Mexico	Beans, Rwanda
Agroecological	- Field adaptation - Maturity - Drought tolerance - Flood tolerance - Lodging resistance	- Performance on poor soils - Performance on good soils - Wind resistance - Drought tolerance - Maturity - Weed resistance	- Performance on poor soils - Performance in heavy rains - Performance in drought - Maturity
Use	- Yield - Eating quality - Price - Volume expansion	- Yield by weight - Yield by volume - Storability	- Yield - Color
Technological	- Not reported	- Fertilizer response - Input schedule demand (fertilizer & weeding)	- Performance under bananas

Farmers' selection concerns are not homogenous and may vary with different agroecological, socioeconomic and cultural conditions. Rich and poor farmers in a productive region probably have very different concerns, as may poor farmers located in productive versus marginal areas. Even with a farming household, there may be differences between male and female concerns. In many crops, such as rice, there may be a clear sexual division of labor that underlines the possibility not only of different concerns, but also of conflicting ones. This area merits further research, given the increasing recognition of the role of women in farming.

Since farmers' concerns are varied, and a good performance with respect to certain concerns often implies poorer performance with respect to others, several varieties are maintained. It is important to underline that in order to explain the development and maintenance of diversity[1] there should be trade-offs among the varieties. Otherwise there would be no need to have several different varieties. For example, Harlan (1992) points out that alleles for disease resistance generally have negative effects on yield in the absence of the disease and sometimes even in its presence. Hence, there are costs associated to resistance. Therefore, it is important to know and understand not only the positive traits of a variety, but also its negative ones. The combination of these two types of traits defines the opportunities for complementarity among varieties.

Variety selection is a process of continual experimentation and evaluation. Much of the new information acquired is transmitted from farmer to farmer. Experimentation and communication have two important roles in the management of diversity. They are the basis of the development of farmers' crop knowledge, and they allow farmers to know and evaluate new and unproved germplasm--in both cases, without jeopardizing their livelihood or scarce resources.

The fact that many small farmers have a well developed knowledge of their crops and crop varieties has been well documented by human ecologists, anthropologists and ethnobiologists (Bellon, 1991; Berlin *et al.*, 1974; Brush *et al.*, 1981; Boster, 1983; Conklin, 1957; Hames, 1983). This knowledge includes ecological, agronomic and consumption characteristics of the crops and crop varieties they plant. In many instances this knowledge is systematized in a regular system of nomenclature, organized in a taxonomic manner, i.e., folk taxonomies (Brush *et al.*, 1981); it may be used to make decisions regarding management, use, storage, culinary aspects and rituals (Bellon, 1991; Boster, 1983; Hames, 1983; Sutlive, 1978).

Variety adaptation

Whenever a farmer finds a variety that is superior for whatever reason, it will be cultivated under the conditions or for the purposes for which is superior. This process contributes to the development of increasingly adapted crop populations. The stronger and more distinctive the selective pressures, the more specialized populations are likely to be. It has been observed that traditional and modern varieties usually are segregated in different areas of the farm, subject to different management and aimed at different uses (Brush, 1991). Bellon (1991) has shown how small maize farmers in Mexico recognize a differential performance of their varieties to soil quality, fertilizer rates and timing of weeding, and they actually manage them accordingly. In rice, the fact that many farmers match different varieties to different field levels that, in turn, reflect different regimes of water availability, is well documented (Lambert, 1985; Lando and Mak, 1994). Certain varieties have been maintained only for very specialized uses, such as making rice-starch cosmetics, medicinal preparations, or traditional snack foods and cakes (Lambert, 1985).

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[1] This refers to diversity that is directly useful. Nevertheless, diversity may be maintained also as an option, because farmers may not know the future benefit or availability of particular varieties, or because humans can value diversity for its own sake, with no ulterior purpose.

Seed selection and storage

Farmers not only choose what varieties to plant or not to plant, or where and how to manage them, but the also the seed that will be the basis for the next season. Variety selection and management are reinforced by a careful and rigorous selection of the seed. Seed selection procedures vary by crop and its reproductive system. In open-pollinated crops, such as maize, seed selection may be fundamental to maintain the integrity of a variety (at least from the point of view of the farmer), which can be easily lost due to hybridization (Bellon and Brush, 1994; Louette, 1994). This may not be a problem in the case of self-pollinated crop, such as rice or beans, or in vegetatively propagated crop, such as potatoes. It may also be important for a farmer to keep varieties separate, in order to facilitate their identification, and for allocation to specific niches. Even if mixtures are planted, in general they are not a random collection of varieties, but specific combinations. For example, in Uttar Pradesh, India, a popular variety in drought prone areas, called gora, is a mixture of brown, black and straw goras, which differ in drought resistance and grain quality (Vaughan and Chang, 1992).

Seed selection may be also important to identify a new population or variety that may arise due to hybridization or mutation. A harvester may single out seed from one or more plants that is perceived as being entirely different from a known cultivar, in an attempt to originate a new strain (Lambert, 1985). This process may be very important to increase diversity in self-pollinated crops, where hybrids between varieties occur at low rates. Nevertheless, the introduction of modern varieties may modify the systems of seed selection because farmers may purchase seed instead. Dennis (1987) noted that it appeared that the practice of on-farm seed selection was declining as improved seed supplies became more available from government agencies. It is also important to emphasize the role of women as seed selectors in many crops, such as beans and rice. Their knowledge and expertise in this respect are increasingly being documented (Conklin, 1986; Sperling *et al.*, 1993).

The processes identified above can be conceptualized as the dependent variables that one may want to explain in a study of the bases of on-farm conservation or may want to influence in a project to foster it; they can be described and measured, with some being qualitative and some quantitative (Table 3). The studies reviewed show that there is variation in the number and types of variables maintained, the rates of variety replacement, the directions and types of seed flows, the variety selection criteria and the seed selection methods. This variation may be the result of a number of independent variables. These variables are the environmental, socioeconomic and cultural factors that influence the farmers' decision-making. These variables and the mechanisms by which they act are beyond the scope of this paper.

A CASE STUDY FROM MEXICO

To illustrate the methods to get and measure some of the variables presented above, I will present my work in Mexico. This work was done in Vicente Guerrero, a community of small peasant maize farmers in central Chiapas. The research site, the methods and results have been extensively presented and discussed elsewhere (Bellon, 1991; Bellon and Taylor, 1993). The methods presented here focus on variety selection and variety adaptation.

These farmers produce maize for self-consumption, as well as important surpluses for the national market. They practice plow and swidden agriculture, in relatively good soils, with favorable weather for maize production. Traditional and modern technologies coexist, with varying rates of fertilizers, herbicides, pesticides and an improved variety in both systems. Nevertheless, several characteristics associated with a more traditional agriculture are still common, such as the use of teams of oxen, wooden plows and the dibbling stick, and the utilization of several maize varieties, including landraces. These farmers have benefitted from the development policies of the Mexican government. They have access to government-provided credit, crop insurance, grain storage and marketing facilities, and produce important maize surpluses, mainly sold to the government marketing facility. Another advantage of this community is that it is located close to the state capital and is connected by a good dirt road.

Table 3: Variables that describe farmers' management of diversity

Varieties and Variety Selection	Variety Flows	Methods of Seed Selection
Number, list and type (e.g. traditional, modern) of varieties: • currently planted • previously planted • planted exclusively to retain seed • planted as an experiment	For each variety listed: • number of years/seasons a variety has been (or was, in the case of discarded varieties) maintainted by the farmer • maximum number of years/seasons a variety has been maintained	Time and place of seed selection
Area planted by variety	Sources of seed for each variety	Plant traits/parts used to select seed
Number of farmers that plant each variety	Methods of seed acquisition (exchange, gift, purchase, from neighbors, family, market, government agency, etc.)	Criteria of seed selection
List of concerns and criteria associated with variety selection	Number and list of varieties where seed has been lost and later recovered	Frequency of seed selection
Performance of each variety listed with respect to each concern	Number and list of varieties where seed has been lost and farmer has tried to recover it unsuccessfully	Persons doing the seed selection
Ranking of each variety performance with respect to each concern	Description of difficulites/constraints to recovering seed Reasons for seed loss	Short description of the method of seed selection
Ranking of each concern relative to the other ones		Storage of seeds
		Degree of mixing or segregation among varieties during seed selection and storage
		Quantity of seed maintained

Although improved varieties have been available for the last 30 years, and some have been adopted, these farmers continue to plant up to 15 different varieties, belonging to six different races. However, there have also been changes in the diversity of the varieties maintained there. New varieties have been introduced and become very important, while others have decreased in importance, although they have not necessarily been eliminated (Bellon, 1991; Bellon and Brush, 1994). Clearly, maize varietal diversity has been dynamic in this community.

For this study I used participatory observation and questionnaires. Of particular importance were two questionnaires: (1) a variety inventory and (2) a landholding inventory. These two questionnaires allowed me to know the level of diversity maintained by farmers, their variety selection criteria, and the association of particular varieties with particular environments.

Variety inventory

In the variety inventory, I asked each farmer[2] in my sample to list the names of all varieties he knew. For each name on the list, I asked: whether he had ever planted it, had planted it and no longer did, or continued to plant it; several plant characteristics such as plant height, days to flowering and color of the grain (during my informal conversations with farmers these characteristics were mentioned as important); whether the variety was planted only to maintain seed (a few farmers had told me that they maintained small plots of varieties with the exclusive purpose of keeping seed of a variety); and finally what were the advantages and the disadvantages of each variety. The answers to the last two questions were open-ended, hence the farmers were able to freely express their thoughts. During my previous conversations with farmers, it became clear that they were aware that each variety had both advantages and disadvantages, and that in their decisions of what variety to plant and how to manage it, they were continually weighing these considerations. The farmers' answers to the last two questions were of two types: they referred to a plant trait, e.g., stature, growing cycle, yield; or to a plant response, e.g., drought resistance, lodging proneness, etc. In most cases, the answers were highly interrelated and referred to the same concern. For example, tall stature was related to lodging proneness. Also, while discussing a specific variety, it was clear that some of the considerations were relative to other varieties. For example, the variety 'A' was considered to be more resistant to lodging that the variety 'B', but less than the variety 'C'.

Then I grouped the farmers' answers in two different ways. First, in order to assess the importance of the traits or responses, the answers referring to a particular trait or response, mentioned for at least one variety, were added together. This measures how many farmers referred to a particular trait and are expressed as a percentage of the total sample size (n=93)[3]. Second, each answer involving a particular trait given by each farmer for each variety was counted. This number counts how many of the farmers' answers associated a particular trait with a specific variety. For each variety, this number was expressed as a percentage of all the answers that referred to such a trait. The analysis was limited to the three most important varieties, that represented a modern improved variety (MV), a traditional variety (TV) and a variety that originally had been improved but that had been in this place for over 30 years, mixing with the local germplasm (IMV).

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2 Maize agriculture was done by male farmers exclusively in this community.

3 The total sample was 97, but there were four missing farmers because they could not be reached for further interviews.

Table 4: Selection concerns, their importance and association with specific varieties

Concern	Positive %[1]	Negative %[1]	MV %[2]	IMV %[2]	TV %[2]
Agroecology					
Short Cycle	64.5	0.0	77.3	22.7	0.0
Long Cycle	0.0	22.6	0.0	7.4	92.6
Drought Resistant	32.3	0.0	0.0	25.8	74.2
Drought Non-resistant	0.0	14.0	71.4	28.6	0.0
Short Stature	53.8	0.0	69.2	30.8	0.0
Tall Stature	0.0	81.7	0.0	12.8	87.2
Lodging Resistant	36.6	0.0	79.0	21.0	0.0
Lodging Non-resistant	0.0	69.9	0.0	15.4	84.5
Strong Stalk	15.1	0.0	60.0	40.0	0.0
Weed Resistant	22.6	0.0	4.4	26.1	69.5
Weed Non-resistant	0.0	19.4	83.3	16.7	0.0
Good Poorest Soil	8.6	0.0	0.0	25.0	75.0
Good Soils	0.0	19.4	83.3	16.7	0.0
Good Intercrop Squash	9.7	0.0	100.0	0.0	0.0
Technology					
Atencion	0.0	18.3	80.0	20.0	0.0
Aguantador (sturdy)	33.6	0.0	0.0	40.6	59.4
Delicado (delicate)	0.0	33.3	89.5	10.5	0.0
High Planting Density	9.7	0.0	100.0	0.0	0.0
Use					
Yield Weight	60.2	0.0	42.9	55.0	2.1
Yield Volume	74.2	0.0	10.9	16.4	72.7
Subsistence	31.2	0.0	0.0	6.7	93.3
Market	15.1	0.0	41.7	58.3	0
Good Storage	44.1	0.0	0.0	64.9	35.1
Poor Storage	31.2	0.0	0.0	0.0	100
Taste	14.0	0.0	0.0	0.0	100

[1] Percentage of farmers that declared such a trait (N=93).
[2] Percentage of answer associated with each variety, for those farmers that declared the trait.
Source: Bellon, 1991.

The farmers' answers reflected concerns with different aspects of maize production and use. These concerns can be grouped into the three major types referred to earlier; agroecological, use and technological. Table 4 presents these concerns, their importance and association with each variety. The farmers believe that each variety performs differently with respect to one or several of these concerns. Hence, they fit different needs or they allow for different management. For example, farmers believe that there are differences in investment and management among varieties. This is described in the folk categories '*aguantador*' (sturdy) and '*delicada*' (delicate). A sturdy variety was one that could withstand delays in weeding and the application of fertilizer without substantial losses in yield, while a delicate one would suffer important losses under those delays.

The variety inventory provided information on several variables: the varieties known and planted, the selection criteria, and the association between the selection criteria and the varieties. It was shown that for the three most important varieties there was consistency between what farmers said and the way they managed them (Bellon, 1991). There are two central findings of my work with these farmers. First is that they have a set of concerns associated with the performance of their maize varieties, as well as a knowledge base of how they perform for each concern in relationship with each other, and can rank them accordingly. The second is that no variety alone seems to address all of the farmers' concerns, and the process of varietal adoption is more complex than a simple dichotomous decision on adopt/do not adopt. Planting one variety did not prevent a farmer from planting another one (Table 5). Farmers are interested in varieties with contrasting traits that fit different needs and constraints, rather than a single plant with a particular trait, such as high yield.

Table 5: Percentage of farmers that planted simultaneously several varieties

Variety Planted	Percentage of farmers who planted the corresponding variety	Percentage of farmers who also planted		
		MV	IMV	TV
MV	77	100	64	34
IMV	66	75	100	37
TV	35	74	68	100

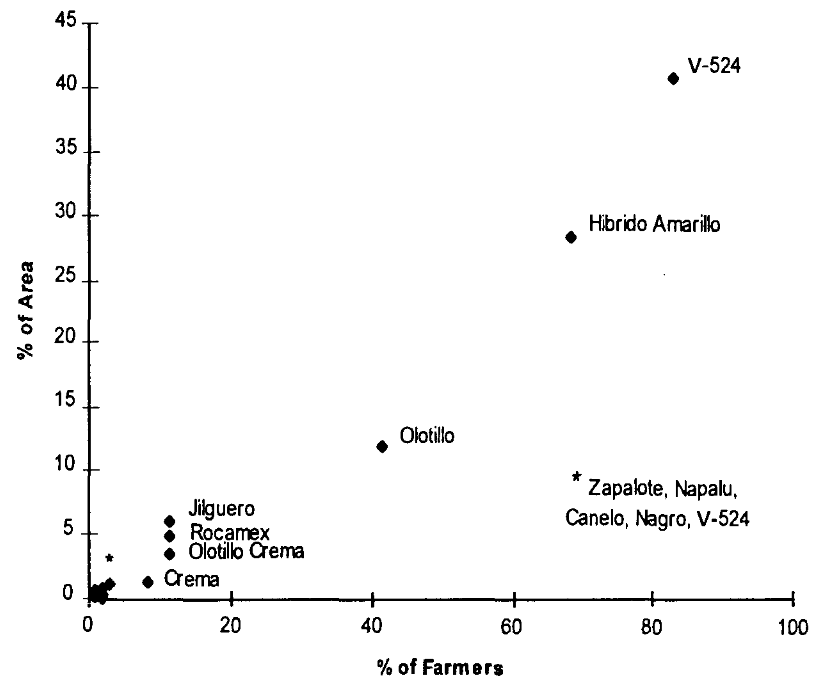
Source: Bellon and Taylor, 1993.

Landholding inventory

In the landholding inventory I asked each farmer in my sample to list the plots of land he had. For each plot, I also asked: the area, both in hectares and in the local units ('*litros*'); the land tenure; the types of soils present according to their folk soil taxonomy; and the area occupied by each soil type declared. Then for each soil type in each plot, I asked what crop was planted, and if maize was, what variety was planted that year and the previous year. Finally, I asked, if two varieties were planted, what were the reasons.

This information allowed me to cross-check the variety inventory (because the varieties planted declared in both inventories should be the same). It provided me with the area planted per variety, as well as the number of farmers planting each variety. Figure 1 presents these results. Two interesting findings are that: while the traditional variety was only planted in 12% of the area, it was planted by almost 40% of the farmers; and that, while the modern variety was planted by approximately 80% of the farmers, it was only in less than 50% of the area. This also shows that most varieties were individually maintained by a few farmers in small areas.

Figure 1: Relative importance of maize varieties by percentage of area and farmers



Source: Bellon and Brush, 1994

This information also allowed me to test the degree of association among varieties and soil types. A colleague and I were able to show statistically that, on average, the improved variety was planted more frequently in the better soils, while the traditional variety was in the worse soil (Bellon and Taylor, 1993).

This information also allowed me to measure the degree of land fragmentation present in farmers' fields, which is related to variety diversity (Bellon and Taylor, 1993; Brush, 1992). This is also related to how different soils are distributed among the farmers. I found that, although there was socioeconomic stratification among farmers, there was no marked concentration of any soil type by any specific socioeconomic group, and soil types are distributed among farmers by their abundance (Bellon, 1994).

Finally, I should point out that seed selection, management and storage are extensively presented and discussed elsewhere (Bellon and Brush, 1994).

CONCLUSIONS

In this paper I have argued that the focus of on-farm conservation is the farmers' management of diversity, which is not just the set of varieties that they keep but also the management processes these varieties are subject to and the knowledge that guides these processes. Farmers' management of diversity has four components: seed flows, variety selection, variety adaptation and seed selection and storage. These components can be conceptualized as the dependent variables that one may want to explain in a study of the bases of on-farm conservation or may want to influence in a project to foster it. I presented some methods to acquire information on two of these components, variety selection and variety adaptation, through the use of variety inventories and landholding inventories.

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ON-FARM GENETIC DIVERSITY IN WET-TROPICAL KERALA

V. Santhakumar

ABSTRACT

This paper discusses the major issues concerning on-farm genetic diversity in Kerala. The farms of this wet-tropical region had traditionally sustained a high degree of biodiversity. Many exotic species were also introduced here which later on emerged as major economic assets. However, in Kerala, the efforts of genetic upgradation in paddy have failed to increase yield rates significantly. The challenges in this state are two-fold: conserving the large number of locally-adapted varieties of paddy; and improving the biodiversity of the homestead. The spread of rubber plantations, replacing both homesteads and paddy fields, is posing a serious threat to on-farm diversity. If valuation measures take account of short-term and long-term benefits and consider the need-satisfying ability of the non-monetizable entities, land with high degree of diversity is shown to be economically comparable to that in monoculture plantations.

INTRODUCTION

This short paper is organized around the following sections:

- The characteristics of the traditional agricultural system that existed in humid-tropic Kerala;
- The successful and not-so-successful efforts to introduce exotic species and genetic material into the farm-land of this region;
- The implications of the reduction of on-farm biodiversity in Kerala;
- The approach of different groups of farmers towards biodiversity;
- The mechanisms which are appropriate to the socio-economic conditions of Kerala and which can conserve and improve on-farm genetic diversity.

This paper draws information on various sources as follows:

1. Details of the traditional agricultural system have been compiled from the natural history studies conducted during the last century (Mateer, 1883; Logan, 1906; Nagam,1906) and from the oral history of the inhabitants of a few villages of mid-land Kerala;
2. The description of the contemporary status of on-farm genetic diversity is based on a field project (in which the author was the co-principal investigator) which aimed to study and develop packages for the integrated management of land, water and biomass resources of a few representative micro-watersheds of Kerala (James *et al.*, 1992).
3. Analysis of the impact of the technological packages used for the management and development of natural resources in Kerala is based on the dissertation and on-going research work of the author.

4. Description of the problems and the potentials of eleven farmers living in different agro-climatic zones of Kerala emerges from a field study by the author (Santhakumar, 1995).

5. The 'active background' of this paper draws on the experience of the author as a resident and a farmer of mid-land Kerala.

As this is a brief paper, citation of statistics and references are generally avoided. For greater detail on any aspect, please contact the author.

TRADITIONAL AGRICULTURE IN WET-TROPICAL KERALA

Human subsistence patterns in Kerala were shaped primarily by its physical, climatic and ecological characteristics. The greatest natural endowment of this humid-tropic region was the existence of a high degree of biodiversity. The agricultural settlements of Kerala, which evolved nearly two thousand years ago, have depended on this biodiversity as their prime resource. People in this area traditionally used their own 'homesteads' [a small garden surrounding the house] for a variety of needs such as food, energy, shelter, medicines, etc....[1] Unlike other parts of tropical India, inhabitants of the agricultural land of Kerala have not depended on forests or community-owned lands for their biomass requirements (with the latter, community-owned lands, generally absent).

A relatively small piece of land[2] could provide a variety of commodities for human sustenance due to the high degree of biodiversity of the region. A typical farmer had three pieces of land. The first one, a small piece of water-logged valley situated at the lowest level of one of the several micro-watersheds, was used for paddy cultivation. The second was the homestead (situated in the dryland adjacent to the paddy field) which sustained a mixed plant/tree system. The third, situated generally on the hill slope near the top of the micro-watershed, also had a mixed-tree land cover with the characteristics of a rural forest. These three components were interrelated in terms of the resource flow and in regard to human patterns of use. The bottom of the valley provided a part of the staple food (paddy) and the straw (as a feed of cattle and in some areas, also as a roofing material). The homestead provided the other part of the staple food (tubers, jackfruit, etc.), non-staple food, timber and other materials for house construction, organic manure, medicinal materials, etc.... The upland patch was used basically for grazing and for collecting organic manure. Organic manure was an important input for paddy cultivation at the valley bottom.

Table 1 lists a few of the most common homestead plants and trees and their uses:

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[1] Agro-ecologists have recently shown greater interest in the complex agro-forestry systems of the homesteads (Gleissman, 1990).

[2] The average size of a land holding in Kerala has always been lower than in other parts of India.

Table 1: Common trees and plants in Kerala homesteads

Name of the tree or plant	Uses
Mango (*Mangifera indica*)	fruit, timber, non-staple food, organic manure
Silanti (*Thespesia populnea*)	timber, organic manure, support for wines
Erukku (*Caotropis giganta*)	organic manure, support
Avarum (*Cassia auriculata*)	" "
Laurel (*Calophyllum inophullum*)	non-edible oil, org. manure
Jack (*Autocarpus integrifolia*)	semi-staple food, fruit, timber
Anjil (another Autocarpus species)	timber
Coconut (*Cocos nusifera*)	several uses
Tamarind (*Tamarindus indica*)	spice
Tree cotton (*Gossypium arboreum*)	silk Cotton
Yam (*Dioscorea esculanta*)	tuber (semi-staple food)
Chempu (*Colocasia antiquorium*)	,, ,,
Elephant Yam (*Typhorium tricobatum*)	,, ,,
Pepper (*Piper nigrum*)	spice
Ginger (*Zingiber officinale*)	,, ,,
Turmeric (*Curcuma longa*)	,, ,,
Plantain (several varieties of *Musa sapientum*)	fruit, semi-staple food

Note: In addition to the trees cited above, there were several other varieties used for organic manure and/or as support for pepper wine.

Table 2 lists the various energy requirements of the family and the homestead energy sources. While such sources provided energy in many traditional societies, the interesting aspect of agricultural Kerala was that such an impressive amount of energy was derived from such small land areas (i.e., less than a hectare in size)---due to the high degree of biodiversity.[3]

Table 2: Energy requirements and sources in Kerala homesteads

Requirements	Sources
Cooking fuel:	twigs of all the trees, various parts of coconut leaves, coconut shell and other biomass
Heating fuel (for ironing etc.):	coconut shell
Lighting fuel:	laurel cake oil coconut oil sesamum oil
Chemical energy for plant growth: (NPK equivalent)	green leaves, ashes, cowdung
Mechanical energy:	non-edible waste products non-edible biomass (converted as bullock power)

3 Note that biodiversity was highest in the forest areas of the humid-tropics. When farmers converted parts of the forest into agricultural lands, crop specialization occurred and diversity was drastically reduced. Many trees and plants which survived in the agricultural lands in the humid-tropics were used for different purposes.

SUCCESSFUL AND NOT-SO-SUCCESSFUL ADOPTIONS OF FOREIGN SPECIES AND GENETIC MATERIAL IN THE FARMLANDS OF KERALA

Kerala has a very long history of trade in agricultural commodities. This exchange started much before the arrival of the Europeans in India, with commodities like pepper reaching distant markets even during the beginning of this millennium. These commodities also played an important role in the early trade with the European merchants.

However, it was the European traders who started introducing exotic species to Kerala. The Portuguese introduced the cashew, which later on led to the emergence of a large number of processing and exporting units of cashew nuts. This small-scale industry supported considerable sections of population and earned significant amounts of foreign exchange. During the nineteenth century, the British introduced tapioca, which emerged as a major semi-staple food and became the prime source of carbohydrate for poor people, whenever this rice-importing state faced shortages of food grains. British planters also introduced rubber, which became the most important cash crop of the state. Since many Indian states do not have the climatic features suitable for rubber cultivation, the natural rubber produced in Kerala has a large domestic market. This situation, coupled with the restrictions on the import of natural rubber (and the production fluctuations in other rubber producing countries of South Asia) has resulted in high profits for the rubber producers. Rubber cultivation has thus emerged in Kerala as the most important economic activity. While Europeans also introduced other plants and trees such as glyricidia and breadfruit, (the former used in thirties and forties as a major source of organic manure), their impact was not as great as that of the three other crop introductions.

The post-independent governments have also tried to introduce exotic plants and genetic materials into Kerala. These include the genetic upgradation of traditional crops like paddy and coconut and the upgradation of local livestock and the introduction of exotic plants such as cocoa and acacia. The net effect of these introductions is briefly discussed below.

GENETIC UPGRADATION IN RICE

The importation of new varieties or genetic material of rice to Kerala started only during the 1950's. Previously, scientific efforts focused on making pure-line seeds of the locally used varieties. During the 1940's, there were also some efforts to cultivate non-native varieties of paddy in Kerala. Varieties from other states of India and from countries like China were tried in different areas of Kerala. However, none of these varieties emerged as superior to the locally-adapted ones. As in the case of other Indian states, the cross-breeding between the indica and the japonica varieties did not meet with success in Kerala. However, intensified efforts of cross-breeding took place during the 'Green Revolution' period, when the mixing was done between the semi-dwarf varieties of Thailand and the local indica types.

A number of studies on Kerala's agriculture have observed that "the state has not come under the influence of any Green Revolution" (Pillai, 1982; Kannan and Pushpangandan, 1991; Nambiar, 1983). This is shown by the stagnation in total production and the yields (per hectare) of the major food crop, rice, during the last three decades. While the yield of paddy increased by 55% during the period 1955-1971, the increase between 1972 and 1986 was only 18%. It was the latter period that covered the phase of Green Revolution, marked by considerable increases in the productivity of food crops in many regions of India.

Why did the Green Revolution not occur in Kerala? Agricultural studies of the last decade give some indications of the climatological factors that influence the performance of the Green Revolution package in humid-tropical regions. Environmental factors such as the seasonal availability of sunlight are now considered as limiting factors on the effectiveness of the Green Revolution package (Gangadharan, 1985; Panikkar, 1973). The wide variations in the success rate of this technology between temperate and tropical countries, between dry tropical and humid-tropical areas and between irrigated and monsoon-fed areas have been interpreted in terms of the influence of the environmental factors.

Based on a long-term analysis of the experimental results of the agricultural research stations, Santhakumar and Rajagopalan (1995), showed that the performance of the Green Revolution package was not impressive even in the research stations of Kerala. This analysis found that the highest yields achieved in the majority of Kerala stations are significantly lower than those recorded in the semi-arid areas situated within and outside Kerala. In all these locations, cultivation is done mainly during the monsoon months. Thus, the locations where summer cultivation is not possible have yield values consistently lower than those at the locations sustaining summer cultivation. Summer cultivation is possible in Kerala only in a few places. The regions which cover 65% of the gross area of paddy continue to be monsoon-dependent. The shortage of sunlight is an important limiting factor in these areas. Even in those areas where high yields of 4.5 to 5 tons per hectare are achieved, the local varieties also perform at this high rate. In sum, the net effect of the genetic upgradation even in such places is found to be marginal.

The increase in yields of paddy achieved by the high yielding varieties (HYVs) in Kerala is found to be less than 40%. This increase achieved by the HYVs in Kerala was not sufficient to overcome the relative advantages of the traditional varieties, such as the higher amount of rice straw.

The study also analyzed the effect of chemical fertilizers. In the case of nitrogen (N), the percentage increase in yields due to its application varied from 23 to 41%. The maximum yields were obtained when the quantity of N was around 60 kg per hectare. Increasing the quantity of N beyond that level did not result in yield increases in humid-tropical Kerala, while the corresponding figure for other parts of India was 150 to 200 kg per hectare. While the real potential of HYV may lie in the increased consumption of N and the corresponding increase in yield, the central factor that limits the productivity of HYV in Kerala is this lack of positive response to higher doses of N.

The study concluded that the so called HYVs could increase the productivity of paddy in Kerala only marginally due to environmental factors. The effect of high yielding varieties and chemical fertilizers was not significant compared to that of the previously used inputs such as pure-line or traditional varieties and organic manure. Since their effect was not significant, the transition to the Green Revolution paradigm by the farmers critically depended on factors such as cost of cultivation. Based on farmers' data, one study observed that the cultivation using the new package increased the cost by 30%, while the output increased only by 40%.

Thus, the genetic upgradation in rice through the cross-breeding with exotic varieties was a not-so-successful attempt in Kerala.

COCONUT CULTIVATION

There have been efforts to breed high yielding varieties of coconut (especially through crossing tall indigenous with dwarf exotic varieties). However, the spread of such varieties has been limited as farmers do not note much difference between HYVs and local varieties, when the two are grown under farmer management and in farmers' fields. The major constraint concerns the lack of water for irrigation during the summer. Scientists have recommended use of large quantities of water during this period as it has been clearly demonstrated that sufficiently irrigated coconut trees yield significantly higher than non-irrigated ones. A number of farmers practice irrigation for coconut. However, several problems arise due to this practice. First, once started, irrigation has to be continued at sufficient doses across years as reduced watering in any one year will affect the tree and the yield significantly. This is basically because of the reduction in the drought-surviving ability of the tree. Second, since coconut is grown in dry land and because its cultivation has extended to even drier lands, such as hill slopes during last few decades, providing irrigation is not an easy task. Sufficient water is not available in nearby dryland areas as the only source is the open well used for collecting drinking water. Moreover, the seepage into the dry soil (not clay, but sandy and gravelly ones) is very high. Only a few farmers, who own sources such as ponds, are able to irrigate coconut during summer. These farmers also find it difficult to irrigate at the doses recommended by the scientists. Some others who initially tried to irrigate coconut, have abandoned the practice. Farmers also believe that local varieties yield for a longer period of time and have higher timber value. This consideration, coupled with the insignificant yield difference between non-irrigated local and hybrid varieties, has led farmers to continue with the traditional varieties.

We have seen two cases where the genetic upgradation failed even on a short-term basis. Let us take a look at a successful case (on a short-term basis) in Kerala. This known as the 'White Revolution'.

GENETIC UPGRADATION OF LOCAL CATTLE

Milk production in Kerala is one sector where governmental policies succeeded in attaining their target. The White Revolution program, started in the 1970's, aimed at the genetic improvement of traditional cattle through cross-breeding. The intensive efforts of cross-breeding drastically changed the genetic composition, sex ratio and the milk production capability of Kerala during the last two decades. Traditional cattle have almost disappeared from Kerala. Maintaining male cattle has also almost stopped as breeding is done through artificial insemination centers and the use of bullock power has been greatly reduced.

The success of the White Revolution is based on several factors, and one outcome of this process has been the complete separation of animal husbandry from farmland. Animals are maintained in stalls with factory-made feed and fodder imported from other states. Such livestock raising could utilize a part of the underemployed labor available in Kerala. Changes in consumption patterns have ensured sufficient demand for the milk produced.

However, this occupation faces certain long-term challenges. The first is the increase in the cost of milk production. Efforts to increase feed production within farms have not been very successful. Dependence on market for inputs and the continuous reduction in the comparative advantage of labor power (through the increase in wage rates in comparable occupations) will continue to reduce the profitability of animal husbandry.

Unless a part of the feed material is generated on-farm in a non-competing manner (that is, use of waste materials and byproducts will not necessitate the use of land which can be used for producing commodities for human consumption), farmers will not be able to gain profits from the 'advantages' of cross-breeding. Thus, the basic direction of sustainable animal husbandry in

Kerala may lie in the reintegration of cattle into the agricultural system and not in the continuous upgradation of the genetic structure.

IMPLICATIONS OF THE REDUCTION OF BIODIVERSITY IN HOMESTEADS

The biodiversity of Kerala homesteads has declined drastically during the last four to five decades. The majority of the homesteads have been converted into small-scale coconut plantations or have moved toward cropping systems with but a few crops. The naturally-grown trees have almost disappeared. *Anjili*, a variety of the Autocarpus species which, with the jackfruit tree, supplied the bulk of timber for house construction, has disappeared from farmlands because farmers just haven't replanted it. The number of jackfruit trees has also declined considerably because of the low-market price for many indigenous varieties of jackfruits.[4] Thus, people now depend on marketed timber, which is taken mostly from forest areas. This has resulted in excessive pressure on forest timber, increased price, and the increased cost of house construction. The non-use of farm-made construction materials (partly due to the non-availability and partly due to the changed concepts of house) has created a situation whereby house construction has become the biggest burden even of middle-class rural families.

Laurel that provided the non-edible oil, which was the main source of lighting fuel, has completely disappeared from agricultural lands. The practice of manufacturing, selling and using laurel oil has also stopped due to the availability of subsidized kerosene and electricity. Till recently, no effort was made to improve the usage of laurel oil as a lighting fuel. As the region faces severe electricity shortages, the quality of supply is quite poor, and the prospects of increasing supply at a reasonable cost are not that bright, a few people are starting to relook at non-edible oils as possible sources of energy.

Though coconut still provides the bulk of the cooking fuel for homesteads, the total biomass available for that purpose has come down. Even medium-size households depend on other fuels, partly due to the scarcity of the biomass and partly due to the availability of 'clean' petroleum-based fuels at subsidized prices. During the last few years, there has been an increased effort to popularize 'high-efficient chulas' (stoves). However, they are not used widely among the middle-class due to the easy availability of petroleum-based fuels.

The major limitation of the contemporary homestead concerns the availability of organic manure. Certain plants and trees which were grown solely for collecting organic manure have not been integrated into commercialized plots. Presently, cultivation is almost fully based on chemical fertilizers and/or commercially-purchased organic manure. The shift to external inputs has not been problem-free and has created a peculiar crisis in Kerala. The failure of the Green Revolution in Kerala at one level and the proven superiority of organic manures at the other level have led to the following situation. Changeover to fertilizers (NPK) has not increased the yield and organic manure is indispensable. This means that farmers are forced either to ignore requirements for organic manure or to purchase it at a high price from the market. (The price of the organic manure has increased faster than that of chemical fertilizer).

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[4] Earlier, jackfruit was a staple food. Today, rice has evolved as the only staple food and jackfruit is taken only as a fruit. Hence, there is a reduction in the number of jackfruit varieties which are not very good as fruits.

Thus, the most important activity needed in Kerala is to conserve the biodiversity of the homesteads. The mixed system provides the much-needed organic manure for further cultivation, apart from providing a variety of commodities. Moreover such systems do not upset the farmer's financial position when the price of any single commodity declines.

Relying on biodiversity may not increase the short-term economic benefits generated from agriculture. However, biodiversity will improve the stability of the system, improve the quality and diversity of commodities available for home consumption, improve the ability of the farmer to make his own dwelling unit, and reduce fluctuations in cash income. It is because of this that, even in this context of generally declining biodiversity, farmers remain interested in preserving it. Within the constraints of distorted markets, lack of information, habit changes, lack of awareness and lack of concern for long-term impacts, farmers still use diverse plant and genetic material for their survival and their economic improvement.

Any attempt to increase on-farm genetic diversity should be based on an analysis of the survival strategies of the farmers. For example, in Kerala, one can define three groups of farmers, based on their response to diversity. They are as follows:

- Marginal farmers generally depend on whatever resources (including the plant and genetic resources) they have or have access to for their survival. There is not much intentional choice on their part. For example, even in an area where most of the cattle are cross-bred ones, certain families depend on local cattle. These local cattle fit in well with farmer resources. They are maintained by female and old-age labor, consume only the wastes generated within the farm family, graze in public spaces and yield milk (for both home consumption and local sale), cowdung (for subsequent cultivation) and draft power. Farmers continue with the local cattle because they do well under a regime that farmers can maintain--not because cross-breeds are unavailable. This group of farmers depends on a particular 'plant-mix' or 'gene-set' as a survival strategy. For others, who depend on hired labor for maintenance, whose land does not generate substantial amount of cattle-feed, and who depend crucially on the cash income generated through selling milk, maintaining cross-bred cattle is the viable option.

- The middle class farmers of Kerala, who cultivate a major part of their land with a monoculture cash-crop (mostly hybrid rubber), keep a small piece of land for growing a number of plants and trees in a mixed system. One may not see explicit economic rationality in this practice. However, farmers feel strongly that at least a certain part of the commodities for home consumption (like coconut, banana, tubers, vegetables, and fruits) should be grown within the family farm. Moreover, people generally prefer to build their house within such a 'mixed homestead' rather than within a rubber plantation. These 'non-monetizable aspirations' encourage these farmers to maintain the mixed system.

  Farmers who go for the most improved varieties of rubber in their cash crop cultivation are found to be rather reluctant to use cross-bred or hybrid varieties of paddy. As said earlier, this reluctance to use HYV paddy is mainly due to their awareness of the insignificant increase in yields achieved by these new varieties. Moreover, Kerala farmers prefer red-kernel varieties and those with a higher amount of straw. This differential attitude towards genetic material shows that farmers use both economic and non-economic criteria when judging new plants and varieties and that the overall availability (through an elaborate distribution infrastructure) and the popularization mechanisms do not necessarily lead to changes in diversity on-farm.

- The third group of farmers, who own relatively larger farms, make direct choices in terms of genetic diversity. The majority of these farmers have plantations of monocrops. However, they also maintain mixed crop-systems in other pieces of land, a practice which is as profitable as, if not more than, monocrop cultivation. Cultivation of a number crops, for example, coconut, pepper, cocoa, tubers, pineapple, clove, banana, arecanut, nutmeg, etc., is common in such farms. These farmers also cultivate timber crops such as teak and manchium, with long-term economic objectives in mind. The current economic interest in timber trees, reflected in the booming of 'plantation share business', also motivates these farmers to grow trees as a money-making proposition.

This third group also includes experimental farmers who look at farming as a more meaningful occupation. A number of them are interested in what is known as 'sustainable agriculture' and are trying to recycle the wastes generated within the farm, to reduce the use of external (chemical) inputs and, consciously, to increase on-farm biodiversity. The number of such farmers is significant in Kerala because of the states' high literacy rate, wide circulation of newspapers and heightened awareness of environmental and ecological issues---as well as because of the presence of a large number of small farmers deriving significant amounts of cash through the cultivation of crops like rubber.

APPROPRIATE STRATEGIES FOR IMPROVING ON-FARM GENETIC DIVERSITY IN KERALA

Since the genetic upgradation of varieties like paddy has not led to significant yield increases in Kerala, there is not much conflict between conserving the genetic resources of paddy and the economic needs of farmers. For example, most of the paddy farmers that I encountered use the seeds that are available on their own farm. These seeds are neither truly local ones nor pure HYVs. The non-use of the traditional variety is solely due to its non-availability. Thus, if these varieties can be made available to the farmers, the conservation of the germplasm of paddy at the farm level is not an impossible task in Kerala. Almost all the farmers show a preference for traditional varieties. (This might a reflection of the non-commercial cultivation of paddy in many areas of Kerala.)

One reason cited for the insignificant impact of HYVs in Kerala is the absence of breeding for different micro-agroclimatic zones of the state. There are ten different zones situated within this small state. Traditional varieties suited to each zone were available earlier. The research establishments function in such a way that they can not adequately consider the distinct characteristics of each zone in their breeding programs. An appropriate breeding strategy for Kerala would both be tuned to the variety of requirements of these different agro-climatic zones and not be oriented only to supplying genetic material from the national and the international breeding programs. Though scientists of the Kerala Agricultural University have been trying to develop a climatic zone-based breeding strategy, their organizational and disciplinary frameworks, as well as the absence of farmers' participation, make these efforts quite inadequate. Close collaboration between the scientists and the farmers of each zone and increased prominence to farmers' trials (that is, trials within the resource constraints of the farm family) might be helpful in evolving acceptable and locally-appropriate 'better yielding varieties'. This may require structural changes in the agricultural research of Kerala. However, overall, I am not that optimistic about the prospects for further genetic improvement in paddy in Kerala.

The case of homestead is more interesting in terms of the potential for conserving on-farm biodiversity. As noted in the cases of two groups of farmers, economic and non-economic interests promote the cause of conservation. Several objectives should be pursued further:

1. Farmers need to increase the production of organic manure within the farm. This manure is needed for paddy cultivation and the crops grown in the homestead itself.

2. Farmers need to increase the timber production within the farm. The non-replanting of many trees was generally due to the lack of awareness and the non-availability of planting material. If material were made easily available and if modest efforts can be made for creating awareness, the planting and maintaining of these trees within the farms would be possible. The possibility should also be explored for multiplying seedlings of certain local as well as exotic (and harmless) varieties. This could be done through tissue culture, in collaboration with scientific organizations (like the Tropical Botanical Garden and Research Institute, Trivandrum) and the forest department. The seedlings distributed through the Social Forestry Program of the Kerala Forest Department do not have adequate representation of local varieties.

3. Adoption of high-efficient chulas (stoves) should be encouraged. Ideally, the biomass production within the farm should be sufficient enough to meet fuel needs. However, one can see that even families with adequate on-farm fuel, go for kerosene and liquidified petroleum gas (LPG). It is not clear to what extent this is due to subsidies given for petroleum fuels. Though the high-efficient-chulas are being widely popularized in Kerala, people are still very attracted to petroleum fuels, even in rural households. However, at a macro-level, the increase in the production of fuel wood at the farm-level would definitely reduce the pressure on forests.

4. To promote biodiversity and reduce household dependance of any single cash crop, farmers should also be encouraged to cultivate a number of crops for income. The wide price fluctuations of certain commodities have already led many farmers to rethink their dependance on one or two commodities. Certain crops like cashew, which were less remunerative some years ago, are fetching better prices today. Farmers who removed those trees in order to plant coconut now face a resource crunch, owing to the generally low price of coconut. Since these crops are perennial trees, farmers cannot change the land use quickly to meet the market requirements. Whenever a commodity fetches a high market price, these marginal farmers make changes in their investment pattern and become severely frustrated and indebted when the price falls. Crops like coconut, pepper, cocoa, arecanut, cashew, etc. are all vulnerable to price fluctuations and a crop combination is a better economic option.

5. This multiple system should not be limited to crops alone but should also include animal husbandry. As observed in the case of cattle, the sustainability of that occupation depends crucially on the ability of the farm to contribute at least a part of the feeding material. Thus, the two-way relation, (i.e., cattle providing organic manure for cultivation and cultivation providing feed for cattle) should be reestablished wherever (and to whatever extent) it is possible. In the case of poultry, farmers generally prefer the local breeds which produce small reddish eggs and have harder meat than the broilers. These birds rarely consume external feeds and survive with the waste produced within the farms.

It is the general preference for short-term profits, the lack of concern for longer-term impacts, and the perennial nature of many crops which constrain most farms from becoming more diversified. However, demonstration farms, campaigns on the economic benefits of mixed systems, easy availability of the planting material, etc.., should be sufficient to strengthen the already visible shift towards a multi-crop production system in Kerala.

Demonstration and the awareness-building programs need assistance from external agencies. The demonstration units of mixed production systems should show attractive economic returns-- on par with, if not more than-- the monoculture units of similar size. Valuation of the by-products, of the commodities with long gestation periods, and of those normally not integrated into the market, are the real challenges in calculating the economic return of these mixed-system units. If the economic returns are comparable, then the non-economic attractions of the mixed systems would become quite obvious to the farmers.

In terms of distributing genetic material, Kerala can make good use of market channels, with such a mechanism being preferable to free or subsidized distribution. As visible in the case of a few tree crops, farmers are quite equipped to buy planting materials on the market. One objective for the project of improving genetic diversity in Kerala is to develop an adequate number of entrepreneurs willing to grow and diffuse genetic and plant materials.

However, one should not forget the impact of macro-level policies and market signals on the genetic and plant composition of a region. These issues limit the success of the micro-level efforts to conserve and improve on-farm genetic diversity. One issue relevant in Kerala is the spread of rubber plantations, replacing the homesteads and even the paddy fields. What are the long-term implications of such a replacement? This large-scale conversion may have harsh economic consequences, if technological or market development leads to the lowering of the natural rubber price. The present production situation in countries like Malaysia is such that even the import of rubber will not affect the high price that is prevalent in Indian market. Thus, the spread of rubber is the greatest threat to on-farm genetic diversity in Kerala. However, in the present situation, it would be very difficult to tell the farmers about the possible unsustainability of large-scale conversion into rubber plantations.

EPILOGUE

Conserving the biodiversity may not be economical on a short-term basis. However, such a move will strengthen the stability of the system, improve the quality and diversity of commodities available for home consumption, improve the ability of farmers to make their own dwelling unit, provide the much-needed organic manure, and reduce fluctuations in cash income. This author has a strong but unsubstantiated feeling that conserving on-farm genetic diversity in Kerala will not affect the economic interests of the farmers. Proper methods for valuating the short-term and long-term benefits and considering the need-satisfying capacity of other non-monetizable entities might show the comparability, if not superiority, of mixed farms. How far this valuation can be done through conventional means (using discount rates and shadow prices, etc.) is yet to be ascertained.

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WHAT DOES *IN SITU* CONSERVATION MEAN IN THE LIFE OF A SMALL-SCALE FARMER?
EXAMPLES FROM ZIMBABWE'S COMMUNAL AREAS

S. van Oosterhout[1]

ABSTRACT

Three periods of major genetic erosion have occurred in Zimbabwe's recent history. The genepool of traditional crops has also been continuously enriched by geneflow across the country's borders through trading of grain and exchange of seeds. Geneflow, in the form of seed distribution, is continuing in the present day but is now largely formalized and is being carried out by government and NGO agencies. Control over genetic resources has thus shifted from being a common property right to being under the corporate control of such bodies as: drought relief operations, international agricultural research centers and multinational seed and fertilizer companies. Notwithstanding this, female, small-scale farmers have persisted with the growing of traditional crops and have distinguished themselves as 'keepers of diversity'. Despite the urgent need of farming families to grow cash crops in order to survive in the market economy, women have emphasized the role played by the traditional crops in ensuring household food security.

High within-crop diversity is concentrated mainly in indigenous sorghum, millets, legumes cucurbits and traditional maize crops. These food crops provide a varied diet, have good storage potential and are well adapted to environmental stress conditions. Due to the demands of the cash economy, which is increasingly impinging on the autonomy of the small-scale farmers, the best resources are devoted to cash crops, more specifically maize. The traditional crops are consequently grown on the poorer soils with minimal inputs and almost exclusively by women farmers, who are concerned with their families' food security. Recurrent droughts over the past decade have caused farmers to loose much of their seed stocks of traditional varieties. Drought relief packages, which were meant to alleviate the food insecurity, have almost exclusively contained hybrid maize seed produced by multinational companies and have not addressed the needs of farmers living in marginal areas where drought tolerant crops are advised.

By building on and strengthening local social structures and by addressing development priorities identified by farmers themselves, such as water harvesting and seed exchange programs, we hope to make in situ conservation an adaptable and dynamic process in which genetic resources are considered to be part of the communities' cultural heritage with farmers being firmly in control

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of the resource base. At the same time, such an approach should serve to stimulate the ongoing debates around improved local food security for resource-poor farmers.

INTRODUCTION

Recent analyses of resource use or economic valuations of natural resources have for the most part neglected the important contribution made by traditional crop genetic resources (Murphree and Cumming, 1991; Swanson and Barbier, 1992; Pearce, 1993) and have largely ignored the steady depletion of traditional crop varieties, with some exceptions (Fowler *et al.*, 1988; Mooney, 1992). The main aim of this paper is to show the influence of historical factors on the current status of traditional crop diversity in Zimbabwe and to indicate how this in turn has affected household food security and the well-being of farming families in the rural areas. The linkage of crop diversity with household food security is identified in this paper as an important gap in current research on biodiversity issues.

GENETIC EROSION OF TRADITIONAL CROP BIODIVERSITY

To understand the present situation regarding the loss of genetic resources of traditional crops, it is necessary to review the historical context of food insecurity and dispossession of the community, which occurred parallel to the disempowerment of women in Zimbabwe.

Movement of germplasm: the historical context

Both loss and gain of local crop varieties are features of agricultural societies. Although droughts regularly ravaged certain parts of the country in historical times, farmers were able to replenish or replace their seed stocks from a variety of sources including neighboring countries with which contact was maintained as people crossed borders to trade, to visit relatives or to search for seeds. Figure 1 indicates the major avenues of germplasm exchange across the borders of Zimbabwe. Zimbabwe lies in southern Africa, immediately north of South Africa, in the sub-tropical semi-arid belt which runs east-west below the tropical regions to the north. The area becomes progressively more arid from the humid forests along the east coast in Mocambique to the stretch of desert along the west coast in Namibia. Along the western and south-eastern borders of Zimbabwe, genetic influences have come from arid regions such as Namibia, Botswana and southern Mocambique. Sorghum and millet varieties grown in this region are generally early maturing and highly drought tolerant. In the northern and north-eastern regions of Zimbabwe, genetic influences from Mocambique and Zambia have resulted in long-season, moisture loving varieties. Movement of crops across geographical borders[2] is likely to be an ancient phenomenon which has occurred over centuries (Dogget, 1970; Rindos, 1984). However, perhaps one of the major genetic influences on traditional crops came during the Ndebele migrations into Zimbabwe around 1860.

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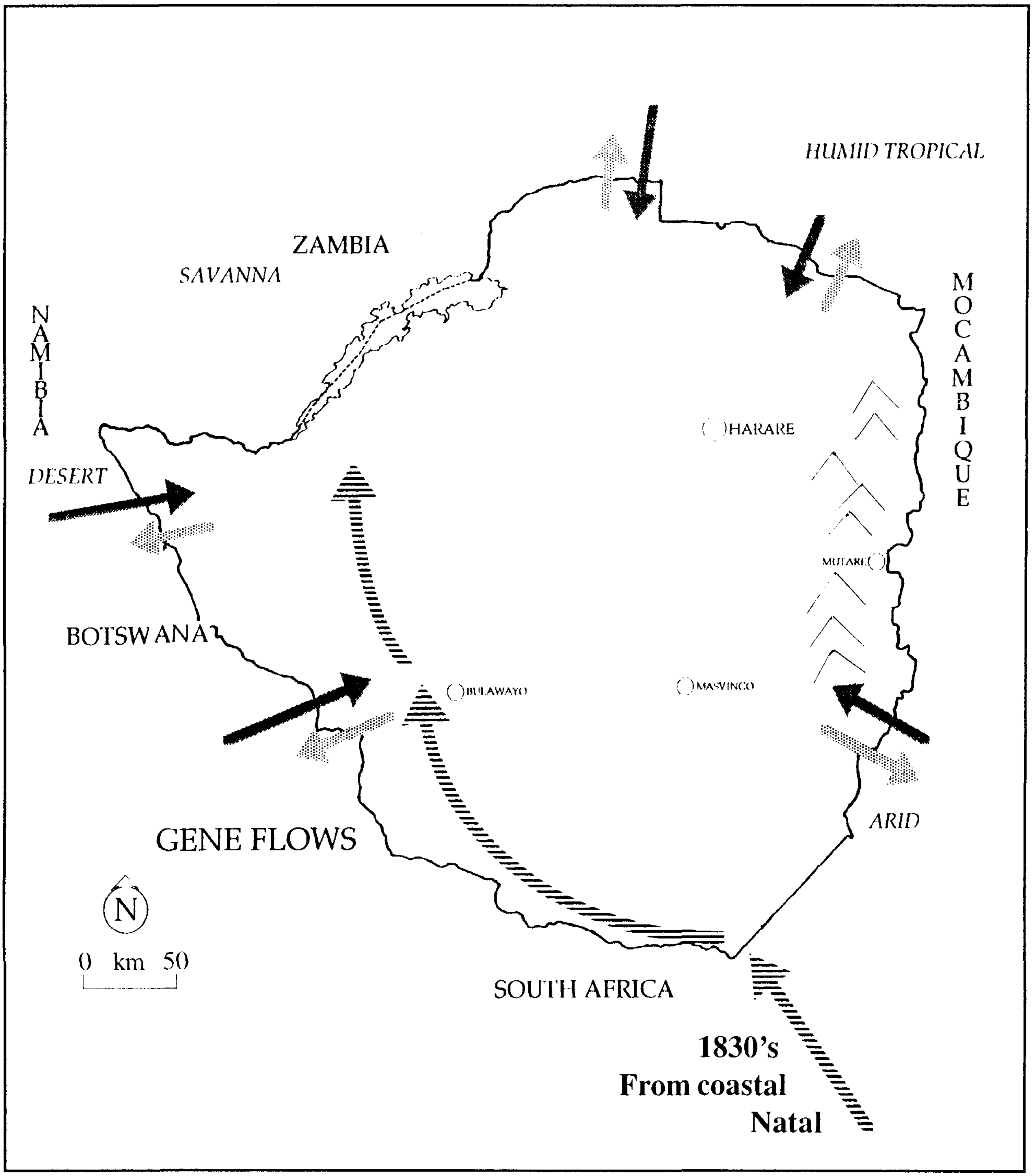
[2] Only since colonial times have rivers become borders. In the Zambezi valley, the River Tonga people occupy both sides (Zimbabwean and Zambian) of the Zambezi river and along the eastern border of Zimbabwe, Manicaland stretches alongside both Zimbabwe and Mocambique.

Figure 1: Movements of crop germplasm in Zimbabwe over the last century. Arrows indicate the major gene highways



Historical background

The Ndebele people escaped from the warrior king, Shaka Zulu in Natal, South Africa, and moved into previously unoccupied territory in western Zimbabwe, taking their food crops with them. The area was prone to drought and trade in cattle for grain increased during such periods (Rukuni, 1990). Sorghum was an important staple food at the time in Natal (anon., ca. 1900) and was grown in the newly settled area, while maize was eaten in smaller quantities as a vegetable or snack food. The Ndebele owned large numbers of cattle and frequently raided the Shona, an agricultural nation living in the central and eastern parts of the country, to obtain grain and slaves to grow their crops (Thomas, 1873; Cobbing, 1974; Phimister, 1974). Both Shona and Ndebele people had advanced grain storage facilities which could accommodate reserves of up to one ton (Page and Page, 1991). In the case of the Ndebele, these consisted of large underground cavities which had been dug underneath the cattle pen. The walls of these granaries were plastered with clay and cowdung and the entrance was covered with large flat stones and sealed with clay. The grain was fumigated by the ammonia-rich gases from the cattle manure and the granary was effectively hidden from invaders. In the case of the Shona, granaries were constructed from poles or woven like baskets and sealed with clay and cowdung. The contents of the granaries were protected with the ashes of various plants. Seeds for both Ndebele and Shona were most often stored as heads inside the thatched roof of the kitchen above the fireplace so that the smoke fumes would protect them from pests. Granary bins constructed from clay were also hidden in secret places sheltered by rocky overhangs as a security measure against drought and attacks from invaders.[3] Trade in grain (sorghum and millets) was well established and was particularly active during the period when European settlers arrived during the last decade of the previous century (Hyatt, 1914). Women dominated the grain trade (Palmer, 1977). Grain was traded during droughts for ivory, gold, tobacco, cloths and cast iron agricultural implements (Beach, 1977; Iliffe, 1990).

In 1890, the British South Africa Company marched with the 'Pioneer Column' into Zimbabwe in search of gold. When gold was not found in sufficient quantities over the next two years, Matabeleland was invaded, the king, Lobengula, was killed and the cattle and other wealth were distributed among the settlers (Rukuni, 1990). During the period from 1893 onwards, differences between the Ndebele and the settlers became sharply focussed as a result of forced labor being exacted to make gold mining more profitable. Most of the remaining national Ndebele cattle herd was captured or shot by the British South Africa Company in 1894 (Beach, 1975) and since this was the principal medium through which Ndebele and Shona people stored wealth, serious conflict was inevitable. Together these events resulted in an uprising which spread across the country during 1896-97. Military records report that the two principal causes of the rebellion were:

> "1. the incompleteness of the conquest of the Ndebele nation in 1893;
> 2. the incapacity of an ..... aristocratic race ..... to accept their natural place in a peaceful and settled civilized community" [*underlining added*].

The records further document the systematic destruction of local grain and food reserves and livestock by military forces of the British South Africa Company. A few months later it was reported that:

> " the chief enemy now to be contended with and feared in Matabeleland is starvation. The scarcity of grain is so great that starvation is imminent. ..... in many

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[3] Personal observation of now defunct granaries in the hills around the Mazowe valley.

instances grain has been hurriedly buried in the veld for fear of it being stolen ..... so that a great part has become mouldy and uneatable." It continues that "..... The pacification of the country having been thus secured, ... and by the liberal distribution of seed grain, the company has endeavored to secure as much land as possible (for) grain cultivation. ..... It may however be considered right that the natives who are responsible for the rebellion should be allowed to suffer ..... " (British South Africa Company reports, 1896-97) [*underlining added*].

This report indicates not only the immoral and unjust occupation of tribal lands by a mining company seeking to increase its profits, but also indicates one of the most serious genetic erosion events of the century in southern Africa. In addition it shows that for the first time, control over seed grain was removed from the ownership of people as a common property right and was transferred to institutionalized corporate control, in this case the British South Africa Company. It will be shown that the pattern of transfer of control over seeds from the people who developed the genetic stocks to those who have financial interests in controlling access to seeds has continued to the present day.

A major condition for peace was that the Ndebele would return to their ancestral lands, but owing to their agriculturally favorable position, these lands had already been granted to settler farmers and the Ndebele could only return as tenants or laborers (Beach, 1975). In the central and eastern parts of the country, Mashonaland, the local people were similarly dispossessed of ancestral lands. This was especially serious for the Shona, as land and soil are intimately connected with their spirituality (Lan, 1985). People were forced to leave fertile lands in high rainfall areas for the low lying, hot and dry marginal areas which form the periphery of the country. These areas were generally uninhabitable due to the presence of malaria and tsetse fly. Even as early as 1912, the tribal trust lands were considered to be congested (Yudelman, 1964). At present these marginal areas, where dryland cropping is considered to be an extremely risky undertaking (Farming Systems Research Unit, 1994), are still occupied by nearly 60% of rural Zimbabweans (Moyo, 1995).

During the first few decades of the century, agricultural production and marketing were still in the hands of black farmers. The settlers were mainly interested in exploiting the country's mineral wealth and were largely ignorant of local climatic conditions, soils and appropriate crops (Palmer, 1977). By 1902, agricultural production by Shona farmers exceeded 70% of total cash earnings and only 13% of Shona men had entered paid employment compared to 48% of Ndebele men (Arrighi, 1973). A few years later, with the failure to find adequate supplies of gold, the British South Africa Company turned its attention to agriculture. Policies were established to promote agriculture by white farmers. This lead to a rapid increase in the production of maize, tobacco and cattle, and African land and labor became primary targets for dispossession (Palmer, 1977; Palmer and Parsons, 1977).

Page and Page (1991) have shown how local agricultural practices were regarded with ambivalence by the settler community. They describe how an intensive ecological survey in Northern Rhodesia[4] considered that indigenous farming technologies under natural conditions were inherently sound and recommended that the "agricultural department investigate local

[4] Northern Rhodesia became Zambia after attaining independence in 1964. Zambia lies immediately north of Zimbabwe and traditional farming methods were similar in the two countries. Southern Rhodesia became Rhodesia in 1963 and then at independence in 1980, it was renamed Zimbabwe.

practices before .....attempting to improve them" (Lewin, 1936; Trapnell and Clothier, 1957). At the same time, economic and political interests in Southern Rhodesia reviled traditional agriculture as "primitive agriculture that wastes and destroys" (Alvord, 1928). Indigenous agriculture incorporated land rotations, systems of mixed cropping consisting of sorghum and millets intercropped with legumes and cucurbits, use of leguminous leaf litter and compost to improve soil fertility, maintenance of beneficial trees in crop fields and zero or minimum tillage using the hand hoe-- all methods which were ecologically balanced with the prevailing environmental conditions. Alvord did his best to discourage these methods of organic farming. He introduced the plow and strongly encouraged farmers to do monocropping and to concentrate on cash crops, especially maize (Page and Page, 1991). Although there is little documented evidence, it is clear that under the above circumstances of intense external cultural negation, of "extension by persuasion" (Alvord, 1950), there would be an appreciable level of genetic erosion of traditional crop germplasm.

To mobilize the labor required for commercial production, an intense campaign of taxes was initiated which would force freeholders to become laborers (Palmer, 1977). Subsequently, by 1930, legislation was enacted which ensured white dominance of agricultural markets by excluding black producers (Yudelman, 1964). Under these conditions there was little possibility for black farmers ever to accumulate more than they consumed but it freed the state from having to pay their workers more than a mere subsistence salary (Lan, 1985).

As commercial agriculture grew in prominence (Muir, 1984)[5], agricultural research was focussed on the needs of the white community who provided the financial support (Kupfuma, 1995). Consequently there was no research agenda to address the needs of black farmers, the idea being that they should slowly be brought up to the level of intensive commercial agriculture, although this was clearly impossible given the reduced resource base and the diminishing availability of male labor in the rural areas. Maize was needed as a staple food for mine workers and for the growing urban population and by 1950 Rhodesia was proud to announce its first commercially certified hybrid maize variety (Rukuni, 1990). The country became an exporter of maize through the surplus production of maize on commercial farms. Black resistance to the loss of ancestral lands, poorly paid wage labor in urban areas, on the mines and commercial farms, unpaid female subsistence labor in the rural areas and the enforced disruption of long established agricultural practices mounted and culminated in the beginning of the liberation war in the early 1970's (Lan, 1985). As the war escalated, rural farming communities were forced to live in "protected villages"[6] to restrict their movements and to reduce ground support for the guerilla fighters. Black farmers who lived through this period recount that great loss of local crop varieties occurred at this time since they were under curfew and could not guard their crops against pests and raids. In addition, they had been unable to move their granaries and seedstocks during the relocation. Reports from a district administrator in northern Zimbabwe state that the level of starvation and poverty was now so great that there was little possibility for the longterm recovery of the local population (Lan, 1985). The restriction on farmers' movements also disrupted local patterns of seed distribution and when seed stocks of particular traditional varieties were depleted these could not easily be replenished from mothers and other relatives who lived far away from

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[5] In 1925, agriculture accounted for 15% of GDP and mining 28%. By 1940 these figures were 25% and 15% respectively (Muir, 1984).

[6] This local version of concentration camps caused severe environmental damage and great loss of personal belongings, events from which farmers have never recovered their pre-war economic status.

their daughters[7]. However, it is likely that seeds from neighboring countries particularly Mocambique and Zambia[8] were transported with the guerilla fighters and were grown in Zimbabwean villages.

When independence was achieved in 1980, the new government immediately sought to redress the imbalance in agricultural production. A number of agricultural research stations were opened in the communal areas and crop packs, containing hybrid maize seeds and fertilizer, were handed out to all non-commercial farmers. Producers prices were revised, credit loan schemes[9] were created and the Sorghum and Millet Improvement Programme was initiated. A decade later, in the throes of the century's worst drought, farmers lamented the loss of their traditional varieties and ascribed this loss to the heavy promotion of hybrid maize and free crops packs which was begun at independence.

ECONOMIC ASPECTS OF TRADITIONAL CROP DIVERSITY: HOUSEHOLD FOOD SECURITY AND THE CASH ECONOMY

Household food security: sales and droughts

After independence, small-scale farmers were progressively pressurized to join in the market economy by the need of the national government to secure foreign exchange to repay loans from multinational lending organizations (Davidson, 1988). Record sales of maize from the communal area sector were achieved within a couple of years and these were ascribed to the new pricing policy, the availability of credit loan schemes and the extension package which promoted hybrid maize and the use of inorganic fertilizers. The media responded by calling Zimbabwe "the breadbasket of Africa". These figures of record sales were interpreted as an indication of increased household food security in the rural areas (Rohrbach, 1989; World Bank Report, 1991). However, a thorough analysis of household food insecurity in high rainfall areas[10] of Zimbabwe indicated that most of these sales could be accounted for as 'distress sales' whereby farmers had to sell most of their harvest in order to repay the credit received at the start of the season. This left almost 50% of farmers in high potential areas food insecure (Page and Chonyera, 1994).

Recently, a situation has developed where small-scale farmers have been unable to grow their traditional crops due to wholesale lack of available seeds as a result of repeated environmental

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7 In Shona patrilineal society, daughters leave the parental homestead to join the husband's family. Daughters take seeds of their mother's , her neighbors and her relatives' varieties with them. Exchange of seeds between related and/or friendly women is an ongoing activity and women may travel great distances to obtain the seeds of a desired variety.

8 Mocambique and Zambia provided safe havens for the Zimbabwean guerrillas during the war. In the north eastern districts of Zimbabwe, many sorghum and millet varieties have portuguese names and there has been on-going seed traffic up to the present time.

9 The credit loan schemes have had a dubious success because they were mostly tied to crop packs containing hybrid maize and fertilizer and left out most of the poorer farmers (Zwart, 1990).

10 In low potential areas the level of food insecurity is that much greater and even in these areas, drought relief crop packs rarely if ever contain drought tolerant sorghum and millet seeds.

disasters in the form of recurrent droughts or contracted rainy seasons. Real producer prices for sorghum, millets and edible legumes have dropped considerably in recent years, since the trade liberalization program, while those for cash crops have doubled[11] (MacGarry, 1994). This has affected all families who cannot afford to buy meat and has lead to increased malnutrition especially in children, who were already vulnerable (Moyo *et al.*, 1985). After the worst drought of the century in 1992, tenders for hybrid maize seed were given to multinational companies such as Cargill and Pioneer, using foreign currency earmarked for economic development. This was because the World Bank forced Zimbabwe to sell its surplus maize stocks, stored as a security for drought years (MacGarry, 1994).

The Famine Early Warning System (Eilerts,1994) states that: "the line between maintenance of health and a slow spiral of deteriorating food security appears very narrow in many of the communal areas." The situation of continuous drought has lead to modified behaviour in the form of reduced food intake and high rates of emigration together with progressive disinvestment in the form of sales of household assets (Eilerts, 1994). "This is a stage where the margin of safety that can cushion future shocks is being substantially eroded. ....on the local scale there may be serious hunger, wasting and nutritional-related mortality." (Eilerts, 1994). This has been a hidden famine because there have been no clearly identified deaths from it. Reports from the Farming Systems Research Unit (1991; 1994) have repeatedly called for small grain varieties to be distributed in the rural areas where demand for improved sorghum and millet seed has continuously outstripped supply (SADC/GTZ report, 1994).

The role of women and small grains

While a number of reports have emphasized the important role played by women farmers in agricultural production and food security, female farmers are still marginalized in terms of access to land, knowledge and technology, and marketing (Davidson, 1988; Zwart,1990; Carr,1991; Mosse,1993; Farming Systems Research Unit,1994). Research into "women's" crops, such as sorghum, millets, groundnuts and other legumes has lagged far behind that of men crops such as maize, cotton and sunflowers. The need for cash by rural farming families has been such that ecological considerations are often overridden. This has had the effect that the bulk of available economic resources, such as inorganic fertilizer, labor and certified seeds, are allocated to cash crops such as maize, cotton or sunflowers. Gender conflict has increased because most of the organic fertilizers, (such as cattle manure, compost, leaf litter collected from the hills, leaf litter from the lopped-off branches of various leguminous trees), the best fields as well as the small patches of soil which are nutrient rich, [such as the soil around the homesteads, the soil at the base of granite outcrops, the soil under specific nutrient enriching trees (eg. Parinari curatellifolia), old homestead sites, anthills and old cattle-pen sites], are now being used for the cultivation of the cash crops (Carter and Murwira, 1995; Oosterhout van and Carter, 1995). This has left the women to grow the traditional crops on the poorest soils, using seed with poor germination quality, little if any fertilizer (organic or inorganic) and weeding only done if there is any labor to spare. Yet it is the women who carry the responsibility of ensuring that the children have enough to eat.

Women farmers have stressed the importance of the small grains for the following reasons:

i. better taste; more variation in the diet;

ii. a smaller amount of flour is needed to cook the main meal compared to maize;

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[11] Figures obtained from the Grain Marketing Board (GMB), 1994.

iii. a meal cooked from the small grains satisfies hunger for a longer period and gives more energy (which is especially important for persons who do heavy manual labor like farmers);

iv. the small grains store better (usually 3-5 years but up to 20 years were reported by some farmers) than maize which cannot be stored beyond eight months. Local cost free storage technologies are available whereas maize needs poisonous organophosphate protectants, often unaffordable by farmers;

v. seeds of several varieties of small grains are available for planting from the farmer's own granary when needed and can be exchanged with neighbors and relatives - they don't need to be purchased;

vi. in years of low rainfall, small grains will give some yield especially when grown in a multicropped system, whereas maize will be a complete failure.

In addition, the type of information which women seek, such as food processing, improved grain storage techniques, methods of organic farming and the care of small livestock, is not available. Women also seek information about prices, credit, seed sources, markets and marketing channels (Zwart, 1990). This is quite the opposite of what was proposed by the president of the Zimbabwe National Farmers Union (1990): "...not being content with educating the (male) farmer, the union has over the years encouraged (farmers') wives to engage in homecraft. To date, it has given stoves and sewing machines to women's clubs...."[12] (The Herald, 1990)[13]. This is despite the fact that about 70% of rural farmers are women (Zwart, 1990) and that they do far more than 50% of all agricultural and domestic labor on the farm (Oosterhout van, 1995, unpubl. data).

GENETIC DIVERSITY: WHERE TO FROM HERE?

Rural stratification and knowledge of traditional crop biodiversity

Recently collected information has also shown that rural stratification is increasing (Oosterhout van, 1995, unpubl. data). Almost half of the farmers (the poorest, 43%) are now being employed as casual laborers by the relatively more wealthy, upper 20%. This has important consequences for women and food security. From Figure 2 it is clear that the poorest wealth group are completely dependant on drought relief food hand-outs since they are unable to produce the minimum amount of maize required for the consumption of an average household of eight persons in a given year. The members of this group, who are mostly women, expend all their labor on the fields of others and are therefore unable to adequately prepare their own fields.

During periods of drought which usually only manifest after the weeding period, casual labor may not be remunerated at the agreed rate due to the employers' experiencing cash shortages (Oosterhout van, 1995, unpubl. data). In general, members of this stratum are unable to educate their children beyond primary school level, and usually not even this, due to the cost of uniforms

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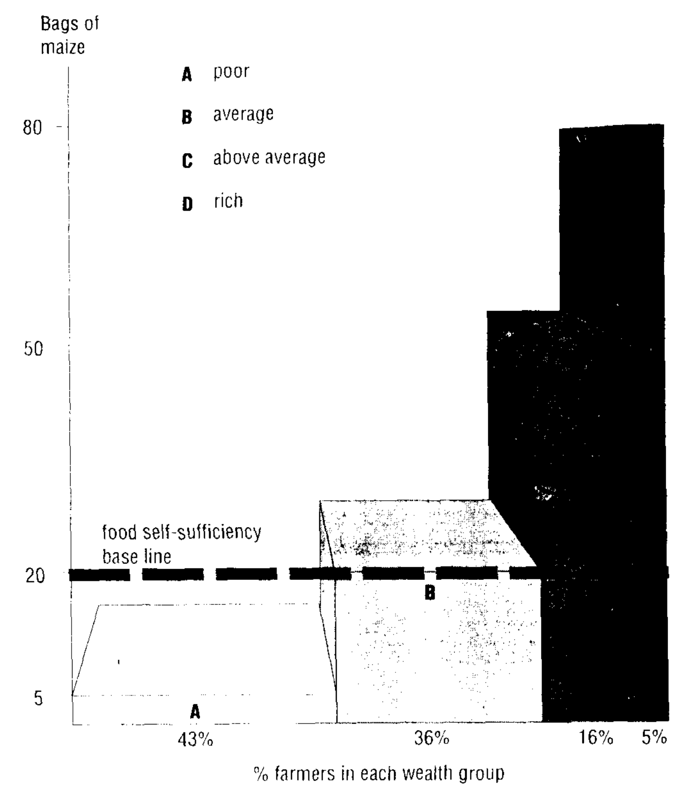
[12] Brackets and italics are mine. The president of the Zimbabwe National Farmers Union (1990) was male. The Zimbabwe National Farmers Union represents the farmers from Zimbabwe's communal farming areas.

[13] Supplement to The Herald, 18-4-1990, the Zimbabwean national newspaper.

Figure 2: Average number of bags produced per annum by members of each wealth group in selected rural communities in Zimbabwe during the past three years (1bag = 90 kg). The absolute minimum level at which an average sized household is able to sustain itself for a year is indicated by the broken line.



and building funds. All farmers from this group were identified by the community as being those with the greatest knowledge about small grain production[14]. Yet for the past three years this group has grown maize exclusively[15] because the drought relief packages which they received have only contained maize seeds. In Matabeleland, non-governmental organizations (NGO's) were particularly involved with supplying farmers with various types of imported sorghum and millet seeds, some completely unsuitable for human grain production, and in Mashonaland small seed enterprises bought up sorghum and millet grain from farmers in exchange for cash straight after

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[14] In the wealth ranking exercises, which were done for each of the selected communities, we asked the group responsible for the ranking to name all the individuals in the community who were particularly knowledgeable about small grain production or those who had grown a wide variety of small grains in the past. Invariably these persons came from the lowest wealth groups but enjoyed the esteem of the community due to their role as keepers of diversity.

[15] The farmers in this class have the smallest, most resource poor farms and do not use organic or inorganic fertilizers due to cost. They experience frequent crop failure and are therefore completely dependant on drought relief. However farmers consider drought relief as a highly unsatisfactory solution to the problem of food insecurity (Oosterhout van, 1995, unpubl. data).

the harvest when farmers were short of cash but not yet hungry. This grain was later sold as seed to the same farmers when all their seeds had been used up due to numerous replantings[16] over the last disastrous season (SADC/GTZ, 1994; Oosterhout van, 1995, unpubl. data). Small grain seed exchange has thus moved from the hands of those who were particularly knowledgeable about traditional crops to distribution agents like government and extension agents, NGO's (who bought the seeds from formal or informal seed suppliers) and small scale business people for the purpose of drought relief, 'development' or as business opportunities.

Extant biodiversity of the traditional crops and breeding for improvement

A key element in the survival of small-scale farmers has been their access to a rich and varied genepool, selected and built-up over the centuries. The importance of using local germplasm and farmers' traditional knowledge in breeding for improved varieties was emphasized as far back as 1951 by Vavilov[17] and again more recently by Collinson (1982)[18]. However, the need to increase food production has been regarded as the overriding priority of crop breeding programs over the past few decades. For multiple reasons, this has led to a progressive narrowing of the genetic base of indigenous food crops and is now recognized as a calamity of world-wide proportions (Frankel and Soule, 1981; Kloppenburg, 1988).

In certain areas of Zimbabwe many indigenous varieties of sorghum are still grown (Wilson, 1987) with up to thirteen in some regions[19] (Mushita, 1991; Guveya, 1993; Oosterhout van, 1993; Murwira, 1994; Figure 3) and with as many as sixteen different varieties of legumes (Masvingo Diversity Fair, Zimbabwe, 1995) present in a community[20]. Individual farmers may grow a number of these varieties but usually not more than three of four varieties of the same crop (Oosterhout van, 1992; Figure 4). What is important for the conservation of biodiversity in crop genetic resources is therefore not individual farmers but the community. This is similar to the situation regarding use and distribution of indigenous rice varieties in the Philippines (M. Bellon, pers. comm., this seminar). However, in the sorghum improvement program almost exclusive use has

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[16] Farmers replant several times if the rains are not consistent, often running out of seeds as the season progresses.

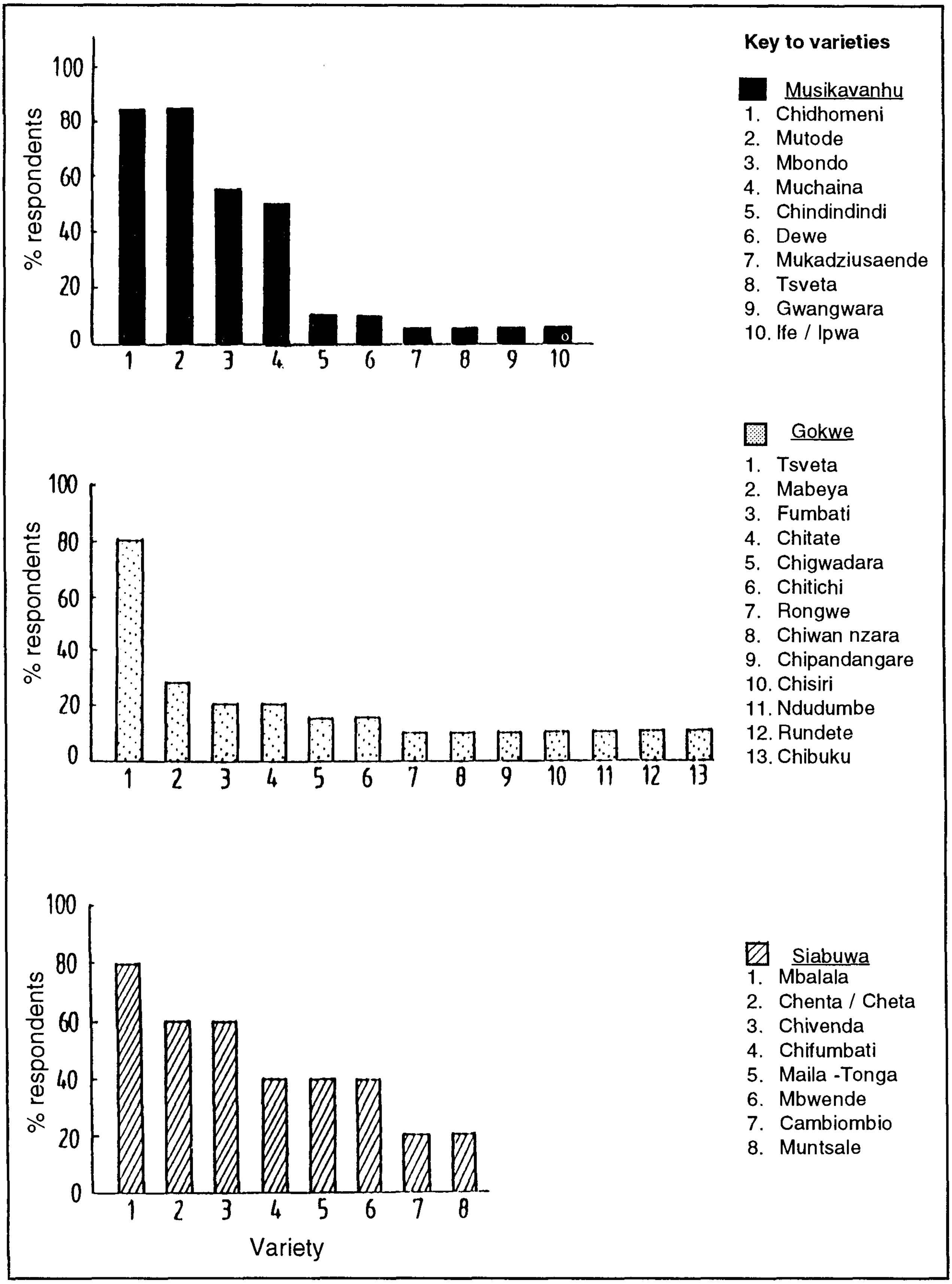
[17] "The first step in breeding should be the maximum utilization of local materials. It is paramount to become well acquainted with the potentials of local materials. This should serve as a starting point for the subsequent improvement of varieties" (Vavilov, 1951).

[18] "Researchers have historically placed heavy emphasis on biological potential and yield as the dominant criteria upon which to base recommendations for farmers. But farmers never seek biological potential for its own sake and never make decisions on which crops to produce on the basis of yield alone" (Collinson, 1982).

[19] Most communities are however without traditional seeds after the serious 1992/93 drought when any seed that had not been planted was eaten. In Chivi,for instance, sorghum hectarage has been reduced to 2% of total fields planted (Farming Systems Research Unit, 1994).

[20] The diversity fair was organized in May 1995 by a local NGO. The top prize went to a farmer who grew more than 34 different varieties and crops. Ironically, Cargill, the multinational hybrid maize and fertilizer company, was asked to donate the prizes for the winners. The prizes consisted of large bags of hybrid maize and agricultural implements which were handed over to the winners after a long speech by the Cargill sales representative.

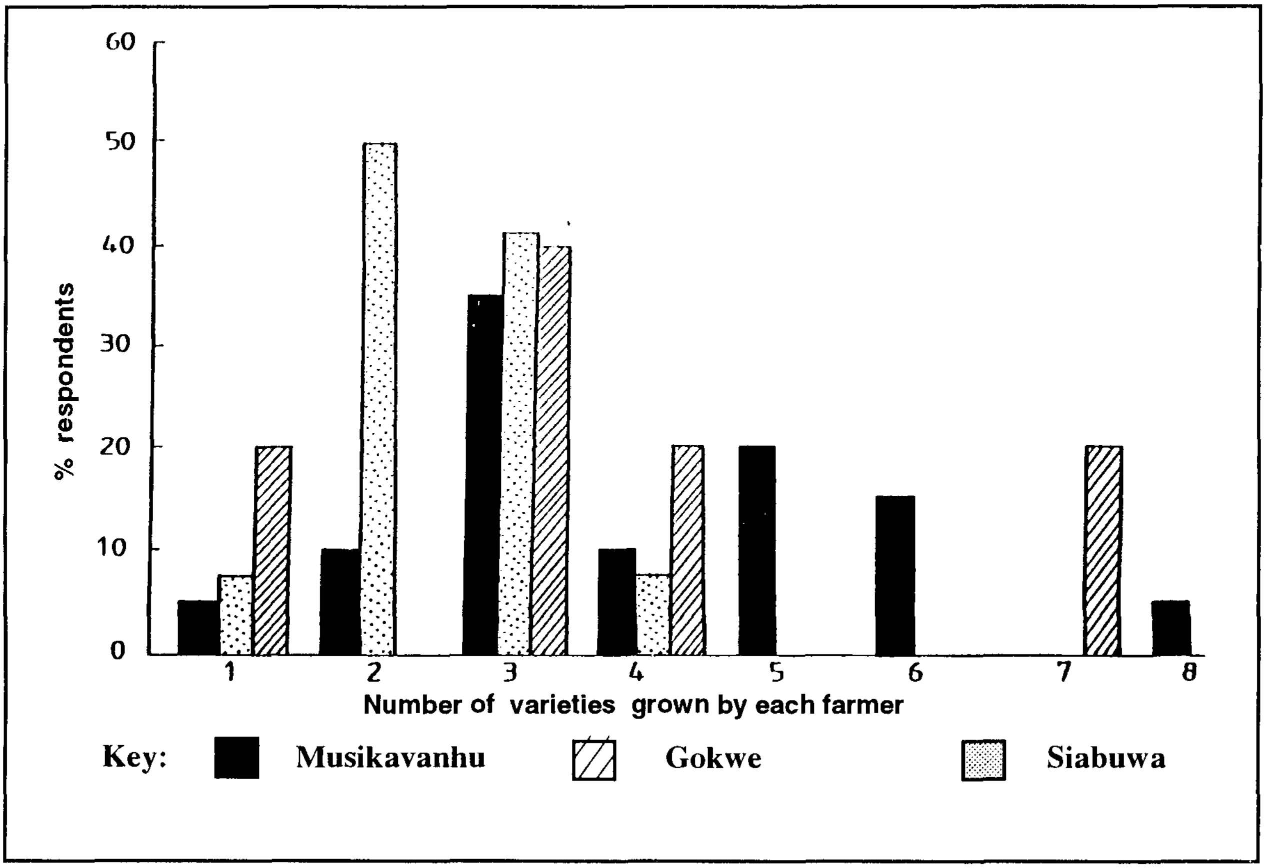
Figure 3: Percentage of respondents growing each sorghum variety in three study areas in Zimbabwe



been made of foreign germplasm obtained from the CGIAR system (i.e. from external genebanks; A. Mushita, pers. comm.).

Analyses of the adoption rates of improved sorghum and millet varieties in rural areas by ICRISAT (Rohrbach, 1994) have been flawed because farmers have been so short of seed, especially after the drought of 1992 when most farmers had consumed their seeds as food due to the hidden famine. Had the experiments been conducted by releasing equal numbers of traditional and improved varieties to farming households, the comparison would have been more scientifically meaningful. As the results stand (Rohrbach, 1994) and in the light of the rural stratification discussed above, they only indicate that farmers were short of seed and would plant anything they were given.

Figure 4 : Maximum number of different sorghum varieties grown by each farmer in three study areas in Zimbabwe



CONCLUSIONS

The three periods of serious loss of traditional genetic resources that have been identified by farmers are:

i. the colonial era which was accompanied by extensive alienation of land and dispossession of resources;

ii. the immediate post-independence period when free hand-outs of hybrid maize seed and fertilizers were given to stimulate production from the small-scale farming sector;

iii. the last decade when Zimbabwe experienced significant climatic change with increasing rainfall deficits, recurrent droughts and contracted rainy periods and integration into the world market economy.

Research has indicated that although genetic erosion of the traditional crops has been extensive (for example, Guveya, 1993), pockets of sorghum, millet and legume diversity still exist in the more remote rural areas. In this context, the areas bordering Mocambique in the north east, Zambia in the north and Botswana in the western regions of Zimbabwe, are genetically diverse in terms of traditional crop germplasm and need more scientific attention (Oosterhout van, 1995, unpubl. data). In several of these areas the system of community seedbanking still exists, whereby all members contribute to the annual seed store which is redistributed the following season by the chief after a blessing ceremony. There is thus a clearly identified need to enhance conservation of the crop biodiversity in these areas. But how to go about this given the historical, environmental and ecological disadvantages experienced by the farmers in these regions? The baseline is that *in situ* conservation cannot be separated from other development issues and that the solutions and *modus operandi* of the research program should be farmer-driven. A good example of such an approach is described for the development of community seedbanks in Tigray, Ethiopia (Berg, 1992).

During our research (Oosterhout van, 1995, unpubl. data), farmers clearly articulated their need for water harvesting and soil fertility management, items which did not exactly coincide with the agenda of the project on *in situ* conservation of traditional crops. It was then that we developed the idea of piggy backing the crop research on to other development initiatives which were identified by the farmers[21]. Exchange visits by a pilot group of farmers from our two study areas to an NGO specializing in water harvesting projects resulted in an immense response and burst of activity on the part of the farmers. Farmers from Matabeleland immediately abandoned their weeding activities[22] and devoted all their time and energy to digging water pits and furrows. In Mashonaland, farmers responded by digging water trenches and intensifying the use of leaf litter and compost, gathered from the hills surrounding their homesteads, on their cropped fields[23].

We had now found an entry point which was relevant to the farmers' own experience and perception about the sequence in which problems needed to be addressed. At the same time we concentrated on the validation of traditional values and knowledge since an important reason why traditional crops have managed to survive this long is because of their use in traditional ceremonies associated with rainmaking and giving of thanks to or appeasement of ancestors and their conservation by female 'keepers of diversity' (Oosterhout van, 1993). Our trials with early released varieties from the national sorghum breeder, under farmer management conditions, have met with little success due to this year's drought, but an informal seed exchange program,

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21 "If we could turn the official and popular interest away from the grandiose projects and to the real needs of the poor, then the battle could be won." (Schumacher, 1973).

22 The NGO is lead by Mr. Phiri Maseko from Zvishavane Water Projects, Zimbabwe. It was in the middle of the 1994 cropping season, but due to the poor rainfall distribution up to that time, farmers in Matabeleland decided that water harvesting would bring better results than weeding.

23 Soils in the area of Matabeleland where our project is sited are highly fertile, but rainfall is desperately low and unreliable. In Mashonaland, rainfall is a little better but the soils in our study area are sandy and of low fertility, hence the use of leaf litter by the farmers.

whereby farmers from Matabeleland and Mashonaland traded seeds with each other, was very successful[24]. Many studies have identified the need for enhanced farmer access to a greater range of traditional crop varieties (Zwart, 1990; Oosterhout van, 1992; Guveya, 1993; Farming Systems Research Unit, 1994) and this should be strongly encouraged.

Farmers, especially women, have also expressed the need for external technological interventions where local knowledge cannot find an adequate solution. Women find the processing of small grains a very tedious and time consuming operation requiring heavy labor. A simple community based mill of intermediate technological design is required to facilitate dehusking and milling of the small grains. This would also encourage greater use of the small grains for household consumption.

Finally, improved on-farm storage facilities and methodologies which do not harm human health, need to be developed in association with farmers, to encourage the conservation and use of the traditional crops and to help farmers in their efforts to be food secure.

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[24] This was because the varieties from Matabeleland are more drought tolerant than those from Mashonaland. While the drought in Mashonaland was more severe than usual during this particular season, our study area received unusually good rains in Matabeleland. This particular rainfall occurrence made the seed exchange program highly successful, but it is clear that the underlying principle of greater access to genetic resources and greater freedom to experiment with the material needs encouragement and support.

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DISCUSSION

SINHA: One of the questions which struck me in these three presentations is the question of genetic erosion--where is it happening? Is the problem essentially confined to the developing areas of the world? What is at present the situation in the developed world, where there is a large amount of commercialization? Are we concerned with centers of diversity or centers of production?

BELLON: My own interest has definitely been more on centers of diversity. In terms of diversity, there ar at least two large issues here. One is socio-economic, the aspect of food security and farmers' well-being. The other is genetic. In terms of this latter, we might ask about the relationship between farmer-held diversity and genetic diversity--whether there is a correlation or not and whether, for example, the centers of diversity are really more genetically-diverse than other centers.

A point I want to make is that we really have to link these two aspects, socio-economic and genetic. You can have a very strong case for diversity just on socio-economic grounds, without any genetic benefit whatsoever, *vice-versa*. It would also be very difficult to try to implement *in-situ* conservation if there is no benefit to farmers.

SPERLING: Saskia [Oosterhout], you described waves of genetic loss in Zimbabwe, and we often associate these waves of loss with political events. In the everyday life of a farmer, might there also be waves of gain, through markets (border markets?) or immigration?

OOSTERHOUT: Yes, what I wanted to show right from the start is that this cross-border effect is continuous. So in the wetter areas near Mozambique there are these long-season varieties that are six to eight months; in the southern area you have varieties that can cope with an arid landscape; and then near Botswana and Namibia, there are the very short-season, quite low-yielding varieties, but very drought tolerant. And in the north by the Zambezi River, there are very interesting long-season varieties that are ratooned for up to four years.

Also when people cross for economic reasons to South Africa and Botswana, they always take grain with them, always. We have done these very interesting maps with people-- "how far do you travel to get grain"-- and the figures are absolutely astounding.

LOEVINSOHN: Have you noticed any waves of gain in the wake of the recent severe droughts in Zimbabwe and particularly in the uptake of the extremely short duration sorghum and millets that you were referring to?

OOSTERHOUT: Because Zimbabwe is keen to keep its image of the bread basket (and with a great deal of World Bank pressure), the moment there are problems, they bring in hybrid maize. This hybrid maize is in the drought relief packages even in the areas where only sorghum is grown. Not one aid parcel contains sorghum seed. Some sorghum seed has been coming from the States and South Africa, but the varieties are not well-adapted and farmers don't like them.

GHILDYAL: I want to comment on the Kerala rice situation [V. Santhakumar's presentation]. My discussions with the Government of India and the Ministry of Agriculture show that rice is going out of cultivation there. The Government of Kerala has banned the conversion of rice land into any other kind of land While this had been banned by legislation, farmers are still trying to grow coconut in the place of rice. This staple crop of rice of Kerala is disappearing because of its non-profitability.

BELLON: I want to comment on this interesting point in terms of the mechanisms of genetic erosion. One mechanism is the complete change in land use, for example, the problem with upland rice, i.e., one crop is being lost to another. The other is the more classic process of genetic erosion whereby improved varieties are being substituted for landraces. These two processes pose different questions, methods and even conservation strategies.

SPERLING: Mr. Santhakumar, you made a very provoking point when you suggested that we should develop different *in situ* strategies for different economic groups of farmers: that is, for marginal farmers, there should be a different strategy, for small farmers and for big farmers---in the same area. Could you elaborate?

SANTHAKUMAR: The issues are different for different groups. For example, local cattle is almost a rare species in Kerala, but the very marginal farmers still depend on them--even though there are artificial insemination facilities and other facilities available in the region. When you consider the people's resource base, the use of these cattle makes sense.

In contrast, wealthier farmers go for mixed cultivation and often profitable investment. They are probably ready to take certain choices, make certain investments and even further improve their biodiversity resource base. So I think the resource constraints of farmers are very important in developing strategies which promote diversity.

MANDAL: I think Mr. Santhakumar mentioned the non-availability of seed material or planting material for small and marginal farmers. My question is whether we can train farmers and help them to develop their own seed, in an organized manner, from a small quantity of seed material--then they can help themselves. As for coconut, Kerala has some excellent trees and farmers could select seed from their own gardens. From one tree they can get about 50 good coconuts and out of those, at least five could be selected for nursery use. So there should not be a dearth of material as far as coconut is concerned.

SANTHAKUMAR: There are few seed problems with crops such as rubber, coconut or even paddy. But there are trees, for example, the *Anjali* variety which used to provide timber for house construction, whose numbers have fallen drastically. Another example is laurel which gave non-edible oil for lighting and certain non-fruit varieties of jackfruit. There has to be some sort of external intervention for planting these trees over larger areas. The Botanical Gardens Research Institute, the Forest Institute, the horticultural department could all help to train farmers.

DIVERSITY OF RICE CULTIVARS IN A RAINFED VILLAGE IN THE ORISSA STATE OF INDIA

K.G. Kshirsagar and S. Pandey[1]

ABSTRACT

Considerable international and national breeding effort has been exerted to develop suitable and acceptable rice cultivars for the unfavorable production environments of Eastern India. However, the existing research suggests that farmers are still using their traditional landraces and the production of rice from these ecosystems has increased only marginally over the past decades.

Therefore, increasing the productivity through improved rice varieties remains a challenge. The answer to this challenge might lie in the traditional landraces cultivated by farmers. As landraces often have important traits that give them resistance to many biotic and abiotic stresses, identification of particularly adapted types should help in developing more promising materials for the rainfed lowlands of Eastern India.

To obtain information on (1) the diversity of rice cultivars grown and (2) the reasons for a limited acceptance of modern cultivars, a farm survey was conducted in a typical rainfed village in Orissa. Findings indicate that farmers are using a diversity of landraces in this complex and heterogeneous environment. As many as 12 rice cultivars are grown by a single rice farmer and farmers have intimate knowledge of the characteristics of rice cultivars which fit well into their specific ecological niches.

Farmers in the study village perceived that improved cultivars perform better under better fertility regimes and when fertilizer is applied. On the other hand, the performance of traditional cultivars is superior under low fertility conditions and they are better in sustaining the soil resources over a long period of time. They also perceived that the performance of traditional cultivars is better under various biotic and abiotic stresses.

Although breeders may use local materials in their breeding programs to develop improved varieties, the local landraces are unlikely to be completely replaced in this rainfed environment. A breeding strategy which helps maintain useful diversity is what is recommended.

INTRODUCTION

Rice is one of the staple food crops of India. It is grown on 42 million ha and hundreds of millions of people depend on rice for their livelihood. Despite the success of 'Green Revolution' in irrigated areas in increasing rice production, farmers still continue to use traditional cultivars in rainfed areas, which account for over 58% of India's rice area.

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[1] The authors wish to thank the Director, CRRI; Coordinator, Rainfed Lowland Rice Ecosystem, CRRI and field investigators for facilitating this research.

Increasing rice productivity through improved varieties continues to remain a challenge, especially in rainfed areas. The answer to this challenge might be sought in the traditional landraces grown. Often landraces have important traits that give them resistance to many biotic and abiotic stresses. Identification of such landraces, and elicitation of farmers perceptions about their traits vis-à-vis that of improved cultivars, should generate information that can be used by rice breeders in focussing research on developing promising and potentially adoptable materials (that is, having characteristics preferred by farmers).

The objective in this paper is to provide a picture of the diversity of rice cultivars grown in a rainfed village in Eastern India and to analyze farmers' perceptions about the characteristics of these cultivars (both modern and traditional).

MATERIALS AND METHODS

The current research in closely linked with the Rainfed Lowland Consortium (RLC) of the International Rice Research Institute, Manila, Philippines. The RLC is actively collaborating with various research institutes including the Central Rice Research Institute (CRRI), Cuttack, Orissa in the development of improved cultivars for the rainfed lowlands of Eastern India. Therefore, in close consultation with the staff of CRRI and local government officials, Garh Madhupur village in Jajpur district of Orissa state was selected for this study.

A census survey was conducted to get information on resource endowment of the households of Garh Madhupur village. The census data formed the basis for a random selection of 50 respondents from 291 households. Two investigators holding masters degree in agriculture were recruited and stationed in the village. This gave the benefit of building excellent rapport with the farmers. Data for the years 1993 and 1994 were collected through direct interviews by using an open-ended format.

RESULTS AND DISCUSSION

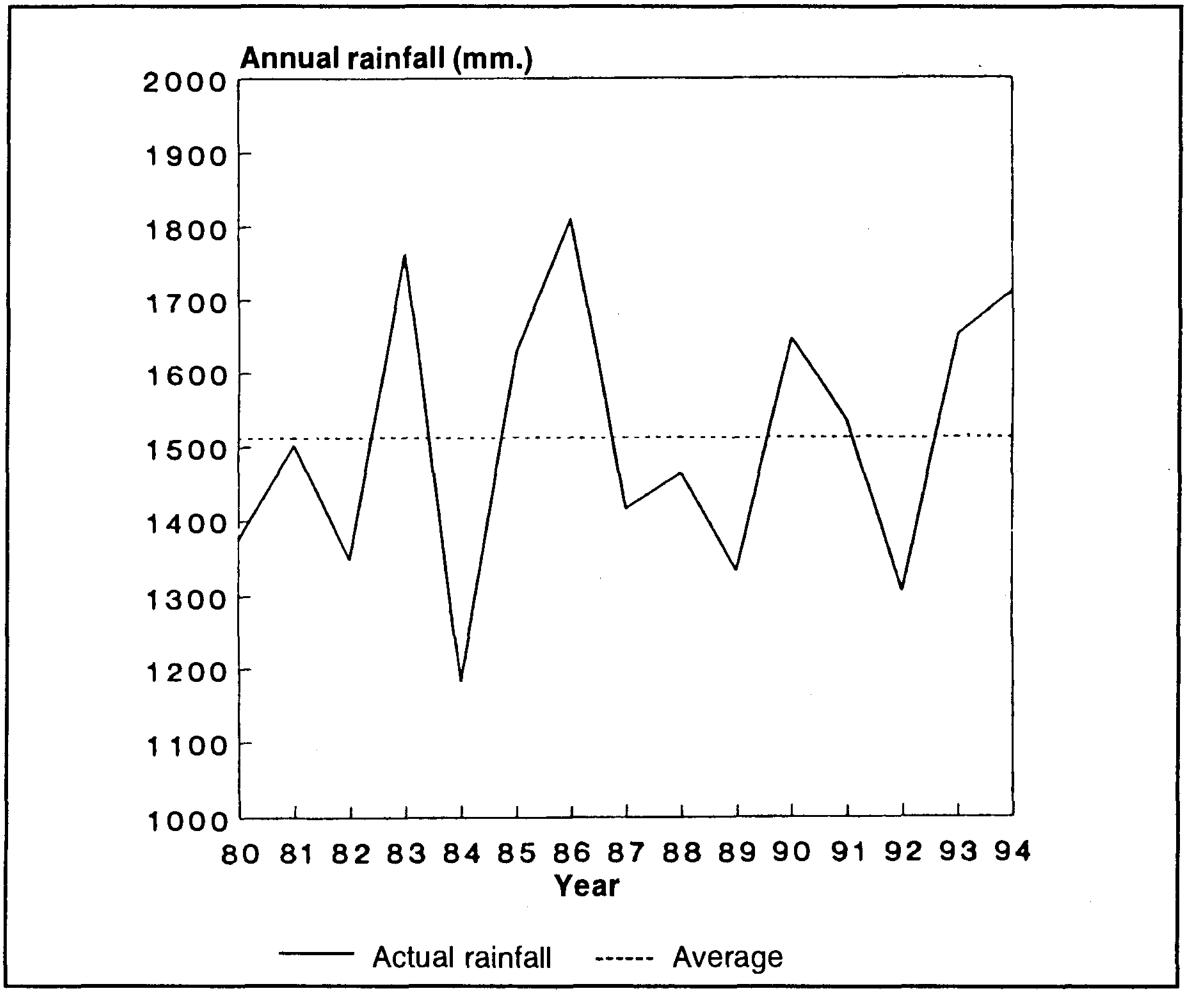
The district and village

The district Jajpur is located in the costal plain agro-climatic zone of Orissa state. Jajpur was carved out of Cuttack district in the year 1993. The district receives an annual precipitation of 1500 mm, with a maximum mean of 352 mm in July and a minimum mean of 5 mm in December (Govt. of Orissa, 1993). The southwest monsoon, during which most of the precipitation occurs, starts in June and continues up to October.

Garh Madhupur is located at a distance of 2 km on the north side of Daitari-Paradeep express highway and about 120 km away from Bhubaneswar, the capital of Orissa state. The population of Garh Madhupur in November 1994 comprised 2237 persons living in 291 households.

No rainfall data has ever been recorded at Garh Madhupur village. Therefore, the average daily rainfall recorded at Jarka and Barchana centers (7 and 15 km away, respectively, from Garh Madhupur) was used to represent the rainfall pattern in the Garh Madhupur area. The average annual rainfall is 1512 mm with a coefficient of variation (CV) of 12% for 15 years from 1980 to 1994 (Figure 1). On an average, 86% of the total rainfall is received during the months of June to October. The average annual rainy days is 79 with a CV of 14%.

Figure 1: Annual rainfall in Garh Madhupur area, 1980-1994



Although the extent of average annual precipitation is adequate for farming, its capricious nature is very clear from Figure 1. Four years among the last 15 years were relatively dry, having less than 1350 mm of rains, while three years were very wet, having more than 1700 mm. This erratic distribution often causes drought and/or floods during crop growth period and results in substantial losses for dryland farmers.

Rice is traditionally grown in two well defined seasons, namely *kharif* and *dalua*. Of these two, *kharif* (rainy) is the most important rice season. The *kharif* rice is the main crop, covering over 85% of the total rice area, and depends entirely on the southwest monsoon. It is sown in June and harvested in October-December, depending upon the duration of the cultivar and topography of the field. The *dalua* (summer) crop coincides with the dry season and depends entirely on irrigation. The source of irrigation water is tank. The *dalua* season stretches from December-January to April-May. Farmers grow only high yielding varieties during this season.

Importance of traditional cultivars

On an average, 87% of the *kharif* area is allocated to traditional cultivars, with the rest occupied by improved varieties (Table 1). This shows the dominance of traditional rice cultivars in this rainfed village. The number of traditional cultivars grown is two to three times greater than the number of improved cultivars. This indicates the local availability of wide indigenous diversity to farmers in comparison to the limited range of improved cultivars.

Table 1: Rice area under local and improved cultivars during Kharif season

Cultivar details	1993	1994
Local cultivars		
No. of farmers growing local cultivars	50	50
No. of local cultivars grown	33	33
% area under local cultivars	86	88
Improved cultivars		
No. of farmers growing improved cultivars	21	19
No. of improved cultivars grown	14	11
% area under improved cultivars	14	12

Respondents planted 33 traditional cultivars on their farms during the *kharif* season. Of these, half a dozen popular cultivars cover more than 50% of the area under traditional cultivars (Table 2). The dominance of these cultivars could be due to their superiority in adapting to the variable production environment of rainfed agriculture.

Table 2: Local cultivars grown during *kharif* season

Local name of the cultivar	1993			1994		
	No. of farmers	Area ha	Area %	No. of farmers	Area ha	Area %
Dhinkiasali	25	8.66	13.34	24	10.50	15.74
Chamarmani	18	5.96	9.18	25	7.56	11.33
Kalachaki	18	7.36	11.34	19	7.32	10.97
Khoda	17	5.97	9.20	16	6.00	8.99
Champa	15	4.92	7.58	12	4.24	6.35
Champasali	12	3.62	5.58	12	3.69	5.53
Bankisaru	10	2.18	3.36	12	2.99	4.48
Saruchina	10	3.32	5.11	11	4.07	6.10
Nagara	11	2.85	4.39	9	3.93	5.89
Jiresali	7	1.69	2.60	6	1.31	1.96
Kendumanjia	6	2.37	3.65	3	1.62	2.43
Parbatkaya	5	2.02	3.11	4	1.23	1.84
Chingudi	4	1.42	2.19	4	1.32	1.98
Nimei	4	1.18	1.82	4	0.57	0.85
Kakudimanji	3	0.40	0.62	5	0.91	1.36
Dudhasara	4	0.73	1.12	3	0.81	1.21
Chinamali	4	1.82	2.80	2	1.21	1.81
Matiasaluri	4	1.13	1.74	2	0.61	0.91
Hati Mahal	3	0.91	1.40	3	1.01	1.51
Salua Gaja	3	1.00	1.54	3	0.87	1.30
Betanashia	3	1.96	3.02	2	1.82	2.73
Kalma	3	0.85	1.31	4	0.83	1.24
Bangaramadhavi	2	0.68	1.05	2	0.47	0.70
Ranga Seuli	2	0.45	0.69	1	0.10	0.15
Others	6	1.47	2.26	11	1.74	2.61
Total		64.92	100.00		66.73	100.00

Landforms, soil types and cultivar selection

We use farmer classification of landforms, soil types and cultivars to analyze cultivar choices. The result are presented in Table 3.

Table 3: Farmer's classification of and percent area under different landforms, soil types and cultivars on selected farms

Particulars	Landform: Terraces		
	Dhipa (Upper)	Majhili (Middle)	Khala (Lower)
Percent of total area	35	40	25
Soil type[1]			
Balia (%)[2]	24	38	7
Kelua (%)	72	50	76
Dorosa (%)	4	12	17
Cultivar			
Preferred group	Laghu dhan (short)	Madham avadhi dhan (medium)	Bada dhan (long)
Duration (days)	< 145	146 - 165	> 165
Common cultivars grown	Jiresali Chingudi Champa Parijat	Dhinkiasali Kalachaki Saruchina CR 1009	Khoda Champesali Bangara Madhavi T 1242

[1] *Balia, Kelua* and *dorosa* are local terms used to represent sandy, clayey and silty or loamy soils, respectively.

[2] Percentage calculated on the basis of total area in each landform.

Farmer classification: landforms

Farmers in the study village identified three major landforms: *dhipa zami* (upper terraces), *majhili zami* (middle terraces), and *khala zami* (lower terraces). The lower terraces were subdivided into *bahaliapata* (very low) and *pata zami* (even lower) fields.

Dhipa zami or upper terraced land is characterized by drought stress that may occur any time during the season. The freely drained profile of upper terraces lose much of their rain water by run-off and seepage. *Majhili zami* (middle terraces) is good paddy land and is affected less frequently by drought and/or flood and submergence. The *khala zami* or lower terraced fields are flood-prone and complete submergence for 10 to 12 days during the periods of heavy rainfall is common. The lower terraces are poorly drained and excess water, rather than water deficit, is the most serious problem. The *pata zami* is kept fallow during *kharif* season due to the stagnation of flood water.

Farmer classification: soil types

The existence of locally recognized soil types is well documented by many researchers (eg., Barrow, 1987; Bellon and Taylor, 1993; Dvorak, 1988). Garh Madhupur farmers divide their soils into three major categories: *balia* (sandy), *kelua* (clayey) and *dorosa* (silty or loamy). Similar classification by the farmers was also reported by Fujisaka *et al.,* (1991) in Cuttack district of Orissa State. *Balia* (sandy) soils have lower water holding capacity and farmers claim that it suffers from drought earlier than any other soil types. *Dorosa* soils are characterized by high water holding capacity and are usually found in middle and lower terraced fields. *Kelua* (clayey) soils fall between *balia* and *dorosa* in terms of water holding capacity and are dominant and distributed in all landforms.

Farmer classification: rice cultivars

Farmers divide rice cultivars into three groups: short (*laghu dhan*), medium (*maadham avadhi dhan*) and long (*bada dhan*) duration cultivars. Farmers' definition of short (less than 145 days), medium (146-165 days) and long duration (more than 165 days) does not necessarily match with that of plant breeders. In this paper, we use the farmers' classification.

Farmer practice: matching of cultivars to environments

Generally, long duration tall cultivars are sown in lower terraces. These are indica cultivars having photosensitive characteristics. These cultivars thrive well under ill-drained or submerged conditions. Moreover, long duration cultivars are slow-growing, have good tillering abilities and adjust well to changes in climatic conditions, thereby providing low but stable yields.

The long duration cultivars are sown in early June. The crop matures and becomes ready to harvest after the cessation of monsoon rains and recession of water from the field by December, a relatively dry month of the year. Moreover, the abundant sunlight and cool nights, during the period of reproductive stage, provides optimal conditions for grain filling and better milling.

There are only a few improved cultivars that are grown in lower terraces. Farmers perceive that improved cultivars do not perform well in flood-prone fields. It has been also reported by scientists that flood in many parts of eastern India restricts the adoption of high-yielding varieties (Muralidharan *et al.*, 1988).

Medium duration cultivars are grown mostly in middle terraces. Cultivars such as Parbatkaya and Nimei (duration 146 to 155 days) are grown in fields that are located in the upper portions of middle terraces or in fields having sandy soils, whereas cultivars such as Dhinkiasali, Kalachaki and Saruchina (duration of 155 to 165 days) are grown in fields having *kelua* and *dorosa* soils.

Medium duration cultivars are sown in early June after the completion of sowing of longer duration cultivars in lower terraced fields. These cultivars such as Kalachaki and Saruchina are valued for eating qualities by the Garh Madhupur farmers and are usually retained for home consumption. There are not many medium duration improved cultivars grown in the village. Improved cultivars such as CR 1009 and Swarna are always planted (90 % of area) in clayey or loamy soils. Farmers preferred to grow improved cultivars on these soil types as they believe these varieties need soils with higher fertility and moisture holding capacity.

The short duration cultivars can be further subdivided into two groups, the first group having a duration of less than 120 days and the second group having a duration from 120 to 145 days. Early maturing short duration cultivars are usually sown in the uppermost terraces to escape late season drought. Most of the improved cultivars adopted by the Garh Madhupur farmers belong to this category. Important among them are Parijat, Annada and Pathara. The second group of cultivars such as Chingudi, Tike Narda, and Champa on the other hand, are allocated to middle and lower portions of upper terraces.

Number of rice cultivars grown

There are several reasons for growing more than one cultivar. First, as seen earlier, farmers may be attempting to match cultivars to specific environmental niches. Therefore, it would be expected that farmers with more heterogeneous environments will plant a larger number of varieties than farmers with more homogeneous environments. Second, varietal diversification can be a method of reducing risk. By not 'putting all eggs in one basket', varietal diversification can help farmers reduce the total yield risk. Third, varietal diversification can help avoid labor bottlenecks in planting, weeding and harvesting. By growing varieties with different timings of peak labor demand, farmers may be able to stagger the labor demand and avoid bottlenecks. Finally, besides helping to meet annual food grain supply, products from different varieties may be appropriate to satisfy a range of demands. For example, some grains may be more suitable for eating as cooked rice while others may be more appropriate for making cakes or for ceremonial use. Similarly, some varieties may produce straws more suitable for thatching or for fodder. Diversification is an attempt to obtain a range of products when there are varietal differences in product quality.

Farmers in the study village almost invariably grow more than one rice cultivar on their farms, with the number ranging from two to more than 10 (Table 4). More than 70% of the respondents cultivated two to five cultivars, where as 20% sample farmers went for six to eight cultivars.

Table 4. Access to landforms and number of cultivars grown

Number of cultivars grown by each farmer	Number of farmers cultivating:					
	Only one landform		Only two landforms		All three landforms	
	1993	1994	1993	1994	1993	1994
1	1	0	0	0	0	0
2	2	4	5	4	1	0
3	4	4	2	6	1	1
4	2	1	7	7	0	1
5	2	2	7	4	3	3
6	1	0	2	2	1	3
7	0	1	1	1	2	1
8	0	0	2	1	1	1
9	0	0	0	0	2	1
10 & more	0	0	0	1	1	1
Average number of cultivars grown by each farmer	3.42	3.42	4.38	4.35	6.42	6.33

To the extent that one of the reasons for varietal diversification is to match the varietal requirement to a specific environmental niche, varietal diversification can be expected to increase with environmental differentiation. To examine this hypothesis, farmers were divided into groups operating within one or more sub-ecosystems as defined by farmers. Detailed environmental characterization to cluster 'homogeneous' sub-ecosystems was beyond the scope of the study. We simply used farmer classification of upper terraces, medium terraces and lower terraces as the basis for sub-ecosystems classification. Data in Table 4 lend some support to the hypothesis that varietal diversity increases with an increase in environmental heterogeneity. The average number of cultivars planted by farmers operating land in all three sub-ecosystems is highest at six. Farmers operating in two sub-ecosystems grow four cultivars on an average, while farmers having land in only one sub-ecosystem grow only three cultivars.

In addition to niche matching, farmer interviews indicated that risk reduction was also a major reason for cultivar diversification. Nearly all farmers reject exclusive reliance on a single cultivar having specific characters which may prove disadvantageous under the unreliable climatic and hydrological conditions which characterize the rainfed lowlands. Staggering of labor demand and differential end uses were also identified by several farmers as reasons for growing multiple varieties.

The implication of farmer preferences for varietal diversity is that the chances of wider adaptability of a single improved cultivar in rainfed lowlands may be limited. A set of improved cultivars having different traits may be more acceptable to farmers. Adequate consideration should be given to this point in our efforts to develop improved cultivars for rainfed lowlands.

Farmers' perceptions on traditional and improved cultivars

The adoption of improved and shorter duration cultivars helps to increase cropping intensity and yield. However, while improved cultivars account for more than 50% of area sown to rice nationwide, adoption has been limited to locations with better production environments. In this section, farmers' rationale for their limited adoption of improved varieties is discussed.

Soils and fertilizers

The adoption of improved varieties seems to be positively correlated to the fertility status of the soil. Ninety percent of the farmers said that they grow improved cultivars on their most fertile piece of land (Table 5). Ninety-four percent of the farmers applied chemical fertilizers to improved cultivars. Besides this, more than 90% of the farmers thought that traditional cultivars did better on low fertility fields and did not erode the fertility status of their fields.

These observation suggest that: (1) farmers perceive that improved cultivars perform better under better fertility regimes; (2) improved cultivars perform better only when chemical fertilizers are applied; (3) the performance of traditional cultivars is superior to that of improved cultivars under low fertility conditions; and (4) traditional cultivars are better in sustaining the fertility of soils.

Most of the farmers in rainfed rice growing areas are subsistence farmers with limited financial resources for purchased inputs such as fertilizers. Their perception that modern varieties need more fertilizers may be a factor constraining the widespread adoption of such varieties. It would be useful to establish whether or not improved cultivars perform equally well under low fertility situations. If modern varieties are not inferior in low fertility situations, this message needs to be communicated to farmers in an appropriate way. On the other hand, if traditional varieties are found to be superior under low fertility conditions, breeders need to consider performance under low fertility conditions as a selection criteria.

Table 5: Farmer's perceptions on traditional and improved cultivars

Perception	Percent of Respondents			
	Traditional	Improved	Both	Don't Know
Soils				
Most fertile land is allocated to	8	90	2	0
Usually fertilizer is applied to	0	94	4	2
Can do better in low fertile land	92	4	2	2
Soil fertility not eroded quickly by	94	0	2	4
Biotic Stress				
Tolerance to pest	88	2	10	0
Tolerance to disease	82	2	4	6
Management				
Needs better management	0	94	6	0
Grown in fields nearer to house	40	52	8	0

Tolerance to pests and diseases

Farmers have identified Dhinkiasali as the most resistant cultivar to insect pests, followed by Kalachaki and Nagara. Moreover, farmers also perceive that these cultivars are tolerant to diseases. When it comes to the traditional and improved cultivars, more than 80% of farmers responded that traditional cultivars are more tolerant (Table 5).

In high rainfall and flood-prone areas of Eastern India, the severity of pests and diseases and difficulty in controlling them by chemical treatments highlight the need for breeding cultivars for multiple resistance.

Management

Farmers in the study village as well as rice experts (Singh *et al.*, 1994) believe that timely completion of various crop management operations is relatively more crucial for improved cultivars than for traditional cultivars. Forty-seven out of 50 respondents felt that improved cultivars need better crop management than traditional ones. Fifty-two percent of farmers reported that they grow improved cultivars in those fields that are relatively nearer to the house so that they can monitor the crop very closely and frequently (Table 5). In addition, fields nearer to house may receive a larger quantity of organic manure due to lower travel time. It would be useful to study farmers' crop and fertilization practices to shed further light on why farmers grow improved varieties closer to the house.

SUMMARY AND IMPLICATIONS

Garh Madhupur village in Jajpur district of Orissa state was selected to study the diversity of landraces and farmers' perceptions on cultivars to understand the reasons for limited acceptance of modern rice cultivars in rainfed lowlands. *Kharif* paddy is the most important crop in the village and traditional cultivars dominate the acreage covering 87% of rice area.

There is a noticeable tendency among farmers to grow more than one rice cultivar on their farms. The number ranges from two to more than ten. Diversity is higher among farmers with more heterogeneous environments (soil types and landforms). Cultivar diversification is an important practice followed by rainfed lowland farmers for a variety of reasons, such as environmental matching, risk reduction, avoiding labor bottlenecks and obtaining a range of product qualities.

Farmers perceive that improved cultivars perform better under better fertility regimes and when fertilizer is applied, while traditional cultivars perform better under low fertility. Farmers' perceptions on the suitability of improved cultivars to fertile fields and need to apply chemical fertilizers to grow improved cultivars may limit the adoption of improved varieties. If improved varieties do indeed perform poorly under low fertility conditions, it would be appropriate to expand breeders' selection criteria to include performance in low-input situations.

Most farmers believe that traditional cultivars are more tolerant to pests and diseases than the improved ones. Susceptibility of available improved varieties to biotic stresses may be a factor limiting their adoption. Therefore, opportunities for exploiting resistance available in traditional cultivars to breed improved cultivars with multiple resistance should be explored.

Farmers believe that improved cultivars demand timely operation and management to realize their full potential. If this is the case, flexibility in crop management operations would be an important trait to select for.

In areas with unreliable climatic and hydrological conditions, the key element in farmer survival strategies has been the ability to match the diverse genetic material with the agro-hydrological conditions existing on individual rice fields. The availability of diverse genetic material and farmers' sound knowledge of landforms, soil types and hydrology gives them immense ability and flexibility in dealing with the risky production environments of rainfed lowlands. In risky production environments, breeding for wide adaptability may not be a very appropriate strategy. What is needed perhaps is to develop a range of improved cultivars with different characteristics so that farmers can choose combinations with traits that are most appropriate for their field conditions. Breeding efforts could perhaps be made more efficient by using farmers' knowledge about appropriate plant types and agro-hydrology through a more direct involvement of farmers in the breeding process.

Although breeders may use local materials in their breeding program to develop improved varieties, the local landraces are unlikely to be completely replaced in this rainfed environment. Maintenance of a degree of diversity of traditional cultivars is an important survival strategy of rainfed farmers. A breeding strategy which helps maintain useful diversity of cultivars is recommended.

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DOCUMENTATION OF LOCAL CROP VARIETIES EVOLVING A PARTICIPATORY METHODOLOGY

R. Tiwari and A. Das

ABSTRACT

The objectives of this exercise were to make an inventory along with farmers of their varieties, their characteristics, use and disuse patterns, preferences, and so on. Side by side, a truly participatory methodology and tools were also to be devised. At the end of the exercise, the basis for a seed exchange mechanism was to be laid down among farmers whereby they could increase their productivity. The area of study was the Himalayan region because SAHAYOG is concerned about the region and is familiar with it. The choice of species to be studied was decided along with the farmers, keeping in mind local use. In order to make the process participatory, both men and women were involved in the process. The methodology included group discussions, key informant interviews as well as a joint meeting of various key resource persons of the different villages. The process was quite drawn out as women were not used to articulating what they know, and the interviewer had to tune into the local nuances of speech and logic. One useful result of the exercise has been that farmers from neighboring villages have had an opportunity to share information at one place and some degree of dialogue has been initiated among them.

INTRODUCTION

In a world order dominated by GATT, Intellectual Property Rights, Unique Selling Propositions and Plastic Money, all the stakes belong to the TransNational Corporations (TNC) as they transcend national boundaries to create a global village. In this scenario the worst casualties are the villagers in a country like ours, who do not figure in the marketplace, but whose knowledge and resources are being increasingly appropriated, intellectually protected, and then put to distorted use by the same market. In the field of agriculture, this market aims to replace local crops with standard ones, varietal diversity with uniformity, labor with machines, local consumption with the market, and the kitchen and stove with the microwave oven and processed food. The knowledge of the farmers is superseded by that of the scientist, and their skills in knowing and growing different varieties and crops, by the standardized extension packages and kits.

Fortunately, the situation is not yet as bleak as the 'powers' that be would like it to become. In the remote corners of India, the farmers continue their traditional practices, unaware of the swift changes taking place all around. If no interventions take place at this point in time, these farmers could well be swept into the overwhelming process of change, and priceless treasure troves of crops, varieties, seeds and knowledge lost in the black hole of 'development'.

In such a situation, it is imperative to find ways and means to enable farmers to assess their collective knowledge and resource base, establish their rights over it, find avenues to use it more productively and improve the quality of their own lives. One major hurdle in this process is the fundamental difference in the way 'scientifically trained' people and traditional farmers approach, store and use knowledge. While the scientist is interested in distilling abstract principles for the technocrat to utilize, the farmer, being both scientist and technocrat, uses her/his collective experience of generations for survival. In such a situation, it is necessary for us to liberate ourselves from the shackles of a 'scientific' approach', if we wish to assist farmers gain control over their knowledge and resources.

SAHAYOG is a voluntary development organization working in the Uttar Pradesh Himalaya in India with the mission of assisting the process of sustainable participatory rural development. Validating local knowledge has been an area of concern for SAHAYOG, and in the past it has been involved in an exercise to document and validate local knowledge and practices regarding the use of local medicinal herbs.

The possibility of conducting a similar exercise with crops was raised during discussions with Dr. Louise Sperling during her visit to Almora in 1994. The opportunity to do so was made available by IDRC in May 1995.

OBJECTIVES OF THE STUDY

The primary concern in this study was to embark on a process of joint discovery along with the farmers, regarding the diversity of seed varieties within the region, possibilities of strengthening their seeds through mutual exchange and improving productivity. Keeping these concerns in mind the following objectives emerged:

1. To make an inventory of the different varieties, their characteristics, and usage patterns for a few selected crops, along with the farmers of the area;

2. To evolve a participatory process, including appropriate tools by which the above is possible;

3. To start a dialogue between farmers of neighboring villages, with a view to exchanging knowledge and resources for better productivity.

AREA OF THE STUDY

The study was conducted in SAHOYOG's project area in the Dhauladevi Block of Almora district of Uttar Pradesh. Five villages were selected for this study, keeping in mind the degree of rapport with the village, their agricultural tradition, and their difference in situation (e.g. altitude, slope, aspect, etc.). The area chosen falls broadly in the region classified as the Mid-Himalayan region. Farming in this region is distinct from other regions, and has the following characteristics:

- Land holdings are small and fragmented;
- Nearly all crops are rainfed, and there is very little provision for irrigation;
- There are very few external inputs in the form of chemical fertilizers or high yielding seed varieties;
- Farmyard manure is the most widely used fertilizer;
- There is widespread cultivation of traditional crops;
- Most of the crops are grown only for local consumption;
- Women perform most of the farming activities: women are farmers; and
- Many able-bodied males migrate out of the region for work;

This region can be further subdivided in terms of altitude, climate, and farming patterns into three areas: the valleys, the higher reaches and the middle slopes. Table 1 provides an idea of differences among these areas. The area in which the study was conducted falls in the middle slopes category.

Table 1: Farming in the Mid-Himalayan region: intra-regional variations

UPPER MOUNTAIN REACHES	Altitude 1600 - 2500 m. There is considerable snowfall. Agriculture is not very intensive.	Main crops: 'phaphar', 'palti', 'napal', 'ooa' (minor millets); rajma, masur, matar (pulses); potato.	In the higher reaches with high snowfall, only one crop is taken, or else two crops. Minor millets are used as flour and 'sattu'.
MID-SLOPES	Altitude 1000 - 1600 m. Agriculture is rainfed and intensive.	Main crops: wheat, paddy, madua, madira, soybean, onion, garlic, coriander, ginger, amaranth, colocasia.	Either two crops are taken in one year, or three crops are taken in three years. Diversity of crops grown is highest in this region.
RIVER VALLEYS	Altitude up to 1000 m. Broad river valleys, provision for irrigation exists, soil is fertile and there is periodic flooding.	Main crops: paddy, wheat, soybean, onion, garlic, potato, coriander, mustard, amaranth.	Two to three crops are taken every year, and there is widespread use of chemical fertilizer and HYVs. Irrigation is common and farming is market oriented.

THE CROPS THAT WERE STUDIED

As farmers' knowledge was the central idea in the study, it was decided to choose crops which are traditional and have been grown for generations. Three important conditions were kept in mind in selecting the crops for the study:

- The crop should be traditional;
- It must be one that is locally consumed; and
- It must be of importance to the villagers and be a major component of their subsistence farming;

The crops that were selected for study were - *madua* (finger millet), *madira* (barnyard millet), wheat, rice and *bhatt* (soybean). In keeping with a participatory approach, farmers were free to discuss other crops too. In the process, a wide variety of crops were mentioned, although we kept our focus primarily on these five. It finally emerged that these five crops were not only important for the villagers but some degree of varietal diversity also existed within them. There were other crops, notably the bean *rajma* which had a much greater varietal diversity, but the crop was relatively less important. Table 2 gives some information about these five crops.

Table 2: The crops that were studied

Local name	English equivalent	Growing season	Use
Madua	Finger Millet or *Eleusine coracana*	Kharif May to September	Used as food. The grains are dehusked and made into flour, and chapati is made from it.
Madira	Barnyard Millet or *Echinochloa frumentacea*	Kharif April to October	Used as food and cattlefeed. Grains are boiled and used as rice. It is sometimes made into flour, and chapatis are made.
Gehu	Wheat	Rabi October to April	Made into flour and chapatis are made. Sometimes made into 'halwa' a sweetmeat during festivals and celebrations.
Dhan	Paddy	Kharif April to September	Used as rice. Also made into flour, and 'puris' are made during festivals.
Bhatt	Black soybean	Kharif April to September	Used as a pulse, and also popped like corn, and used as a snack in winters. Also used as cattlefeed.

CONDUCTING THE STUDY WITH THE FARMERS:EVOLVING A METHODOLOGY

The investigators in this study had no expertise or knowledge in agriculture. One of them is a resident of the region and as such had some experience in helping in various farming activities at home in the past. The somewhat presumptuous decision to carry out such a study was taken on the basis of our interest in the idea and some previous experience in participatory research. Keeping a participatory framework in mind, it was decided at the very outset that:

- The purpose of the study would not be only to collect information but also find ways of sharing it among the farmers who provided it;
- While we had decided on five crops, farmers would be free to share information about as many crops as they wished. We, for our part, would validate our choice from farmers, and change our list if necessary;
- We would explain the purpose and steps of the study in detail and encourage the farmers to redefine it if necessary;
- We would try to visit farmers in an informal setting, i.e. in their homes or fields and try not to intimidate them with formats or tape recorders; and
- We would be open to changing the framework that upon which we had first decided.

Initially we had decided upon an approach in which we would first visit key resource persons like old men and progressive farmers for information and seed samples, and then compare the data given by different individuals from different villages in village-wise meetings. As we started our study, we realized that the first interaction in the village needed to be an informal meeting, and only after having explained the purpose of the study in the meeting and having generated some interest in the community, could we proceed to individual interviews. The other thing we realized is that women are the greater repositories of knowledge and information regarding traditional crops and varieties, while men are more interested in improved seeds, new crops and practices. Thus the framework that finally emerged was:

- An initial village-wise informal meeting in which a large section of the community participated;
- Follow-up visits to key resource persons identified in these meetings; and
- A final workshop with the key resource persons from all the villages.

The informal meetings were attended only by those individuals who were familiar with SAHAYOG, and their numbers varied from six in one village to thirty-five in another. These meetings served as a forum for explaining the purpose of the entire study, starting the process of information sharing and seed collection, and identifying the key resource persons. Women tended to be silent in these meetings, and opened up only after they were separated from the men. Men were quicker in their responses, but the women provided more information. Women had difficulty in sharing information during abstract discussions, and became animated and articulate only after seed samples were displayed. It was necessary to display seed samples from other villages to motivate farmers to bring out their own seed samples. Seed samples of *rajma* varieties proved crucial to demonstrate the concept of varietal differences. A total of 98 farmers from five villages participated in these informal meetings.

After the initial meeting had introduced the exercise, follow-up visits were made to the key resource persons identified during the meetings. These farmers were visited once or twice in their fields or at home. During these visits, we directly observed ongoing farming activities (harvesting and threshing of wheat, sowing of *madua* and *madira*, seed selection and storage). Semi-structured interviews were also conducted to generate more information about the crops that we had decided to study. The farmers were also encouraged to rate and rank the various crops and varieties. A total of 24 farmers were interviewed at this stage.

The information gathered was compiled and collated on a variety-wise format. Seeds were collated in a village-wise and crop-wise manner. We were faced with some difficulty in deciding on the appropriate storing and displaying of the seed samples. Our main concerns were:

- Portability: it had to fit into a small backpack;
- Accessibility: farmers should be able to hold/feel the seed; and
- Durability: the packing had to be transparent and tear resistent.

We finally settled upon clear polythene ziploc pouches, and slide holding sheets, but this storage/ display system can surely be improved upon.

Once these interviews were over, we held a one-day workshop at a central place with the key informants of the study. Fourteen farmers attended the workshop, a majority of whom were farm women.

The workshop started off with a sharing of the data collected so far in the form of a seed display from all the villages. As they handled the seeds, women became animated in discussing each others' village samples. The specific differences between varieties were defined, and identification was finalized. Some inter-village differences in perception became apparent at this stage. More data on characteristics emerged, and some information on the history of varieties was also elicited.

After this, the participants split up into small groups and described the cropping cycles used for these major food crops. A sort of calendar emerged from this discussion. Following this, there was an attempt to do a ranking exercise for the varieties of seeds. At first, the preference criteria were defined, and it turned out that crop residue (for fodder) and low water requirements were very important. Also, a consistent productivity was expected, failing which a variety could be totally rejected. Table 3 summarizes the methodological process.

Table 3: Summary of the tools used and their utility

Activity	Tools used	Utility
Informal village meetings	- General discussions - Small group discussions (sex-wise) - Seed sample display - Ranking	- Explain the purpose of the study - Initiate sharing process - Energize participants - Collect seed samples
Individual interviews	- Semi structured interviews - Direct observations - Seed sample display	- Detailed sharing - Cross-checking information - Observation of farming practices
Workshop	- General discussions - Small group discussions - (with reporters) - Seed sample display - Ranking/correlating	- Sharing and discovery between villages - Validating each others knowledge and experiences - Understanding differences - Starting a mutual relationship on the issue

SOME ISSUES AND CONCERNS

In the course of this exercise a number of issues emerged, many of which we dealt with as best as we could; others remained unresolved.

- As the study was restricted to individuals within the community who were familiar with SAHAYOG, it is possible that information gathered is incomplete;
- In meetings with both men and women, men tended to dominate. Women opened up only when they had a separate space for themselves;
- Men were quick with responses, even though some of it proved inconsistent with what the women shared later;

- Only those men who had lived outside the area were keen farmers, and they were more interested in improved varieties and techniques;

- Women were not consistent in their preferences and were unable to rank in terms of good, better, best;

- The investigators were both male and had to enlist the support of female workers to establish rapport with the women. Familiarity with the language, customs and farming practices was useful in generating information;

- Farmers, especially the women, were unable to discuss information in abstract terms, and it was essential to use seed displays to generate interest and active participation;

- Considerable patience was required to elicit 'coherent' information from the women. They were responding according to their logic, which was difficult for the investigators to comprehend. They, in turn, must have experienced similar difficulty in understanding the 'logical' queries. Each party was restricted by their own operational logic and world view.

- The study was completed in a period of slightly less than one month, and this time was inadequate. Even though we interacted with each key resource person three to four times, getting information was a slow process. Visiting them further could result in 'interview fatigue'.

RESULTS

Tables 4 through 10 provide some information about the different varieties, that we found, their characteristics and the sex-wise division of labor. It clearly emerges that women are the farmers and, except for plowing, perform all farming activities. The interest of men is limited and only those who are exposed to other ideas and practices are keen on farming. As far as varieties are concerned, only two or three varieties of crops were found in each village. There were some differences in the varieties from village to village.

One of the important considerations in this study was to identify the changes occurring in the varieties grown, crops, their uses, and also to determine how seed exchange takes place. What emerged was as follows:

Crops

A cereal called *china* used to be grown and consumed, but people have stopped growing it for the past thirty years or so. The area devoted to *madua*, *madira* and a cereal called *ozo* has decreased as well as that of *bhatt*. There has been a consequent increase in the area under garlic, onion, ginger, potato and improved soybean.

Table 4: Sex-wise division of labor in different farming activities

Activity	Men					Women				
	V-1	V-2	V-3	V-4	V-5	V-1	V-2	V-3	V-4	V-5
Plowing	✓	✓	✓	✓	✓					
Levelling						✓	✓	✓	✓	✓
Sowing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hoeing and Weeding						✓	✓	✓	✓	✓
Harvesting						✓	✓	✓	✓	✓
Threshing	✓		✓		✓	✓	✓	✓	✓	✓
Collecting Seed						✓	✓	✓	✓	✓
Processing and Storing						✓	✓	✓	✓	✓
Seed Selection	✓		✓	✓	✓	✓	✓	✓	✓	✓
Head-loading FYM/harvesting	✓		✓							

V-1: Chamua; V-2: Kitora; V-3: Kadori; V-4: Bahtan; V-5: Khali

Table 5: Village-wise distribution of varieties of the different crops

	Villages				
Crops	Chauma	Kitora	Kaduri	Bahtan	Khali
Wheat	- Lal Noyi - Safed Noyi	- Lal Noyi - Safed Noyi	- Lal Noyi - Safed Noyi	- Jhuswao - Safed Noyi - Dawatkhani	- Lal Noyi - Safed Noyi - Dawatkhani
Madua or Finger millet	- Garau - Putki - Dwiti	- Garau - Putki - Ganolli (extinct)	- Garau - Putki - Nangchuni	- Garau - Putki - Nangchuni	- Garau - Putki
Madira or Barnyard millet	- Lal madir - Safed madir	- Lal madir - Safed madir	- Lal madir - Safed madir	- Lal madir - Safed madir	- Safed madir
Bhatt or Black Soybean	- Lagili - Improved soy	- Lagili - Improved soy	- Lagili - Thumri - Bhangrail - Improved soy	- Lagili - Thumri - Bhangrail - Improved soy	- Lagili - Thumri - Bhangrail - Improved soy
Paddy	- Bandpas - Chhirku	- Chhirku - Baku	- Bandpas - Bhattu	--	--

Varieties

As far as wheat is concerned, the area under Lal Noyi is going down in all villages, because of reducing yields, and as a consequence Safed Noyi is becoming more prevalent. Dewatkhani used to be found in all villages but, at present, is restricted to two villages. In Khali village, it made a comeback two years ago because Lal Noyi production had declined drastically. Jhuswao, a variety promoted by the government only established itself in one village, even though it gives a better yield. Farmers say that it needs more water and it has an undesirable taste. One person in Khali village tried growing the wheat available through the government Public Distribution System (PDS) and, while he got a good yield the first year, the subsequent year was disastrous.

Two varieties of *madua*, Timasi and Ganoli, seem also to have disappeared-- more than thirty years ago. Local *bhatt* is being displaced by improved soybean, as the latter is a cash crop.

Usage

Use of *madira* and *ozo* for human consumption is decreasing, and, while the area under these crops has decreased, the proportion used as cattle feed has increased. Improved soybean is grown as a cash crop and there is little local use (versus the case of *bhatt*). Wheat and rice are replacing local cereals as the major staple, as they are easily available through the PDS. It is now considered a matter of status to consume rice and wheat only, and some families denied consuming *madira* and *ozo*, and said that they grew them only for animals.

Seed selection and storage

No special seed specialists could be identified, except for one man in Khali village who multiplied Dawatkhani wheat seed and distributed it to the entire village one year ago. Selection of seeds is done either during winnowing (the seeds that fall directly under the winnowing tray are kept for seed), or a field with a good crop is set aside for seed purposes. Each farmer grows his/her own seed and exchanges it every few years.

Seed storage techniques are undergoing changes. Traditionally, seeds were stored in hollowed gourd shells, *tumari*, when the quantity to be stored is small, in wooden boxes, *bhakar*, or covered bamboo baskets plastered with dung, when the quantity is large. Seeds were mixed with oak ash to discourage insects. Tin canisters are now replacing the earlier storage vessels and seeds are being increasingly mixed with 'DDT' or some other insecticide powder.

Seed exchange

Informal seed exchange systems exist within the village, the most common being between the farmers of the same village. Women also get seeds from their homes at marriage or afterwards. Further, seeds are brought in from neighboring villages where there are relatives. Only one instance was found where seed had been brought from the house of an old comrade in arms (in the police force). By and large, seed exchange appeared to take place within the same caste group.

Government systems for seed distribution appeared non-existent at the village level. Interested male farmers visited the block office to get new seeds for wheat and soybean. A few women admitted to consuming seeds provided by the government as seed 'mini-kits'.

Table 6: Variety-wise differences: 'Madua'

	GARAU	PUTKI	DWITI	NANGCHUNI
PLANT	Stem is greenish white; tall and weak, can bend and break in the wind	Smaller than garau, stronger has a sweet taste	Small plant	Average height, prominent nodes on stem, tips can be broken off with fingers
SEED	Deep, brownish black seeds, round	Same	Same	Larger seeds
EAR	Like the spread out fingers of the human hand	Like the close in fingers of the human hand	Midway	Like the closed in fingers
SOIL	Can grow in soil	Same	Same	Same
WATER	Irregular rains	Same	Regular rains	Regular rains
LABOR	Similar	Similar	Similar	Similar
DISEASES	---	Plant dries up	---	---
PRODUCE	High	Better	Less	Average
TASTE	Good	Better	Very good	Good
NUTRITION	High	High	High	High

Table 7: Variety-wise differences: 'Madira'

	SAFED MADIR	LAL MADIR
PLANT	A tall plant, can even grow up to six feet	Smaller plant than Safed Madir
SEED	Very small, greenish-brown	Very small, greenish-brown with a faint raddish tinge
EAR	Large, opened out, pale greenish-white	Large, opened out with reddish tinge
SOIL	Can grow in less fertile soil	Same
WATER	Rainfed	Rainfed
LABOR	Similar	Similar
DISEASES	Crubs and parrots 'kurmula'	Same
PRODUCE	Lower	Higher
TASTE	Good	Good
NUTRITION	High	Good

Table 8: Variety-wise differences: Wheat

	LAL NOYI	SAFED NOYI	DAWATKHANI	JHUSWAO
PLANT	Shorter stem; reddish tinge	Longer stem, yellowish white	White or yellowish stem	--
SEED	Brownish red	Brownish white	Reddish brown	Larger whitish
SOIL	Poor soil	Poorer soil	Average soil	Good soil
WATER	Rainfed	Rainfed	Needs more	Needs irrigation
FYM	Less	Less	15 baskets/nali	More
LABOR	In levelling field	Less	More than Lal and Safed Noyi	Most
DISEASES	Plant turns black	Seeds turns black and sooty	Plant dries up	Very susceptible
YIELD	Good	As good as Lal Noyi with good rains	Very good	Very good
TASTE	Good	Good	Good	Unsatisfactory
NUTRITION	High	High	High	Poor

Table 9: Variety-wise differences: Paddy

	BANDRAS	CHHIRKU	BAKU	BHATTU
PLANT	Average size	Average size	Short, white	Tall
SEED	Slightly reddish	Yellowish white	Reddish brown	Reddish black
SOIL	Average soil	Less fertile	Fertile	Less fertile
WATER	Rainfed	Rainfed	Needs more water	Rainfed
FYM	Good quantity	Same	Same	Same
LABOR	Less	Less	More	More
DISEASES	Seed dries up	Seeds turns black	Plant dries up	Seed dries up
YIELD	Good	Good	Good	Good
TASTE	Good	Good	Good	Good
NUTRITION	High	High	High	Average

Table 10: Variety-wise differences: 'Bhatt'

	LAGILI	THUMRI	BHANGRAIL
PLANT	Creeper, small broad leaves	Small plant leaves bigger than Lagili	Small plant
SEED	Small, flat, deep blue black	Small round, deep blue black	Flat and oval, brown and larger
FRUIT	Smaller than a finger	Larger	Similar to Thumri
SOIL	Less fertile soil	Average soil	Average or less fertile soil
WATER	Rain is enough	Same	Same
FYM	Average	Less	Less
YIELD	Average	High	Average
TASTE	Best	Average	Average
NUTRITION	Highest	Good	Good

CONCLUSIONS

As mentioned earlier, this study was conducted by investigators with no background in agriculture. While this helped because we didn't have many preconceived notions, there is a great possibility of inaccurate information having been recorded. No secondary sources were consulted in the course of this study, and that remains an important shortcoming. There was very little attempt made to analyze the data, other than with respondents, and thus the report may appear naive to the expert. But then, in any participatory exercise, the fruits of the research must benefit those who generate (and analyze) the information. This study not only allowed us to gain some insight into the farming systems of the area, but also enabled the farmers to get an opportunity to share their information with farmers of other villages and castes.

We will consider our efforts successful if they can initiate further dialogue among farmers of the different villages (and different castes) on seed variety and seed exchange, and if, in the long run, they can assist rural people to gain control over their rich indigenous knowledge base and their diverse resources.

CONTRIBUTIONS OF TRIBAL COMMUNITIES IN THE CONSERVATION OF TRADITIONAL CULTIVARS

T. Ravishankar and V. Selvam[1]

ABSTRACT

Over the generations, tribal communities, namely Irulas, Malayalis and Muthuvans living in the state of Tamil Nadu, have been cultivating traditional cultivars of paddy, millets, pulses and vegetables. The subsistence life style, local diet habits as well as dependence on monsoon rain for irrigation have led them to cultivate traditional varieties and to conserve local seeds for consumption and for sowing the following season. The cropping practices of these subsistence farmers, particularly the mixed cropping system which results in intensive farming in a limited area, is unique. Their knowledge of seed selection, their traditional methods of conserving seeds and grains in eco-friendly traditional granaries, and their communities' participation in maintaining germplasm provide important insights to global efforts aimed at genetic conservation. Their traditional practices are blessings in disguise and have saved many forms of specific and intra-specific varieties of millets and paddy.

INTRODUCTION

By the end of this century, the population of India is going to reach one billion. Simultaneously, farmland is expected to be engulfed by urbanization and environmental degradation. To maintain a satisfactory food security system, crop production should increase by 3% a year. This is not an impossible task as, between 1960 and 1980, cereal yield increased by 750 kg/ha, largely due to the high yielding varieties. However, the continued success behind breeding programs largely depends on the availability of wider germplasm in the form of traditional cultivars and landraces cultivated by tribal families.

Tribal communities, namely *Irulas*, *Malayalis* and *Muthuvans* living in the state of Tamil Nadu, have been cultivating traditional cultivars of paddy, millets, pulses and vegetables. The traditional cultivars sown by them, over generations, form the principal crops of their agricultural system. The subsistence life style, local diet habits and organoleptic preferences of these tribes, as well as their dependence on monsoon rain for irrigation, have led them to cultivate and conserve local seeds for consumption and for sowing the following season. This traditional practice is a blessing in disguise and has saved many forms of specific and intra-specific varieties of millets and paddy.

By careful selection and conservation, these communities have enhanced the genetic potential of their seeds and have been able to remain self-reliant for generations. Nearly 54 traditional cultivars have so far been identified from the tribal communities (Table 1). The tribals prefer to continue the cultivation of their own traditional cultivars as these crops are ecologically suitable (Table 2), drought resistant, pest tolerant and disease resistant.

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[1] We thank the tribal headmen and farming families of tribal communities in the study area for sharing their knowledge and Prof. M.S. Swaminathan, Chairman, MSSRF for critical comments on this paper. Help and assistance from the officials of the Department of Forests of Tamil Nadu is also gratefully acknowledged.

Table 1: Traditional cultivars used by the Irula, Malayali, and Muthuvan tribes

Local name or description of the cultivars	Botanical name Paddy
Paddy	*Oryza sativa*
1. Modumulingi (or) Perunellu (or) Dhonanellu (or) Mottanellu	
2. Kottanellu	
3. Manavari	
Minor Millets: Samai (Little Millet)	*Panicum* sp.
4. Vellasama	
5. Kothusamai (or) Pillusamai	
6. Karunsamai	
7. Odusamai	
Ragi (Finger Millet)	*Eleusine coracana*
8. Vellasurattai	
9. Karunsurattai	
10. Vellari	
11. Thooval Kevuru	
12. Periya ragi	
13. Sendu ragi	
Varagu	*Paspalam* sp.
14. Thiri varagu	
15. Pani varagu	
16. Varagu	
Thinai (Foxtail Millet)	*Setaria* sp.
17. Karunthinai	
18. Vellanthinai	
19. Korai	
Kambu (Millet)	*Pennisetum* sp.
20. Malakambu (or) Pottukambu	
21. Kattukambu	
Makkasolam	*Zea mays*
22. Mokkasolam	
23. Silippisolam	
24. Pottusolam	

Table 1: Traditional cultivars used by the Irula, Malayali, and Muthuvan tribes (contd.)

Local name or description of the cultivars	Botanical name Paddy
Pulses	*Dolichos* sp.
25. Kollu	
26. Avarai	
27. Pandhal avarai	
28. Mochai	
29. Karuppu avarai	
30. Vellai avarai	
31. Oor avarai	
32. Thuvarai	
33. Ulundu	*Phaseolus* sp.
34. Thatta payiru	*Vigna* sp.
Culinary	
35. Molagai	*Capsicum* sp.
36. Yellu	*Sesamum* sp.
Vegetables	
37. Poosani	*Cucurbita* sp.
38. Parangi	*Cucurbita* sp.
39. Suraikkai	*Lagenari* sp.
40. Kothavaranga	*Dolichos* sp.
Thinai (or) Pandi	
41. Uppan thinai	*Setari* sp.
42. Sen thinai	
43. Arapandi	
Thatta Payiru	*Vigna sp.*
44. Kuthukaramani	
45. Kodithattapayiru	
Keerai	*Amaranthus* sp.
46. Pink variety	
47. Dark brown variety	
48. Pale brown variety	
49. Green variety	
50. Vella keerai	
51. Karungkeerai	
52. Padukukeerai	
53. Mullukeerai	
54. Silukeerai	

Table 2: Input and output ratio of traditional crops grown by Malayalis

No.	Name	Quantity sown (kg/acre)	Duration of Crop (months)	Yield (kg/acre)	Manure
1.	*Panicum* sp. (Vella Saamai)	30	4 (May/June to Sept)	800	Organic
2.	*Panicum* sp. (Kothu saamai)	7 1/2 to 8	6 (June/July - Dec/Jan)	600-800	Organic
	+				
	Eleusine sp. (Kevuru)	15	5 (June/July to Nov/Dec) or (May/June to Sept/Oct)	800-100	Organic
3.	*Panicum* sp. (Karun Saamai)	7 1/2 to 8	5 to 6 (May/June to Sept/Oct) (May/June to Dec/Jan)	800	Organic
	+				
	Setaria sp. (Thinai (Korai)	15	5 (May/June to Sept/Oct)	1000-1200	Organic
4.	*Setaria* sp. (Sen thinai)	1	5 (May/June to Sept/Oct)	500	Organic
5.	*Paspalum* sp. Pani varagu	30	3 (May/June to July/Aug)	800	Organic
6.	*Oryza* sp. Periya nellu or Madumulingi or Dhona nellu	50	5 (May/June to Oct/Nov)	1000-1200	Organic
7.	*Oryza* sp. Kotta nellu or Pulidikaaru	50	5 (May/June to Oct/Nov)	1000-1200	Organic
8.	*Oryza* sp. (Manavaari)	50	6 (Nov/Dec to April/May)	800	Organic

KNOWLEDGE OF TRIBES ON TRADITIONAL AGRICULTURAL PRACTICES

The traditional knowledge of tribes as relates to their farming practices gives real meaning to the word 'sustainability'. Such knowledge also helps them derive maximum benefits from traditional farming techniques adopted and practiced by them over generations. One important aspect of their agricultural system is the mixed cropping system which enables them to cultivate cereals, leafy vegetables, pulses and oil crops in a given area, depending on monsoon rain, and to harvest different crops in different periods in a year to meet their food and economic requirements. This concept of intensive farming can be adopted in places where rainfed monocropping is in vogue as it increases the return value to farmers' efforts. Nearly 60% of arable land in the world is still under cultivation by traditional or subsistence methods (Altieri 1983). With the growing population and the increasing demand for food resources, intensive farming needs to be practiced in increasingly limited land areas; there are few land options for expanding agriculture. Under these circumstances, mixed cropping agriculture needs to be introduced in areas wherever monocropping is practiced, depending on the monsoon rain.

In the mixed cropping system, seeds of common millet, finger millet, grain and leaf amaranths, pulses and castor are mixed together and broadcast. Primarily, the common millet is harvested, followed by finger millet. Edible leaves of amaranth and seeds and pods of pulses are used for daily consumption. Edible grains of amaranth are harvested and stored for future use. Amaranth seeds, puffed and mixed with honey, are highly relished by *Muthuvans.* Castor seeds are harvested and used for both domestic consumption and for market sale. The mixed cropping system not only helps in utilizing the seasonal rainfall but also in keeping the soil unexposed during dry season to prevent top soil erosion. The combination of crops with legumes also helps in nitrogen fixation, thus maintaining the soil fertility. It is observed that vegetable crops like ash gourd, bitter gourd and pumpkin are cultivated along field bunds to substantiate their diet resources.

SELECTION OF BETTER GENETIC MATERIAL OF CROPS

By virtue of their age-old knowledge of the viability of grains, healthy cobs or grains are selected and stored every season, thereby enhancing the genetic potential of the crop to withstand biotic and abiotic stresses. For example, healthy cobs are left in the field so as to allow them to dry to the maximum number of days--to make sure that no moisture is left in the seeds. The selection of large and healthy seeds, and also the selection based on the color of the seed, has also helped them select more viable seeds.

Traditional methods of storing

The tribal communities store their seed material and grains for consumption either in granaries, made up of bamboo coated with red soil and thatched with local grass, or in earthen pots. This traditional practice of storing has saved many varieties of cereals and minor millets in Tamil Nadu in India over the years. Knowingly or unknowingly, this practice has enabled them to maintain/preserve/conserve seed material. Due to the free flow of air in and out of these indigenous granaries, seeds can maintain their viability. Apart from this, storing of seeds, along with the pods or entire fruits in case of legumes, has prevented contact between the seeds, thereby helping to reduce the fungal or bacterial infection/contamination. Leaves of a few botanicals, particularly neem and *vitex*, are used by these people as insect and pest repellents.

Maintenance

Tribals periodically check-up on their stocks in order to monitor the presence of moisture, which encourages fungal or bacterial growth and can result in the production of aflotoxins.

Community efforts for the conservation of seed material

The community cooperation and participation prevailing in the Malayali tribal community has helped conserve the seed material of minor millets for many years. Every family in the community has to contribute an amount of grain to the community granary, which is then maintained and managed by the chieftain of the hamlet. During important occasions, e.g., marriages, social events, festivals or in the event that someone lacks fare for daily consumption, grain can be borrowed on loan. This system has enabled the tribals to conserve seed material, even if some community members produce less in any one season or exhaust their own household stocks.

The tribal communities studied share the view that high yielding varieties are susceptible to pests and diseases and also need constant irrigation. In addition, high yielding varieties require fertilizer application, whereas traditional cultivars do well when receiving domestic refuse and botanical green manure. Also, traditional cultivars suit local dietary habits and can be easily cultivated without external inputs. Overall, the traditional cultivars are highly suitable and adapted to the local agroclimatic conditions--as shown by their continued cultivation and, hence, conservation over a long period of time.

CONCLUSIONS

The above practices clearly reveal the traditional wisdom of tribal communities in understanding the physiological traits of their cultivars. Due to the reasons stated above, the genetic strains could be conserved by these people for the long-term. Now, because of increasing population pressure in tribal areas and contact with people dwelling in the plains (who practice unsustainable life styles), there are significant threats to the genetic material conserved by the tribes. Hence, these genetic strains should be conserved-- not only because they serve as the base material for plant breeding experiments--but also because they secure the livelihood of the many communities who depend on them.

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DISCUSSION

KOTHARI: I have a small question for Ravishankar. I am a little intrigued by the use of the term 'community seedbank' for the *ex situ* collection which is based at your center [MSSRF] in Madras. My perception of a community seedbank is that it is in the community where the seeds are being grown seed. What sort of participation is there of the tribals in your seed bank?

RAVISHANKAR: As we mostly collect seeds from rural and tribal communities we call it a community genebank but actually the name of the genebank is the Scarascia Mugnozza Genetic Resources Centre. We collect from communities because they are the ones who have the seeds.

KOTHARI: In that case, the 1 lakh [100,000] accessions of Dr. Rana's [National Bureau of Plant Genetic Resources] would also be a 'community seedbank'.

VIJAYALAKSHMI: To add a question on the topic: I would like to know on what terms and conditions the Centre [MSSRF] accepts seed of varieties and on what terms they give it back to the community. We find in several *ex situ* collections that, after conservation, it is very difficult for farmers to get back their seeds.

RAVISHANKAR: We collect seed along with lots of detailed information: for example, who is cultivating it, who has supplied it, when it has been supplied and how long it has been cultivated. In case we were to give it to a plant breeder, we would have to develop specific mechanisms for getting the royalties back to the farmers from whom these seeds have been collected. We want to act as a resource center for the tribals--that is our primary aim and that is why we are collecting. So far, we haven't ventured to give the material to anyone else. We need to help develop a legal system so that the tribals will not be deprived of their benefits. They have been the custodians of landraces.

SAHAI: I would like to add a comment here with respect to genebanks or storage centers or seedbanks. I have an apprehension I would like to throw into the arena because it relates to the whole question of ownership and rights and who derives benefits (i.e. Intellectual Property Rights). How many levels of storage or how many levels of ownership of genebanks are we going to be looking at? At the one level, we have a national level, like NBPGR. At the other level we have the community bank, where communities themselves control the access to the germplasm and where they are able to devise the terms and conditions of that access. The intermediary level that Ravishankar brought up [MSSRF] concerns institutions between these two aforementioned. There should be some uniformity in discussing the *modus operandi* of these, the terms and conditions. I see a certain, let us say, gray area.

KOTHARI: Kshirsagar mentioned that 90% of the people interviewed [in the Jaipur District of Orissa State] suggested that the new, so-called 'improved' variety should be grown on fertile lands. He also mentioned that farmers grow these varieties closer to their homes because they require more management. What is the correlation between the two? Would there be a negative impact if one does not match the other--or do they inevitably match?

KSHIRSAGAR: I said that farmers grow improved cultivars nearer to their houses and there are several implications of this. If you see the landscape of Orissa, in general, and the villages studied, in particular, they cannot transport fertilizer by vehicular means; they have to take it on their shoulders or on their heads. Whatever green manure the use, they apply to the fields nearer to the house.

Another reason may be to reduce travelling time for observing the improved varieties, which need better management. And farmers do believe that traditional cultivars do better under a low fertility situation.

REDDI: I would like to congratulate Kshirsagar and Ravishankar on their presentations which moved me very much in the sense that I was able to reconstruct the history of the Green Revolution. In 1965, Dr. Richharia vehemently argued that, within India, we had ten or twelve local high yielding rice cultivars--superior to those recommended by IRRI. His statements were based on five to six years of experimentation. But at that time, our government was unable to listen to this advice.

KSHIRSAGAR: I consider myself too young to talk about the Green Revolution but I think we were expecting some magic. Even now, when I go to the tribal areas, I listen to people say that extension workers come and give high yielding varieties--but there is no follow-up action. They say these varieties cannot be stored. So now, they are losing both, traditional cultivars as well as the high yielding. When the people go to talk to the extension officers, their concerns fall on deaf ears.

BELLON: We have been talking a lot about the advantages of local cultivars. Perhaps we also have to focus on the disadvantages, the trade-offs, because that is what really creates opportunities for diversity. In studying ecology, I have learned that there is not one organism that takes over everything because when you grow bigger, then you have to sacrifice in other aspects. Farmers tend to maintain a lot of different varieties because certain varieties perform well under certain circumstances, but not under others. If we can focus on both the disadvantages and advantages, we can also understand such opportunities for diversity.

GUPTA: A methodological point. There are two or three things the researchers presenting could have done to get more light on their data. One is to make a plot by plot map of the village and put all the varieties found on it, for both seasons and, if possible, over several years (previous, current, next). We did this in 1985 and in 1988 with Dr. Maurya in Eastern India. Several questions that arose this morning, for example, on fertility and varieties, and which were not answered properly, could have been made clearer.....If you had made maps of several factors, for example, drainage maps, weed maps, date of sowing maps, farmyard manure application, varietal maps, you would notice that with a variability of 1 1/2 to 2 inches in the drainage level, the variety used would change. This is very easily understandable and precise and empirical and also helps in distinguishing another factor which caused some confusion this morning, about class preferences. We got interested in this issue to disentangle class from ecological distinctions. You would notice, for example, that there are patches where everybody grows a particular variety, no matter rich or poor, and in that case, of course, it is the ecological factor which is determinant--just as in other cases, class variables will come into play. There are not neat distinctions which one can make in all conditions of drainage and elevation. Such mapping can also help us avoid making oversimplistic generalizations.

RANA: It was remarked this morning that farmers may find it difficult to get materials from the national genebank? Was this an impression or based on real contact? Let me explain the background.

A genebank generally serves as a safety mechanism. At the village or community level, the farmer may decide that, due to a shortage of rainfall or temperature or some other consideration, he is not going to plant a particular variety or even a crop. So, there should be a provision on site where one can store for one season or more the materials that are required to sustain agriculture in that area. If that does not happen, then an effort is made to collect these seeds and put them in the general area collected, not really on site, but in the broad ecological area. We call it an 'active germplasm site' because form there, the farmers or communities, who have contributed, can get these materials back. These centers also supply researchers who are engaged entirely in improving the productivity of these crops....

For these active collections, we are trying to develop what we call 'medium storage conditions' so that one can store for five to eight years.... This entire collection is also, theoretically put into long-term storage, and there are scientific methods to store these seeds almost indefinitely--not all crops, but the fraction which can be dried and are not sensitive to low temperatures....A large number of perennials, particularly, are either in the form of culture or embryos, and so on.

So it is not really that these three levels are working at cross purposes. In fact, they are expected to reinforce each other. The only difficulty is that since you have lakhs (100,000s) of farm households, you cannot work directly with all of them. ...There should not be any misgiving that the national and other systems or the community systems are working at cross purposes. In fact, they grow together and this system [NBPGR] has to reinforce the community center--if it is to have worthwhile success.

PARTICIPATORY BREEDING AND SELECTION: DECENTRALIZATION WITH GREATER USER INVOLVEMENT

THE IMPACT OF FARMER PARTICIPATORY RESEARCH ON BIODIVERSITY OF CROPS

J.R. Witcombe and A. Joshi[1]

ABSTRACT

Farmers are increasingly participating in agricultural research as scientists and development workers become more aware of the philosophy of 'farmer first' and its effectiveness. Many farmer participatory approaches are possible in farmer participatory research for improved crop cultivars by farmers. They should be broadly categorized into farmer participatory varietal selection (PVS) and farmer participatory plant breeding (PPB) since they conveniently define two approaches that are very different, and are likely to have very different impacts. Methods are reviewed in PVS and PPB that employ differing levels of farmer participation and researcher inputs. Depending on the situation, either PVS or PPB can be the most appropriate method to use. PPB often follows from the successful participatory identification of cultivars.

Although both PVS and PPB can increase biodiversity found in farmers' fields, PPB has the greatest effect. Indeed, if PPB is used with the maximum possible involvement of farmers using material generated from landrace x exotic crosses then it represents a dynamic form of in situ genetic conservation. This method is likely to have the greatest impact on conserving biodiversity.

Little attention has been paid to the impact of farmer participatory research on biodiversity. In the published examples on participatory plant breeding (Salazar, 1992 and Worede and Mekbib, 1993) the idea of preserving biodiversity has been in the mind of the researchers, and there has been emphasis on improving landraces or using them as parents. The issue of biodiversity has hardly been considered in the work on PVS.

In this paper, work and results are reported in PVS and, to a lesser extent, in PPB of the Crops Programme of the Krishak Bharati Cooperative Indo British Rainfed Farming Project (KRIBP).

INTRODUCTION

Alternative approaches for identifying cultivars that are acceptable to farmers have been suggested and tried by a number of authors. Chambers (1989) reviewed the small amount of work published at that time on providing farmers with varied genetic material. Published examples now encompass India, Rwanda, and Namibia in rice, beans and pearl millet. In rice, Maurya *et al.* (1988) tested advanced lines with villagers in Uttar Pradesh and successfully identified superior material that was preferred by farmers. Joshi and Witcombe (1995) used farmer participatory methods to identify released rice cultivars that were not recommended in the research area. In Rwanda, farmers selected 21 varieties from a wide range of bean cultivars grown in their fields that were first selected by them in on-station trials (Sperling *et al.*, 1993). In Namibia, Lechner

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[1] We would like to thank Dr. J.N. Khare and Mr. P.S. Sodhi of the KRIBP project. Without their unstinting efforts in managing the KRIBP project it would not have been possible to conduct the research in India reported here.

many crops in India, cultivars can be introduced from other states for a participatory varietal selection program since many cultivars have only been released in single states.

There is a considerable body of evidence to support the assumption that farmers are not rapidly adopting new cultivars because most cultivars under cultivation are old. There is also good evidence that only a few of the released cultivars are widely grown. For example, in wheat in India, the average age of cultivars under breeder seed indent is nine years, and the average of cultivars in certified seed production is 13 years in the three states of the KRIBP project, Gujarat, Madhya Pradesh and Rajasthan (Witcombe *et al.*, unpublished). The two most popular cultivars are Sonalika (released in 1967), and HD-2285 (released in 1982) and these account for a large proportion of the area. However, for wheat, there is a good choice of cultivars as there have been 44 releases in the period 1984 to 1992 inclusive. In most crops, cultivars are on average older than those in wheat. For example, the average age of cultivars under breeder seed indent is 11 years in rice, 13 years in chickpea, 15 years in groundnut, 16 years in sorghum, and 17 years in maize (Witcombe *et al.*, unpublished).

Choosing from amongst released cultivars has the advantage that any non-governmental organization or governmental organization (NGO or GO, respectively) can, in principle, readily procure seeds in sufficient quantities for testing with farmers. If they are identified as being farmer-acceptable it should be much easier, than is the case for pre-release or breeder's lines, to provide large quantities of seed to the farmers with little delay. Nonetheless, to increase the size of the basket of choices and exploit recent outputs from plant breeding research, pre-release cultivars might also be included in the search process and a number have identified as being suitable for testing with farmers in the KRIBP project (Table 1). Some of the pre-release cultivars would be defined by others as advanced material.

Table 1: Cultivars identified by participatory varietal selection in the KRIBP project and performance of recommended cultivars

Crop	Performance of recommended cultivars	Cultivars tested[1] Rel.	Pre-rel.	Cultivars identified	Release location	Year of release
Rice	All recommended cultivars tried failed in farmers' fields.	9	7	Kalinga III Sathi-34-36	Orissa Gujarat	1983 1955
Maize (white)	Recommended cultivar not distinguished from local by farmers.	3	3	Shweta	U.P.	1980
Chickpea	One of the recommended cultivars, Dahod yellow, is the local cultivar. Other failed.	4	1	ICCV 2 ICCV 10 ICCV 88202	A.P. SZ[2] Not rel.	1989 1992 -
Black gram	Recommended cultivar T-9 was less preferred. Others not tested as very old.	2	2	TPU-4 IU8-6	National Not rel.	1992 -

1 Rel. = released cultivar and Pre-rel. = pre-released cultivar

2 SZ = Southern Zone comprising Andhra Pradesh, southern Madhya Pradesh and Tamil Nadu (ICCV 10)

Amongst advanced material

Maurya *et al.* 1988, after a PRA on farmers' needs, searched among characterized advanced lines to find suitable material for testing with farmers. In other cases, breeders have searched amongst pre-released cultivars (entries in advanced stages of testing) having local adaptation and have deliberately chosen material that represents a wide range of phenotypes (Weltzien *et al.*, 1995, this volume). Sperling *et al.* (1993) and Lechner (pers. commun.) have successfully used farmer visits to research stations trials to identify suitable cultivars amongst the trial entries of non-released material.

Experimentation for PVS

Once genotypes or released cultivars have been identified and seed of them procured, various testing and evaluation systems can be employed that can vary greatly in terms of the extent of farmer participation. Many 'on farm trials' are conducted almost entirely by researchers on farmers' fields, so there is little or no involvement of farmers. At the other extreme, very limited inputs can be provided by outsiders such as scientists and development workers. To do so, farmers can be given a range of cultivars to grow for testing without intervention from outsiders. Outsider inputs in evaluating the material are also minimized by asking farmers in informal discussions which of the cultivars they like the most. Even these informal discussions can be avoided by merely waiting for demand for seed from farmers. On the basis of such discussions or demand from farmers, an NGO, a seed company, or a GO can make decisions on what seeds to provide to farmers. This informal research, with minimal outsider inputs, can be highly cost effective, and is recommended for NGOs with limited resources that have as a development objective the provision of seed of farmer-acceptable improved cultivars.

There are other methods that lie between the extremes of maximum and minimum inputs from outsiders. Scientists' participation increases when farmers are asked to grow more than one introduced cultivar, since it necessitates an experimental design in which farmers, if unaided, can easily make planting errors. The scientists' contribution will also vary according to the quantity and quality of the data that is collected, and is greatest when quantitative estimates of yield using field-sampling techniques are employed. Therefore, a method that requires considerable input from scientists is when farmers are asked, with researcher help, to grow a set of cultivars, and quantitative data on their yield is taken by the researchers. However, most researchers when using participatory methods have asked farmers to grow only one introduction side by side with their local with no change in management, and have collected data that pertains to farmers' perceptions of the cultivars.

The methods used by the authors are described in detail as an example of PVS. The varietal trials were carried out by farmers in Farmer Managed Participatory Research (FAMPAR) trials. The trials were divided into introductory and adaptive trials. The main difference between these two stages is that small quantities of seed were given to farmers in the introductory trials, but, to avoid overestimating the acceptability of cultivars to farmers, seed was sold at commercial rates in the adaptive trials (Joshi and Witcombe, 1995). The trials were made as simple as possible. Each participating farmer was randomly assigned a single variety, and asked to grow it alongside the local variety in the same field. Each farmer was given two bags of seed, so that the plot could be resown, if required, from the second bag of seed. Farmers were asked to mark the plots and to do this they sometimes grew a row of different crop between the two cultivars. They were also asked not to change the management of the crop in any way. Enough seed was provided for an average plot size 100 m^2, which is much larger than that used in advanced on-station trials.

In the introductory trials, data were collected by means of Focus Group Discussions (FGDs) before and after harvest, on all aspects of the crop including taste, market value, threshing characteristics and storability. Evaluation was facilitated by 'farm walks' in which the participating farmers visited each other's plots. All the cultivars could then be compared in the discussions, and it permitted the assessment of the reactions to each cultivar of all of the farmers that participated in the farm walks. The focused group discussions were followed by questionnaires completed for individual households, called household level questionnaires (HLQ), in which the household members' reactions to the variety were assessed by means of a detailed questionnaire that included questions on post harvest traits, such as cooking quality and market value of the grain.

Results obtained from participatory selection in KRIBP

Summary

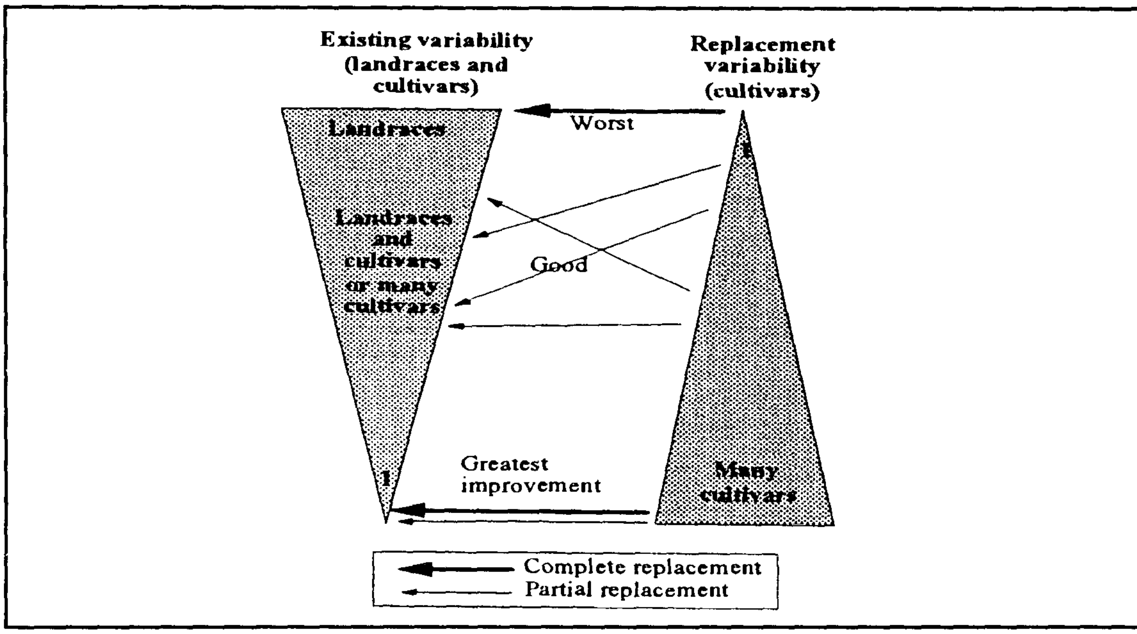
Using these techniques, we have identified in the KRIBP project three cultivars of chickpea, two cultivars of rice, one cultivar of maize, and two cultivars of black gram that are markedly preferred by farmers (Table 1). This has been achieved in only three years. One of the most revealing results is that recommended cultivars are rarely, if ever, preferred because their true recommendation domain is for areas where farmers grow crops in highly fertile soils, where water is not limiting. Instead, all of the preferred cultivars, apart from one cultivar of rice and a national release in black gram, are introductions from outside of the three states in which the project area is situated. This indicates that the recommendation domains of released cultivars have been defined too restrictively. Unfortunately, there is no mechanism of ensuring that once a cultivar is popular in one state of India that it is extensively tested in other states. An argument commonly used against the need to do this is that the material has already been tested in coordinated project trials. However, every case needs to be examined in detail. Often the number of locations in which an entry has been tested in any particular state will have been very small, and sometimes the trials that included the entry in question were rejected because the trial had excessive experimental error or because it failed.

PVS in rice

In 1993, introductory trials of rice were planned with 25 participating farmers in six villages, making a total of 150 farmers. Successful trials were conducted by 128 farmers, because some farmers failed to plant the seed. In each village, five cultivars were grown and every cultivar was replicated across three to five farmers. The cultivars were Kalinga III, Sathi-34-36, Jaldi Dhan-1, Jaldi Dhan-3, and GR-3.

The farmers' perceptions of Kalinga III, the most preferred variety, were compared in six villages. For yield, there was perfect agreement that Kalinga III was higher yielding in all villages in Madhya Pradesh and Gujarat (Fig. 1). From observations of farmers' fields, Kalinga III was seen to be considerably higher yielding. However, perceptions that Kalinga III was higher yielding than the local were far less marked in Rajasthan, but were always considered to be so by 50% or more of the farmers (Fig. 1). The probable reason is that the land is less sloping and more fertile in these Rajasthan villages, so there is a reduction in the advantage of Kalinga III, a cultivar that is highly adapted to low input conditions.

Figure 1: The infinite possibilities of replacement of existing variability with new genetic material



PVS in chickpea

In *rabi* (dry season) 1992/1993, five chickpea cultivars were grown in six villages. In each village, each cultivar was grown by four farmers to give a total of 120 farmers. After the harvest in 1993, a HLQ was conducted and farmers were asked if they would grow their chickpea cultivar again. Three cultivars, ICCV 2, ICCV 88202 and ICCV 10, were selected by a good proportion of the farmers, but ICCC 4 the official released variety was not liked. Differences between the cultivars were less clear when the cultivar choice was restricted to the cultivar the farmer had grown, than when choice was restricted to the remaining cultivars (Table 2). Probably the availability of seed of the cultivar the farmer has grown greatly influences the decision in favor of regrowing it.

Table 2: Number of farmers participating in the 1992-1993 participatory varietal selection trials who said they would grow one of the test cultivars in the following year

Cultivar choice	Sample size per cultivar[1]	Number of farmers who said they would grow the cultivar next year[2]				
		ICCC 4	ICCV 37	ICCV 10	ICCV 88202	ICCV 2
Cultivar farmer had grown in the trials	24	10	13	17	21	17
Remaining cultivar	96	1	5	13	25	35
Total	120	11	18	30	46	52

1 The maximum number of farmers that could choose an individual cultivar.

2 When interviewed, farmers were asked to assume that the seed would have to be purchased at commercial rates if they did not already have the seed.

The second-year adoption rates of the preferred cultivars were found for the cultivars by interviewing farmers in two villages, (those that had participated in trials in 1993/94), at the end of the 1994/95 season . The differences in adoption rates into the second year showed that ICCC 4 was even less liked than was indicated by the HLQ (Table 3). ICCV 37 was resown by two of the four farmers and no seed was given to others. Adoption rates were higher for the three preferred cultivars in the HLQ. ICCV 88202 and ICCV 2 were more preferred than ICCV 10 in terms of both adoption rate and the number of recipients of seed and this result agreed with those from the HLQ. Since the two surveys had only one village in common, this agreement was even more impressive. The three farmer-preferred cultivars will spread with farmer-to-farmer seed supply, and the area under these cultivars will increase quite rapidly, even if no further seed is supplied from outside. Multiplication rates are conservatively estimated at between two and three times and there is a high rate of spread of seed to new areas (Table 3).

Table 3: The results of a survey in 1995 in two villages on resowing rates of cultivars first grown in *rabi* 1993-1994

Cultivar	Sample size	Percentage resowing	Increase in area in project village (times)[1]	Number of new farmers given seed of cultivar	Mean distance of new farmers from village (km)	Total amount given (kg)
ICCC 4	5	0	-	0	-	0
ICCV 37	4	50	2.4	0	-	0
ICCV 10	7	57	2.9	5	3.4	7
ICCV 88202	8	75	1.8	10	10.5	25
ICCV 2	8	75	2.8	4	5.6	3

[1] Ratio of sown seed in 94/95 over seed sown by all farmers in 93/94. Area sown in 94/95 excludes new farmers given seed in 93/94 as they were not interviewed.

An FGD for 1993-1994 crop was conducted in three villages after the 1994 harvest. There was a total of 23 participants. It was found that the preference ranking changed somewhat as ICCV 10 was preferred the most over the local. There was little difference in the preference over the local between ICCV 88202 and ICCV 2.

The results from the three different surveys all agree in finding ICCV 2, ICCV 88202 and ICCV 10 as the preferred varieties, but the order of preference changed somewhat. This is perhaps unsurprising as the three cultivars all have markedly different characteristics. ICCV 2 is very early kabuli type, the seeds of which fetch a higher market price. ICCV 88202 is a very early desi type, and ICCV 10 is later than ICCV 88202 but higher yielding. Different villages may have different preferences according to such factors as access to markets and soil types. By exposing the farmers to a diverse range of genotypes, a number of cultivars have been adopted and biodiversity has been increased since they are all being adopted and partially replacing the uniform single 'landrace cultivar', Dahod yellow, that was exclusively cultivated in the area before these introductions.

PARTICIPATORY PLANT BREEDING

Participatory varietal selection has been extended to participatory plant breeding (PPB) on the assumption that if it is desirable to involve farmers in selection of cultivars then why wait until there are finished products? Farmers can be involved at a much earlier stage whilst material is still segregating. However, participatory plant breeding is more resource consuming than PVS, and hence the first recourse should be to the least expensive method. PPB has to be used when PVS has been tried and failed, or when the search process has failed to identify any suitable candidate cultivars.

The methods used in participatory plant breeding are poorly documented since there are no reports in the literature of a completed participatory plant breeding program. Sthapit *et al.* (this volume) have used F_5 bulk families as the starting point for their participatory breeding program. These were derived from seed harvested from F_4 families that were grown in the farmers' village. The breeding scheme is at the F_5 stage in the monsoon season of 1995, and it is intended to monitor progress in the farmers' fields until a finished product is produced. In contrast, Thakur (1995) has screened material in farmers' fields at the F_2 stage, but subsequent generations have been grown by researchers. The authors, in collaboration with Dr. Goyal of Gujarat Agricultural University, are starting a participatory plant breeding in maize with the fourth random mating generation of a composite created from six farmer-acceptable open-pollinated cultivars. In Ethiopia, farmer enhancement of landraces by mass selection has been done in collaboration with scientists from the Plant Genetic Resources Centre (Worede and Mekbib, 1993). In participatory plant breeding in rice in the Philippines, farmers are involved in selecting from progeny of crosses between traditional and improved cultivars but, unfortunately, the methods used are not described in detail (Salazar, 1992).

A range of participatory plant breeding methods are possible with predominantly self-pollinating crops, and they have been ordered by degree of farmer participation in Table 4. The methods vary according to which generations are grown by farmers and by the extent of researcher participation. The method with the greatest farmer participation and the greatest number of generations requires little breeder input during the selection stages. However, an essential role is played by breeders and participatory plant breeding is not intended to make plant breeders redundant. In all of the methods, the plant breeder is the facilitator of the research. Only the plant breeder can make the crosses between the parents and have the essential understanding of the underlying genetics in the segregating generations. Moreover, only the plant breeder has the knowledge of the official release system, and cultivar release is still a very desirable end product to make the results of the participatory research more widely available.

For predominantly open-pollinating crops, plant breeders can create composites in isolation and give the third or fourth random mating to farmers for mass selection. Large plots of composite have to be grown by farmers, or small plots need to be isolated by time of flowering or distance from other plots of the same crop. Because of these constraints, it is difficult to carry out the breeding scheme in many locations. Mass selection can be done with or without an off-season generation controlled by the plant breeder. However, to breed for wider adaptation, plant breeders can recombine selections from different farmers in the off-season. Although it is likely to reduce the progress made by selection over the best farmer's selection, it avoids the risk of continuing a population from a poor selection by one farmer or from a population where outcrossing with other farmers' crops happened to be higher than expected.

Table 4: Methods of participatory plant breeding in predominantly self pollinating crops

Methods in increasing order of farmer participation	Site specificity	Reference
1. Early generation (F_2) in farmers' fields. All other generations and procedures with plant breeder.	Single location	Thakur *et al.*, 1995
2. Best advanced lines at F_7 or F_8 given to farmers for testing. Closest method to participatory varietal selection since farmers given nearly-finished product.	Easy to use across locations	Recommended by Galt, 1989 Maurya *et al.*, 1988
3. From F_3 onwards farmers and plant breeders work together to select and identify the best material. Farmers are the selectors. Plant breeders facilitate the process by giving advice on which characters are heritable, and on selection methods. Pre-release multiplication can take place in parallel to the participatory plant breeding. Release proposal prepared by plant breeder.	Possible to run selection procedures in more than one location.	Sthapit *et al.*, 1995
4. Breeder gives F_3 or F_4 material to farmers. All selection and advancement of generations left to farmers. At F_7 to F_8 or later stage, breeders monitor diversity in farmers' fields. They identify, by phenotypic appearance and farmers' perceptions, best material to enter in conventional trials and pre-release multiplication.	Extremely easy to run selection schemes in many locations.	

Greater plant breeder input is possible by using a method of progeny testing. Plant breeders can produce progeny before giving material to farmers, and can produce progeny between generations of farmer selection. In the most extremely breeder-oriented system, the farmers' grow progeny trials of full-sib or S_1 families, and the breeder recombines from remnant seed the farmer-preferred progeny.

IMPACT OF FARMER PARTICIPATORY RESEARCH ON BIODIVERSITY

Biodiversity in crops

Biodiversity in crops is very difficult to define and a number of simplifications are assumed in the following discussions. The degree of genetic relatedness of one cultivar to another is not considered. It is assumed that if one cultivar partially replaces another, or several cultivars replace one cultivar, there is an increase in biodiversity. However, the degree of increase will vary considerably depending on the genetic dissimilarities among a range of cultivars that are adopted, or the genetic dissimilarity between an existing cultivar and one that partially replaces it. Moreover, biodiversity is not only a function of the total number of cultivars. Given two agroecosystems with an equal number of cultivars, the agroecosystem having a large proportion of the area occupied by a single cultivar is more genetically vulnerable than one where the cultivars occupy nearly equal areas. Great difficulties then arise between balancing the total number of cultivars against how equally they occupy the cultivated area. For example, in the case of rice in KRIBP, the question can be asked: does the adoption of Kalinga III reduce or increase biodiversity? Assuming it does not replace any single landrace completely, has it contributed to an increase in biodiversity by increasing the number of cultivars grown, or has it reduced biodiversity by occupying a large proportion of the area where previously several landraces were grown?

Biodiversity can be over both space and time. When one cultivar totally replaces another, there is an increase in biodiversity over time. There is also a temporary increase in biodiversity over space until the replacement is complete because, while replacement is occurring, there are two cultivars in farmers' fields instead of one. The pattern by which this replacement takes place, from many or only a few foci, will also be important. We can assume that there is greater biodiversity when the new cultivars spreads from many foci. An example of this type of spread is seen in the case for new chickpea cultivars in KRIBP (Table 3). The spread from many foci will give a more complex pattern between farmers' fields, providing a useful increase in biodiversity. The vulnerability of a crop to a disease is reduced when there are many field-to-field differences than when there are few. This strategy of field-to-field variability has been recommended by Priestly and Bayles (1980, 1982). However, regional variation in cultivar diversity is also suggested as useful in disease control by Frey *et al.* (1977).

When participatory research increases replacement rates, and thus reduces the longevity of individual cultivars, biodiversity is increased over time. It is again a useful increase in biodiversity since pathogens and pests are exposed to a particular genotype for less time and have less chance to overcome host plant resistances.

Participatory varietal selection

When farmers are exposed to the 'basket of choices' of a range of new cultivars in a participatory selection program, the outcome in a specific region may be an increase or a reduction in biodiversity. The situation is complex and changes in biodiversity depend on existing variability in fàrmers' fields, the variability in the new cultivars offered to farmers and their acceptability, and the variability in the target environment, both physical and socio-economic. A few common scenarios are illustrated in Table 5, but the number of combinations of existing variability in farmers' fields and the variability in the material that replaces or partially replaces are infinite (Fig. 2).

Often the most important variable will be the range of diversity that farmers can be offered in the 'basket of choices'. The more variability in the basket for quality traits, and the better the adaptation of the cultivars to the local environments, the more likely that several cultivars will be adopted. The basket of choices is likely to be larger when there are local breeding programs with specific objectives producing a range of products, rather than networked breeding programs targeting the production of cultivars with wide adaptation.

The greater the physical diversity in the environment, the more likely it is that more than one cultivar will be adopted by farmers. Diversity of economic use will also make it more likely that several cultivars are found acceptable and are adopted. Often farmers will prefer different grain types for different purposes. High yielding cultivars with poor quality grain may be grown as a cash crop or to reduce risk, whilst cultivars with high quality grain will be grown for home consumption, and for special social and religious occasions.

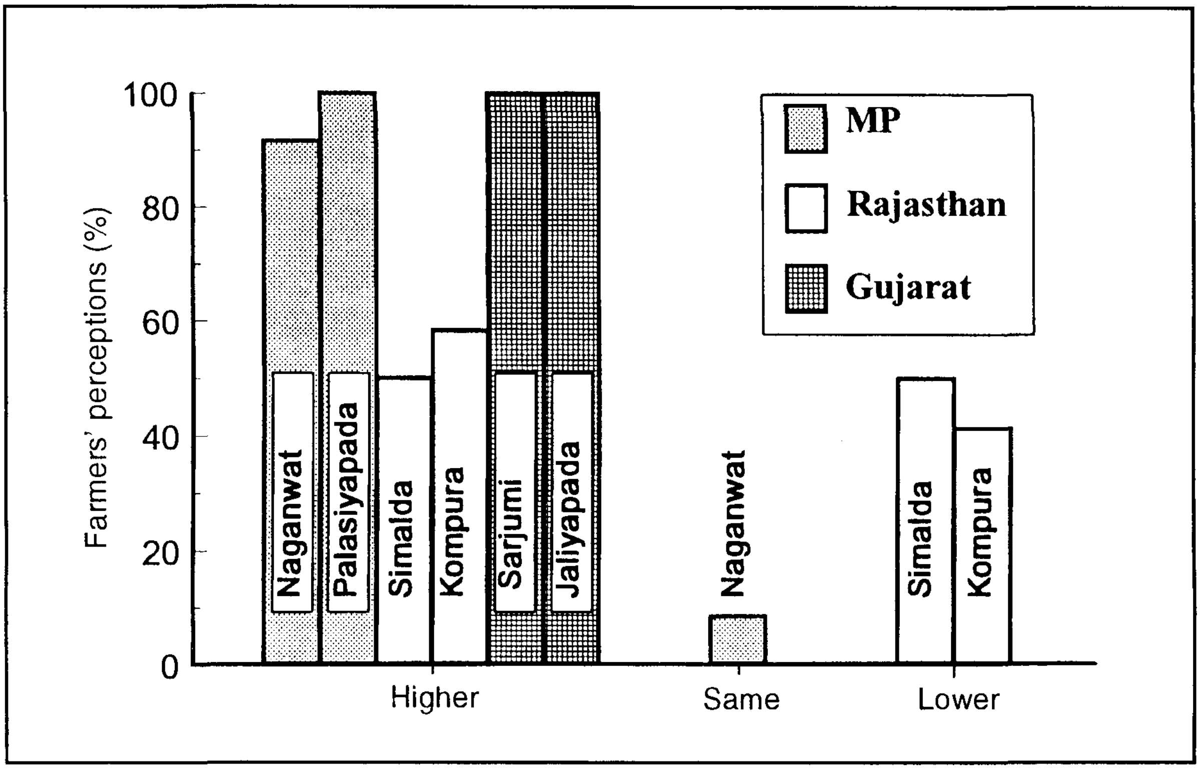
Nonetheless, when conditions are right for several or many cultivars to be adopted then it is likely that great diversity already exists in farmers' fields. When PVS is employed in areas where highly variable landraces are grown and there is no or little adoption of improved cultivars then its success will reduce biodiversity. This dilemma is faced by NGOs that wish to conserve biodiversity and help resource-poor farmers. One example of the problem is given by Cromwell and Wiggins (1993). An NGO, the Save the Children Federation in The Gambia, were faced with 'the dilemma of seeing just one of its introduced rice varieties almost completely replace the range of local varieties previously grown, which were no longer suitable because of declining rainfall."

Table 5: Examples of the effect of participatory varietal selection (PVS) on biodiversity in a single agroecological zone

	Biodiversity		
Environment	Decrease	Increase	Comments
Marginal	New cultivar or cultivars replace landraces.		Common situation in marginal areas where adoption rates of improved cultivars are so low that landraces remain in farmers' fields.
	Single cultivar replaces a range of improved cultivars.		Under conventional varietal testing system the existence of a range of introduced cultivars in a marginal environment is unlikely. Moreover, PVS exposes farmers to a range of cultivars and often more than not one will be adopted.
		New cultivar partially replaces existing cultivar or cultivars.	Increase in biodiversity over medium to long term.
High potential		New cultivar completely replaces existing cultivar.	Biodiversity over time increased.
		Replacement rates increased.	Increase in biodiversity over time.
		Greater number of cultivars adopted than those existing.	Likely because farmers exposed to a greater choice of cultivars.

Biodiversity can also be considered over a wider area such as at the national level. We can assume that the widespread adoption of participatory methods will increase the replacement rate of cultivars, so that the average age of cultivars grown by farmers will be reduced and biodiversity over time increased. It is also likely that adoption ceilings of improved cultivars will increase at the cost of reduced biodiversity. Overcoming inefficiencies that limit the adoption of improved cultivars to relatively small areas will be balanced by the adoption in any area of a greater number of cultivars. PVS reduces biodiversity when a cultivar is adopted over a wider area, and a good example is the rapid adoption of Kalinga III in western India following PVS by farmers when the cultivar was previously only released in eastern India (Joshi and Witcombe, 1995). However, in the longer term, PVS should have only beneficial effects on biodiversity. If many more farmers are exposed to many more cultivars, the number of cultivars adopted will increase and the patchwork of cultivars between fields, districts and regions will increase in complexity.

Figure 2: Farmers' perceptions on a village to village basis of yield of Kalinga III in comparison to local in six villages in three states, *kharif* 1993



Participatory plant breeding

The impact on biodiversity of participatory plant breeding, in contrast to PVS, is easy to predict since PPB will increase biodiversity under nearly all circumstances (Table 6). When compared to PVS, the increase in biodiversity will be at both the intra- and inter-varietal level. The effects of PPB will be more uneven than with PVS, with a very high impact on biodiversity in the participating villages, and an impact that elsewhere is restricted to cultivars that spread from village to village (Table 6).

Table 6. Comparison of farmer participatory varietal selection and participatory plant breeding in relation to biodiversity

Participatory varietal selection	Participatory plant breeding
No effect on intra cultivar variability.	Increase in intra-cultivar variability.
Smaller increase in number of cultivars in cultivation.	Large increase in number of cultivars.
Fairly uniform impact in increase in cultivar number over large areas.	Variable impact. Maximum and considerable impact in participating villages. Number of new cultivars decreases with increasing distance from these villages.
Breeding strategies to produce finished cultivars unchanged.	Breeding strategies changed. All changes tend to favor increase in biodiversity.

In predominantly self-pollinating crops, the adoption of PPB brings a change of methodology (Table 7). Instead of conventional pedigree breeding, bulk population breeding is employed whereby farmers mass select within segregating populations, such as the F_4 bulk families used by Sthapit *et al.* in Nepal. Hence PPB increases biodiversity at the intra-cultivar level overcoming the 'disease of cultivar uniformity' (Lopez, 1994). Intra-cultivar variability in the form of multiline cultivars is recommended as a strategy for reducing disease (Browning and Frey, 1981), but in this method intra-cultivar diversity is deliberately minimized apart from variability for disease resistance genes. The intra-cultivar diversity generated from PPB is more akin to a varietal mixture and such mixtures have been effective in disease control (Wolfe, 1990).

Table 7: The influence of participatory plant breeding on cultivar uniformity in predominantly inbreeding crops and its implications

Participatory plant breeding	Conventional breeding
Bulk population breeding is used since it is suitable for participatory breeding. It requires less resources than pedigree breeding.	Pedigree breeding may be more effective, (but pedigree breeding not likely to be more cost-effective).
Method does not produce a pure-line cultivar. Increases biodiversity within the cultivar but causes seed certification difficulties. It is possible to overcome this by reducing diversity; single pure-line cultivar, or a version selected for uniformity. Could be produced using little extra resources.	Method produces uniform pure-line cultivar. Procedures for testing release, and certification of cultivar already in place.
Biodiversity promoted in participatory villages both within and between cultivars.	More difficult to monitor spread of any variety in participating villages because of biodiversity created. Concern on part of breeders that farmers may have produced many varieties so which one to identify and promote? However, any improved preferred variety is better than none.

PPB is also a logical second stage to PVS, and if the appropriate breeding methods are employed then it comes closest to the ideals of genetic conservation. After PVS has been successful, the farmer-preferred cultivars can be crossed to other materials for farmers to select in the progeny. Breeding strategies will involve crossing the cultivar identified by participatory varietal selection (termed the PVS cultivar) with landraces and with high-yielding released cultivars. In the first strategy, the landrace is chosen as a parent to give genes for adaptation, and, in the second, a released cultivar is chosen to give genes for high yield potential. When landrace x PVS cultivar crosses are used and there is maximal farmer input in the breeding (the last method in Table 4). then we have a breeding strategy that most closely resembles *in situ* conservation of landraces. Farmer experimentation on naturally existing genetic variation has produced landraces, and this method enhances such farmer experimentation. Genetic variation is increased by the hybridization between the landraces and the PVS cultivar, and selection procedures by farmers and farmer awareness are enhanced by interaction with scientists. Nonetheless, in this process there is a possibility that some useful genes present in the landraces will be lost so *ex situ* conservation will still be desirable. Certainly, if there is a desire to wholly preserve the existing landraces, then *ex situ* conservation is essential. We can say that *in situ* PPB conserves genetic resources in farmers' fields whereas *ex situ* conservation preserves genetic resources.

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RESULTS, METHODS, AND INSTITUTIONAL ISSUES IN PARTICIPATORY SELECTION: THE CASE OF BEANS IN RWANDA[1]

L. Sperling and U. Scheidegger

ABSTRACT

The paper presents results of a five-year program (1988-93) on participatory selection of beans (Phaseolus vulgaris L.) in Rwanda. It looks at the technical and social challenges of integrating farmers into on-station selection as well as issues in setting up a country-wide program on decentralized selection in community plots. Choice of farmers, trial design, and evaluation procedure can affect the technical findings but also influence the potential to institutionalize participatory selection procedures on a broad scale. Some of the trade-offs between a research-focused v. a development-focused participatory selection program are highlighted. Finally, the paper discusses participatory selection in the light of the recent and wide-scale civil disruptions in Rwanda. Farmer-centered methods are being used to evaluate possible varietal and genetic erosion, and participatory selection has been proposed as a major means for reintroducing landrace material to Rwandan communities.

INTRODUCTION: BEANS AND BEAN EXPERTISE IN RWANDA

Beans (*phaseolus vulgaris L.*) are pivotal to the Rwandan household. Eaten twice daily — with pods, green seeds, leaves and grains all variously thrown into the cooking pot — beans provide 65% of the protein and 32% of the caloric intake (MINIPLAN, 1988). Beans are the "meat" and to some extent the "bread" of the Rwandan countryside.

The centrality of beans for nutrition is matched by their key role in agriculture. Grown by 95% of farmers, in all major regions of the country (from 1000-2200 meters), beans are sown two, sometimes three seasons a year. A third remarkable aspect lies in their genetic diversity with Rwanda providing one the most varied and vibrant bean varietal pools in the world. At least 550 local varieties are found countrywide, with important and unique types having evolved from both the MesoAmerican and Andean genepools (Scheidegger, in CIAT 1993; and S. Beebe, personal communication). Households manage varietal mixtures of up to 30 components (Lamb and Hardman, 1985; Voss, 1992), altering blends according to different soil conditions, crop associations and seasons. Such mixture use encourages production stability as well as utilization of the country's highly diverse production niches.

Yet, while most Rwandan farmers need and directly grow beans, have been exposed to very diverse materials, and manage complex mixes, they were for many years at the fringes of the

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research system. The selection sequence of the Institut des Sciences Agronomiques du Rwanda (ISAR), paralleling western models, sought farmer feedback at the very last stages, in on-farm trials, if at all. Further, farmers were offered but two to five options — the tip of a selection funnel originally numbering some 200 entries. Follow-up surveys in 1988, showed ISAR with some laudable bean successes — but short of what could be expected in a country where a Rwanda farmer on her own may test 75-100 varieties in a lifetime (Sperling, 1992).

In was in the spirit of improving performance for highly heterogeneous production environments that ISAR and International Center for Tropical Agriculture (CIAT) researchers took the first steps towards a participatory selection program in 1988. Two key questions shaped inquiry. Was there 'untapped potential'? — that is, could farmers absorb and productively use a much greater range of cultivars than that currently delivered by the formal research system? Second, could breeders and farmers, working together, achieve important gains: could they target more environments, faster, and more productively?

OVERVIEW OF THE PARTICIPATORY SELECTION PROGRAM

Phase I:1988-1990

The results of the first phase of research have been reported elsewhere (Sperling, 1992, Sperling *et al.* 1993). In brief, from 1988-1990 the experiment centered on participatory, on-station screening. Local experts, in Rwanda, drawn from the pool of older women, evaluated 15 cultivars in on-station trials two to four seasons before normal on-farm testing. On-station evaluations revealed that experts select bush beans along two general axes, preference and performance criteria, with many of the attributes not easily anticipated in a formal breeding framework. On-farm results demonstrated farmers' ability to target cultivars from station fields to their home plots. Farmer bush bean selections outperformed their own mixtures with average production increases of up to 38%; breeder selections in the same region on average showed negative or insignificant production increases. In addition, the diversity of cultivars desired by farmers was considerably greater than that normally on offer: the number adopted over the two-year experimental period, 21, matched the total number of varieties released by the national program in the previous 25 years (Sperling, 1992; Sperling *et al.*, 1993).

The first phase of the participatory selection, although collaborative, remain very much research-oriented. The major conclusions are summarized in Box 1.

Box 1
Participatory Selection with Rwanda Bean Farmers:
Technical Results: Phase I, 1988-1990

1. Communities recognize differing expertise in varietal selection. These go beyond the frequently-cited divisions of gender and age. Some women are known for astutely distinguishing among varieties for particular farming contexts.
2. Farmers' varietal criteria overlap with breeder concerns but also contain 'composite' traits. These composites, which represent combinations of features, help determine actual performance on-farm and are hard for formal breeders to anticipate.
3. Farmers can target from station to on-farm plots, both meeting their own agronomic and socio-economic criteria as well as achieving production gains.
4. Farmers are ready to use a wide diversity/number of cultivars.

Phase II: 1990-1993

In 1990, CIAT and ISAR expanded the farmer participation experiment, exploring specific themes in several directions.

The format

On-station, researchers wondered whether farmers could be brought a stage earlier, five to seven seasons before normal on-farm testing. This also implied that farmers would be screening many more lines. Was there a limit on what farmers could handle?

For the three years, farmers viewed a trial normally containing about 80 lines. To minimize risk, the CIAT pathologist screened this trial earlier than usual and eliminated the most disease susceptible entries (to anthracnose, aschochyta, bean common mosaic virus and rust). So in fact, farmers screened what researchers felt was the 'largest possible reduced risk pool', some 79, 41 and 43 lines in 1990, 1991, and 1992 respectively. Bringing farmers in this early amounts to what might be termed 'prototype screening' and in any such premature collaboration, researchers should make special efforts to anticipate risks which farmers cannot.

In terms of broadening the program on-farm, the concerns of Phase II focused on how to encourage communities to select their own expert representatives and how to evolve much of the on-farm testing to where it belongs — communities themselves. The move towards 'devolution' was a healthy mixture of empowerment and economics. Communities should have the right to select their own delegates to screen on-station. Communities should also control how those 20 or 25 chosen varieties are subsequently tested in rural areas. In practical terms, such a selection program can only be widely decentralized, targeting germplasm for many different areas,if communities bear the brunt of the local-level costs (Sperling and Berkowitz, 1994).

From March 1990 onwards, women experts coming to station represented the interests of three types of ad hoc local groups : farmers' research groups backed by non-governmental organizations (NGOs) for specific development projects, self-organized and independent groups of 'research-oriented farmers'; and several groups of farmers united by geographic proximity in an administrative unit known as 'commune'.[2] The cultivars women selected were then managed in various types of community plots, the NGO probably serving several hundred farmers, the commune units potentially reaching up to 6,000 households. (Hence total potential population reached, 27,000 households or about 135,000 persons). Thirty to fifty farmers were normally invited to review each community plot. One or two of the selected varieties were to be given to each evaluator at harvest, eventually to be tested in their home plots the following seasons.

It is important to note concerns among scientists towards the concept of Phase II, which some saw as at the border of biological research — and moving towards extension. The participatory program came under yearly review from the Great Lakes Regional Bean Network Oversight Committee, an interdisciplinary group representing national institutes of Burundi and Zaire and

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[2] In other contexts, such as Zaire, the participatory experiment was carried out with well-organized farmers' cooperatives. Unfortunately, Rwanda has a limited tradition of farmers cooperatives or with any grassroots organizations which might lobby for farmers interests or organize collective ventures on a large scale, for example, credit or marketing.

Rwanda. Here, the feeling was that research itself would be needed to determine the 'hows' of the program's institutionalization, not only for Rwanda, but for a range of African national partners. Partially to address issues of rigor, the program was eventually set up as an experiment in which the normal breeding sequence served as the 'control' and the participatory program as the 'treatment'. The two schema were eventually to be compared along such parameters as number of acceptable varieties identified and adoption rates. Box 2 outlines the testing framework (Scheidegger, fieldnotes).

Box 2
Research experiment to compare two varietal selection frameworks

Season*	Classic procedure (ISAR)	Decentralized selection with farmer participation
1989A	Triage trial	
1990A	Comparative trial	
1990B	Comparative trial	Selection on-station by expert farmers---20 varieties
1991A	Multilocation 1	Commmunity selection plot; 50 farmers per community
1991B	Multilocation 1	Farmer designed and managed trials c.150 (no researcher intervention). Independent evaluation by farmers.
1992A	Multilocation 2	Follow-up of 150 trials to identify which to test in controlled plot
1992B	Multilocation 2	WAIT
1993A	On-farm trials	
1993B	On-farm trials Release of varieties	
1994 A& B	Researcher managed trials to compare the varieties chosen for diffusion with the 4 most frequently multiplied by farmers. 4 replicates, 1 trial in 6 communities in Southern Rwanda	
1995A	Adoption study of 6 communes	

*'A' denotes the season covering the period from September through January. For example, 1989A, extended from September 1988 through January 1989. 'B' denotes the season covering the period February through July.

Select results, Phase II

From the initial screenings, it was clear not only that different farming communities wanted to test a number of varieties, but that they had diverse needs and preferences, for instance, some farming areas were moving principally toward climbing bean varieties, others focusing on what they felt would be 'poor soil performers'. Table I suggests the span for trial evaluations near the end of 1992: only 5 of 19 bush bean entries were chosen across all farmer groups. Communities represented in the on-station screening were located within about a 50 km radius, and gradients in soil fertility was perhaps their most important differentiating variable.

Table 1: Farmer selection of bush beans from community plots, Rwanda, 12/92-1/93*

Variety	SITES				
	Sahera	Rutsatira	Gikongoro	Save	Muganza
RWR 756	X	X	X	X	X
RWR 1058	X	X		X	X
RWR 1115	X	X	X	X	X
RWR 785	X		X	X	X
RWR 779	X	X	X	X	
RWR 911	X	X	X	X	X
RWR 1134	X				
XAN 162	X	X	X	X	X
G484	X	X	X	X	X
RWR 719	X	X	X		X
MLB 49-89A	X			X	
URUGEZI		X	X	X	X
SCAM 80 CM/5		X		X	
RWR 14			X		
RWR 802			X	X	X
RWR 853			X		
RWR 1056			X		
MLB 40 89A			X		X
RWR 1059				X	

* Shading highlights varieties chosen by all farmer groups.

The participatory experiment had proposed that varieties selected by communities and which later showed wider adoption, should be brought back into the formal system and baptized as farmer-breeder varieties. Subsequent seed multiplication and distribution would have to be decentralized to meet diverse regional needs.

Perhaps the most important insights during Phase II lay with institutional concerns. Turning over both the choice of on-station representatives to communities as well as subsequent community plot testing does not always mean that community needs are served. This certainly rang true in Rwanda where relationships even at the neighborhood or 'hill' level are marked by hierarchy and where women fall near the bottom of the heap no matter what the class or ethnic group. "Women have no race" goes one proverb, indicating that their power derives from their relationships to significant male others, brother, father, whatever the case may be.

In practical terms, the power structures and particularly male hierarchies, distorted the expansion of the experiment at several key points. In the selection of farmer representatives to screen on-station trials, researchers had the sense that some of the so-called community-selected experts, were neither very informed, nor very representative of community interests. For instance, one community was represented by the government agronomist's sister, and the sector head's wife. The male authorities in charge linked power with knowledge, and imputed male knowledge to their female sidekicks. If he was an important official, she must be a farmer expert.

There was also concern that key figures in charge sometimes fell short on their obligations to community participants at very last stage. The community plot was laid, evaluations completed, but seed of selected varieties was never distributed. So in theory, the data was in, but the seeds never got out to home plots. The advantages of working through administrative structures are many: these units exist countrywide, in all agro-ecological zones and potentially canvasing all farmers. They have the land and could incorporate a mandate of decentralized selection. The philosophy of such units, however, is sometimes governed by 'control' rather than 'service'. Given their substantial strengths, researchers hoped they could be reshaped to collaborate more fully.

The experiment did thrive when women themselves had some control and when the community saw itself as a true community. The women's cooperative, supported by a Belgian NGO, was well organized and very serious about the research. Five experts were sent to station, varieties chosen were subsequently tested on designated group members' plots, and the cooperative as a whole agreed what to multiply, what to discard and what to test further. Over a ton of seed was multiplied before other communities had started to budge.

TECHNICAL AND INSTITUTIONAL CONCERNS

Participatory breeding programs are often viewed by scientists as technical experiments (e.g. do farmers' have expertise? can they effectively screen segregating populations?), yet some of the greatest challenges may lie in identifying appropriate institutional forms. Within the Consultative Group for International Agricultural Research (CGIAR), institution building has principally been focused on national institutions, for instance, helping National Agricultural Research Systems (NARS) become more client-oriented (Merrill-Sands *et al.*, 1991) However, equal if not greater challenges may rest at the community level: how to identify or help create organizational bodies which represent the full range of farmer interests and which can serve as on-going research partners to a welcoming formal sector. Incipient work on the effectiveness of working with local farmer groups (Ashby *et al.*, 1995) and larger farmer organizations (Merrill-

Sands *et al.*, forthcoming) is pathbreaking. However, it remains marginalized and detached from the hard core science concerns within the CGIAR.

While it may be a conceptual leap, cost-effective breeding hinges on identifying legitimate and representative local partners, and in some cases, expanding the local power base. In the longer-term, local partners, and particularly solidly-organized local groups, should create a demand-pull on research, reshaping the larger pool of varieties on offer and selecting from this the most promising options for localized experiments (see Ashby and Sperling, 1995). Expressed in popular form, one might think of the research station as an inventory warehouse: the goods are on offer to whet clients interests/needs, with customers selecting out only what is relevant. Future stocks, even prototype models, might be developed together with clients, and certainly, with clients' needs in mind.

The shift from a focus on exploring of technical expertise to one of experimenting with institutional options was accompanied by a changing methodological emphasis.

On-station procedures

In terms of technical concerns, great care was taken on-station to find out how to make the on-station trials 'transparent' to farmers, that is, to assure there were no hidden biases. Though seed color and shape of trial entries might be similar to local varieties, it was explained that farmers were evaluating varieties new to the region. Any use of manure was signalled, as was any other management practice which might enhance yields. For one season, researchers planted varieties in a box format, 3m by 3m, rather than sowing in two lines, so that farmers could better see a clump of the variety, walk around it, and more easily exchange comments among themselves. Farmers said they appreciated the effort, but it made no difference; they were used to testing varieties in small, odd patches.

Another experiment tried to examine validity of farmer evaluations in the face of a single replicate assessment. Eight varieties of bush and climbing beans (total 16), which had been chosen by women farmers the preceding year from ISAR's trial, were grown with and without 30 t/ha of farmyard manure. While farmers normally evaluate a single replicate, during 1991, a select group scanned some six. Repeatability of farmer scores was high for clearly good or bad yielders, while scores were not fully consistent over replications for intermediate varieties. It was observed that farmers differentiate parts of higher and lower soil fertility within an experimental plot and then estimate yield for both parts separately. This way of looking at experimental plots, if less objective, may be more refined than the experimental procedure of determining total plot yield and, under highly diverse soil conditions, could result in a fairer judgement of varieties. Farmers also stated that there were no visible differences among replications, that is, there was no relation between fertilization and crop development. This qualitative assessment was in full agreement with statistical analysis of yield data (Scheidegger, in CIAT 1991).

During the initial phase of the program, there was also a strong focus on direct "feedback". Scientists wanted to learn first-hand how farmers evaluate: by which criteria, the ranges of acceptability within criterion, as well as the trade-offs among varietal features. The evaluation format was comprehensive: farmers scored each variety and assessed its positive and negative traits. Interviewing was often one on one, scientist (or technician) to farmer.

As the experiment evolved, exposing farmers to a greater range of germplasm and moving towards a community (versus individual) focus, so too methods had to be retooled. From the scientist point of view, in-depth evaluation of 80 entries was no longer logistically possible, nor perhaps necessary. The evaluation format aimed for efficient procedures which encouraged sharing among farmers and gave feedback (or 'feedforward') out to communities rather than channel back primarily to research offices. Farmer groups, each region sending three to five representatives, were given two sets of colored ribbons to indicate varieties they wanted to test in future community plots and those they felt should be eliminated. They marked as many entries as desired, negatively and positively. After the tagging, plenary field discussions focused on the varieties most often signalled, the outlyers (those with one ribbon), and any variety which particularly captured farmer interest. While one might argue that ribbons confounded results, that is, farmers visualizing others' choices might be unduly influenced, farmer representatives, eager to ferret out the most suitable varieties for their own home areas, perceived no problem. On the contrary, they enjoyed exchanging ideas and reflecting on inter-group differences. They found the final tallies particularly exciting. Ribbons allowed them not only to reflect on their own choices, but to immediately synthesize the results of five group selections. Such synthesis, usually confined to office corridors, was visually striking and illuminating. During the second phase of on-station evaluation, feedforward came at the expense of detailed feedback, with more cursory identification also the consequence of greatly enlarging the options on offer.

On-farm procedures

On-farm procedures also followed a course from intensive to more extensive monitoring. Farmers designed and managed their individual home trials during phase I, but researchers asked for a local check and were on hand to weigh and sometimes help harvest experimental plots. For the research community, qualitative and quantitative information was critical for assessing whether farmer selections from on-station trials had actually performed. Farmers, of course, often carry checks in their heads and don't need a scale to show if the variety is a winner.

During the second stage, tested paradigms within communities were determined by participants themselves and in part reflected the group's orientation towards its members. The farmers' research group, technically assisted by an NGO, decentralized testing and evaluated together. A core group, designated as the research contingent, divided up the station-selected varieties and tested them on individual plots: group evaluation was then completed by means of a walking tour (PAMU, 1993). The group subsequently multiplied and diffused the most promising entries. The Rwandan Program received a written report on the farmer evaluation, by which time the varieties had already been launched on their way among other community members.

The experiment within the administrative units ('communes') was conducted in a very different and more standard manner. The agronomist took control, station researchers drew up a standardized protocol (varieties sown in lines, at given densities) and some local farmers were invited to evaluate the plot and select varieties for home use. One advantage was that more farmers were exposed to a greater range of cultivars than in the previous model. Such a top-down research posture at the community level is not atypical of many local grassroots groups, who may have some trained technicians---trained under standard models. Due to their greater involvement in commune evaluations, researchers received feedback more quickly, but the progress towards adaptive testing on individual plots and further diffusion was significantly slower.

The different methods and designs used through the experiment represented trade-offs for the various actors involved. Researchers were initially disappointed by the level of farmer expertise proffered--when communities themselves controlled participant selection. Perhaps with greater experience, the power structures would have better signalled exceptional skills within the global group 'women'. Some scientists also lamented the decline in detailed feedback as farmers screened a larger pool of germplasm and as some subsequent community designs and evaluations ignored 'researcher language' altogether, for example, no yield data. The move towards community-oriented models, however, brought important gains to local participating groups. Ribbon evaluations were more transparent; more farmers directly benefitted on farm, and, in the best of cases, farmers identified and distributed productive varieties with unusual speed. As institutionalization of the approach hinges on community participation, standard research models will have to reorient towards communities' own research and development (R&D) concerns.[3] Box 3 summaries select institutional issues of the second phase of research.

Box 3
Participatory Selection with Rwanda Bean Farmers:
Institutional Concerns: Phase II, 1990-1993

1. Differences in varietal preferences among even closely-spaced farming communities suggests that participatory selection has to be coupled early with decentralized seed multiplication programs.

2. Scaling up of a participatory selection program, implies formal sector research must partner with organized groups of farmers, rather than individuals, to share the costs and responsibilities of widespread varietal research.

3. Working through community institutions does not guarantee that community needs are served. Local power structures--for example, male hierarchies--can distort the fundamental premises of a 'participatory' program. The challenge is to identify local organizations which represent the range of farmer interests and which can serve as research partners.

4. Working with farmer groups demands that methods be developed which 'feedforward' information to communities as well as feedback insights to the formal sector. There may be important methodological trade-offs between community R&D and formal sector R&D approaches.

EMERGING RESEARCH MODELS

Perhaps the most important technical lesson of the five-year experiment is that farmers use a wider range of criteria than breeders do for selecting varieties: observed yield is important--but so is, for instance, a variety's compatibility growing with bananas. Furthermore, the criteria farmers use and their relative importance varies by region. If given access to appropriate germplasm, farmers have the edge in targeting for their varied local circumstances.

Institutionally, it has also become also clear that farmers can organize themselves to test quite a wide range of germplasm on-farm, although the different organizational structures and protocols used will influence which and how many households can be reached and even the number of germplasm entries potentially accommodated. Research on possible arrangements for community testing needs to be carried much further.

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[3] For instance, facing similar challenges in India, the KRIBHCO project is recommending that 'farmer-acceptability' data, versus the standard yield trials, be considered as sufficient evidence for varietal release (J. Witcombe, personal communication).

The results of experimental program suggest that the standard breeding models may not be using each partners', breeders and farmers, talents to best advantage, particularly in areas marked by marginal, heterogenous environments. Breeders may not be the best candidates to select for the diversity of needs/preferences nor for the difficult 'composite' traits. Breeders' unique expertise lies in their capacity to generate new genetic variability. Farmers do cross and select, but at an extremely slow rate: scientific breeding accelerates the process. Breeders might also concentrate on those constraints/opportunities which are 'invisible' to farmers: e.g., certain pathogens and diseases. In turn, the finishing of the product, targeting the variety to a particular production system, can and should be left to farmers. To pursue this goal, farmers' would need access to a wide range of germplasm (Box 4).

Box 4
Conceptualizing a new division of breeding labor

Breeders	Farmers
• Create new genetic variability → → →	← ← ←
• Make accessible wide range of germplasm (local and exotic)	• Target for agronomic conditions performance)
• Screen large amounts of material for 'minimum' criteria	• Target for socio-economic circumstances (preference)
• Screen for key stresses 'invisible' to farmers	

Rethinking the breeding division of labor probably also demands that the scientific community rethink how they evaluate the relative success or failure of the growing number of participatory breeding trials. In Rwanda, initial stages were marked by an exclusive focus on production or impact achievements. Our conceptual framework sought to compare the standard program and experimental program in terms of 'end-result' variables: for instance, number of acceptable varieties identified, number of disease resistant varieties identified, rates of adoption of the two sets of material adoption. Varietal diversity of the ISAR-released v. farmer-selected material mainly came into view as a evaluation-variable when it became clear that farmers wanted many and varied cultivars. However, aside from giving farmers access to a wider range of options on-station, the experiment was not shaped to specifically enhance genetic diversity on-farm. Much more could have been done to 'promote genetic diversity' had the participatory program been conceived with this primary goal in mind.

As the experiment evolved, 'community capacity to serve as research partners' lunged to the forefront as a process to strengthen. The technical findings alone (e.g. "farmers can expertly target varieties") could not deliver adapted varieties to local groups. Enhancing community control and research skills therefore became a central issue in enhancing the efficiency of breeding. Within such a perspective, 'empowering communities' becomes a functional necessity for achieving cost-efficient research programs. Box 5 starts to sketch parameters along which we might start to evaluate our participatory breeding trials, according to each program's specific focus. Broadly, at least three perspectives presently guide such participatory experiments: some practitioners focus on production achievements, some on the enhancement of genetic diversity, and still others on the shifting of control (of germplasm and the breeding process itself) to communities and other grassroots organizations. Successful participatory breeding programs should probably show positive indicators in all three categories. Relative emphasis will vary greatly according to the primary objective of the program.

Box 5
Participatory breeding programs: potential evaluation criteria

Functional perspectives
(orientation:products)

Production/Impact Enhancement	Genetic Diversity
# farmer-acceptable varieties	genetic profile of released varieties
# disease-resistant varieties	incidence of landrace parents
absolute production gains	•
rates of adoption	•
•	
•	

Control/empowerment perspectives
(orientation:process)

degree to which:

farmer skills are enhanced to more effectively cross/select themselves

farmers gain fuller access to wide pool of germplasm

farmers control local testing

farmers are involved in decisions of varietal release

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AFTER THE GENOCIDE: VARIETAL ASSESSMENTS AND REINTRODUCTIONS

The escalation of the Rwandan civil war in April 1994 resulted in the death of about one million persons and the displacement another two million. Agriculture, the main occupation of upwards of 90% of the population, was acutely affected as civil disruptions peaked in the midst of the normal February-June growing season. Harvest losses overall during this period have been estimated as high as 60 % (Dr. Iyameremye, nd).

The aid community, particularly NGOs and various United Nations agencies, responded swiftly and on a wide scale to the agricultural crisis. During the subsequent growing season, September 1994-January 1995, large amounts of seed of key crops were distributed: 6970 MT of bean, 1707 MT of maize, and 7230 kg of vegetable seed (MINAGRI/UNREO/PNUD/FAO, 1994).

The CGIAR has responded along lines of its own advantage, assessing the state of varietal and genetic erosion and developing strategies to restock germplasm in national research sites as well as on farmers' fields. A 'Seeds of Hope' (SOH)[4], initiative, is now multiplying collections of local material, breeding lines, and improved lines appreciated by farmers for possible reintroduction. For beans alone, 170 landraces have been obtained through national and international genebanks. The first nationwide surveys, conducted through a range of NGOs (CARE, World Vision, Swiss Disaster Relief, Catholic Relief Services and Medécins sans Frontières) has suggested that varietal loss has been less than anticipated: 45% of the seed sown during the first post-event season came from farmers' own stocks (Sperling, 1995a). In August/September 1995, surveys will further examine this issue of varietal loss for the most vulnerable areas, those which experienced large-scale population movements.

Methodologically, in reference to farmer participatory selection, two interesting developments can be signalled.

First, SOH is looking at the complementarity and differences between farmer varietal assessments and molecular genetic assessments. Farmer assessments tend to be site specific and indicate the degree to which farmers can access desired varieties (that is, varieties which have useful traits which are available in useful combinations). Molecular assessments (using RFLP) suggest the presence/absence of genetic characters nationwide and map region variations at community (versus farm) levels. Both programs aim to determine the genetic and varietal needs of Rwandan

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[4] The Seeds of Hope Initiative is a joint rehabilitation initiative of the CGIAR. Formalized in September 1995, many African NARS have contributed germplasm, field space, and advice to the initiative: those of Burundi, Ethiopia, Kenya, Malawi, Tanzania, Uganda, Zaire, Zimbabwe and, more recently, Rwanda. In addition, some eight of the International Agricultural Research Centers (IARCs) are strongly involved in the Rwandan Agricultural reconstruction:

International Center for Tropical Agriculture (CIAT)
International Maize and Wheat Improvement Center (CIMMYT)
International Potato Center (CIP and its network PRAPACE)
International Center for Research in Agroforestry (ICRAF)
International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)
International Institute of Tropical Agriculture (IITA)
International Livestock Research Institute (ILRI)
International Plant Genetic Resources Institute (IPGRI)

farmers and to guide the rebuilding of genetic collections at ISAR (Sperling, 1995b, and S. Beebe, personal communication).

Second, farmer participatory selection is being proffered as a major method of reintroducing germplasm at the community level, should varietal restocking be necessary (World Vision, J. Hooper, personal communication). As provenance data on the 170 landraces needs to be sharpened, the proposals suggest that entries roughly be sorted by high, medium and low-altitude adaptation and then be moved to community plots for further targeting. In the Rwandan context, farmer participatory selection thus becomes a chosen strategy for research and development initiatives but also for emergency aid and rehabilitation efforts. Let farmers help get the germplasm to where it can best be used.

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DEVOLUTION OF PLANT BREEDING

T. Berg[1]

ABSTRACT

Centralized plant breeding, producing uniform varieties broadly adapted to huge areas, leads to a reduction of farmer-managed crop diversity and an increased dependence on genebanks for the survival of the genetic resource base. Much evidence points to decentralized breeding, specific local adaptation, and intra-varietal diversity as advantages from a biological point of view. The exploitation of location-specific adaptation and more heterogeneous varieties require a different organizational framework compared to that of the established formal plant breeding institutions.

The systematic use of improved, but still location-specific and heterogeneous varieties is possible if seed selection is devolved to the community level. Potentials of that approach are discussed with reference to two cases: one, in Ethiopia, which involves traditional seed selectors, and one, in the Philippines, which re-introduces abandoned seed selection practices. Organization of such decentralized seed selection is likely to result in new demands on the genebanks and new challenges to the scientific breeding community. While genebank collections are little used in current plant breeding, local seed selectors will be interested in previously collected landraces from their own or ecologically-similar areas. Plant breeders will be challenged to supply enhanced germplasm or populations for local selection or reselection.

INTRODUCTION

A major objective in modern plant breeding is the making of crop varieties with the highest possible yield potential. Yield potential is defined as "the yield of a crop when growth is not limited by water or nutrients, pests, diseases, or weeds" (Kropff *et al.*, 1994). For farmers, whose crops are indeed limited by such constraints, this yield concept may not be seen as the most relevant objective.

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[1] I am indebted to farmers in Tigray in Northern Ethiopia and their representatives in REST (Relief Society of Tigray) who received me with great hospitality shortly after end of the civil war in 1991. They introduced me to their land, their culture and farming system, and particularly to their organizational approach to seed management issues, their Community Seedbanks.

I also thank farmers organized in the CONSERVE project at Cotabato in Mindanao, the Philippines, the CONSERVE staff, and their supporters in SEARICE, Manila. They, too, received me with never failing rural hospitality and shared their experiences and views during a visit in August 1994. I also owe much to Ms. Mary Lou L. Alcid, Manila, who reviewed the project together with me.

In the recent couple of years, I have also learned from friends within the Community Biodiversity Development and Conservation Programme (the CBDC-programme) whose vast experience from working with communities in Latin America, Africa and South East Asia has been a great inspiration. The viewpoints and reflections in this paper are, however, entirely my own responsibility.

Relieving crops of all sorts of environmental stress leaves light and temperature, together with varietal characteristics, as the only determinants of yield. That achieved, the same high yielding variety can be used all over a climatic zone, and the target area for the variety is enormous. If stress can not be eliminated, however, adaptation to a usually site-specific environment becomes necessary. In that case, the target area for each variety will be small.

Do these different perspectives warrant different approaches to plant breeding? Conventional wisdom says no. In experiments where varieties are tested at various levels of inputs, the same high yielding variety usually comes out as the top yielder at all levels. Therefore, plant breeders often claim that their varieties not only perform excellently under high-input conditions, but would also be better than traditional varieties in a low-input environment. However, when these trials are taken outside of experimental farms and the varieties are tested under local or farm conditions, researchers discover what is called 'crossover in performance'. At a certain level of stress there is a crossover point beyond which local varieties or landraces perform better than the high yielding varieties (see Evans, 1993:164-168 and Ceccarelli, 1996).

Farmers who experience such situations are not a tiny minority. To some degree, most if not all farmers have to cope with local stress conditions. The stress-free environment is hard to achieve, and even harder to sustain. In many favorable areas, farmers abandon the high-input technology for economic reasons[2] or because of ecological problems[3], thus increasing the need for locally-adapted germplasm. But modern plant breeding, whether public or private, can not supply adapted germplasm everywhere. Only a system of local seed selection can ensure that. And that means devolution of plant breeding.

Can such decentralized breeding be compatible with development needs in a changing world and meet economic aspirations in a poor society? If the answer to these questions is going to be 'yes', the decentralized breeding must be able to take advantage of the power of science as well as of the capacities of local communities. Three aspects should be considered and made mutually compatible: breeding technology, participatory research methods, and organization at the community level.

TECHNOLOGY: TOWARDS AN EVOLUTIONARY PLANT BREEDING

Commercial varieties enter the market through a system of trials and official release. That system requires uniform and stable varieties, and the breeding work must be streamlined for such end results. But local selection is not constrained by those requirements and therefore enjoys some freedom that does not exist within the formal system. Farmer-breeders are free to distribute heterogeneous varieties and can allow crops to continue evolving.

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[2] Pingali (1993:298) summaries the economic situation for irrigated rice production in this way: "Given low prices, declining or stagnant yields and increasing input costs, the profitability of rice production has been steadily declining".

[3] The International Rice Research Institute (IRRI) has experienced declining yields in long term experiments with high yielding varieties and the same amount and timing of nitrogen inputs. In the early years of the Green Revolution, dry season yields of 9 t/ha and wet season yields of 6-7 t/ha were common. Today the yields are 6,5 t/ha in the dry season and 4-5 t/ha in the wet season (Cassman *et al.*, 1994).

Exploiting heterogeneity and crop evolution in farmers' fields are outside the scope of most plant breeding research. One exceptional experiment, however, has shed some scientific light on the issue. It was started at the University of California (UC) in 1928. Composite cross populations of barley were produced, some of which were extremely diverse in origin of sources. These populations were exposed to continuous natural selection in current modern farming environments (Allard 1988, 1992) and became the subject of studies during the career span of several generations of UC professors. It appears that after low yields in the initial years, the composite cross populations gradually improved in performance and eventually became quite good yielders, with excellent yield stability and disease resistance. These results inspired Suneson (1956) to propose an evolutionary plant breeding method. After assessment of later generations of the same material, Soliman and Allard (1991) concluded that such evolutionary breeding "is unwarranted" if yield potential is the major goal. However, if disease resistance and yield stability are two major objectives, "the composite cross approach is an efficient method". This amounts to saying that a major part of world agriculture, many high-input systems included, could be well served by this approach.

In short, this means constructing a body of broadly diversified germplasm and exposing it to natural selection in areas of contemplated use (Suneson 1956). For those who are familiar with traditional farmers' breeding, this may sound like reinventing the wheel. In fact it is an improvement of the old wheel of plant breeding.

The first step, constructing a body of of broadly diversified germplasm, is not all that straightforward. Science has access to world collections and information sources that are unavailable to farmers. A research institute can chose relevant germplasm and make composite cross populations with an evolutionary potential most probably far beyond that of locally available varieties.

The immediate outcome, the early generation composite cross population, will be unadapted everywhere and is likely to yield poorly. With time, however, recombinations and natural sorting will improve the adaptation, and, according to the Californian experience, narrow the gap with commercial varieties. The long term outcome could be populations that outperform commercial varieties in disease resistance and yield stability and that may be used as a source of artificial selection for high yield.

The disease resistance appears to have evolved through the building up of polygenic complexes. Therefore, it provides a durable resistance (Allard, 1990) as opposed to the monogenic and, therefore, mostly non-durable resistance usually bred into commercial pure line varieties. The stability, at least to some degree, depends on the buffering effect of crop heterogeneity. The Californian experiment shows that when the population is propagated in isolation for a very long time, diversity will start declining, resulting eventually in reduced stability (Soliman and Allard, 1991).

Taking the lessons from these experimental findings into the context of current development needs, a few conclusions can be drawn. We need breeding populations with a very high evolutionary potential, and these populations must be exposed to the stress conditions of, or similar to, current farm environments. Furthermore, a certain level of diversity within populations must be maintained in order to sustain evolutionary potential and yield stability.

Landraces are usually found to be heterogeneous. But do they have the evolutionary potential required by current development needs? Are they being subjected to a selection pressure that ensures yield stability, and are they as high yielding as they could be?

Scientific evidence may not be available to give direct answers to such questions. Community visits may not be helpful either. A confusing picture of different selection practices and frequent change of seeds (and therefore lack of persistent long term selection), appears in many communities where traditional seed systems prevail. It is also common to see the coexistence of modern and traditional varieties (Brush, 1995). More systematic efforts and a certain level of organization are necessary to make full use of the knowledge already existing within a culture, to exploit fully the potential within the locally available germplasm, and to take advantage of opportunities provided by science.

COMMUNITY ORGANIZATION

Widely diverse forms of organizations dealing with seed management have sprouted up at the community level in recent years. I will present an Ethiopian case representing a traditional society, and a Philippine case representing a modern society. Criteria of classifying these societies as traditional and modern are access to external markets and farm inputs. These were absent in the Ethiopian case and present in the Philippine context.

The Ethiopian case is from Tigray, in the middle of the famous Abyssinian gene center (Berg 1992). Renowned for genetic richness and for knowledge and culture related to seed management, the area should be expected to provide an excellent site for community seedbanks. But seedbanks were organized more because of poor seeds than because of genetic wealth. Poor seeds were seen as one of the reasons for poor agricultural performance. This was in the 1980s and the area was isolated by war. No external support was possible and community leaders had to look for sources of improvement within their own communities. They knew that those sources existed as, in all societies, there were experts known for their skills in traditional seed selection who had fine local seeds. But they needed an organization to extend the benefits of those experts and those seeds to the wider community.

The Philippine case is from Mindanao, from a community where all farmers have formal school education, and where most of them have taken over their farms after the introduction of modern farming. These farmers had no memory of a pre-Green Revolution practices, such as seed selection and traditional seed management. In recent years, however, some of them have switched to organic farming because of declining profit margins in the high-input system. This has created a need for a different type of seed and also an organization to recover and reintroduce the lost traditional seeds as well as to re-establish a local seed system.

These two cases, one isolated from, and the other influenced by, the modern system required different organizational approaches to their seed management problems. In both cases, however, local seeds and on-farm selection were established as the platform on which to build.

In Ethiopia, the felt problem was poverty and recurrent famines. Community leaders saw poor crop performance associated with poor seeds as one of the causes, but also knew about individuals who had good seeds and had a reputation of being excellent seed selectors. They decided to extend the good seeds through a credit scheme. Community seedbanks were established and the local experts on traditional seed selection were used to identify good seeds for lending. Unlike genebanks, they were not concerned with conservation, but rather with the circulation of seeds. Like a commercial bank, they put their capital to work. They also had social concerns and gave priority to loan applicants who were poor and had a particular need for access to good seeds (and who needed protection against private moneylenders). The seedbanks were owned by the community and controlled by democratically-elected community assemblies.

The first of these seedbanks was established in 1988 and, within a few years, was replicated in most local districts of a region of close to four million people. The growth of the community seedbanks continued after peace, in 1991. But now the challenge is twofold: the seedbanks must develop in order to remain relevant; and they must protect their integrity and independence when government institutions and seed companies start appearing in the area.

During the war, people had no choice. They had to depend on their own resources. And they proved to themselves that the necessary skills and the required good seeds existed within their own community and could be used to solve their immediate problems. Currently, these Ethiopians do not seem to consider their seed effort as an emergency measure that can be phased out when government services and seed companies begin to function and, perhaps, to take over. They want to keep their seedbanks as permanent institutions. Their challenge now is to realize the development potential of these institutions and the evolutionary potential of their seeds within the context of an opened-up economy. But the seedbanks and their associated seed supply system are also a challenge for the scientific plant breeding system which is now being re-established in the area. That challenge need not render the local seed supply system obsolete by supplying better commercial seeds; scientists could opt to work with local farmer-breeders in order to ensure that seeds offered through the seedbanks remain competitive.

The case from the Philippines, the Community Based Native Seed Research Center (CONSERVE) in Mindanao, arose as a response to critical economic problems of the high-input system of rice cultivation. With increasing prices for inputs and decreasing prices for the produce, profit margins were shrinking, and farmers became dangerously dependent on moneylenders. Some individuals saw a switch to organic farming as the only way out. In that situation, farmers needed a new organization. Unlike the Ethiopian case, where community assemblies representing the entire community were the organizers and owners of the seed activities, this Philippine group was a minority, and membership was individual.

Starting in 1992, this group organized a search for local traditional seeds, which were recovered from farms in isolated remote areas. These seeds were multiplied and distributed to the members for on-farm evaluation and screening. After only two years of operation, I visited the project and found farmers discussing seeds with excitement. From an initial challenge of sorting and selecting among a great number of landraces offered to them, some had already started selecting within landraces, and some had started crossing varieties and keeping written records of what they were doing. They involved their wives and children.

More than a change of seeds had occurred; there was a change of mind also. Before, these farmers grew modern varieties. Such varieties are supposed to be pure, and off-types are considered as impurities. In case they were saving seeds, they had been taught to rogue the off-types before harvest to maintain varietal integrity. The change of mind involved seeing diversity in the field as a resource, rather than an impurity, and seeing themselves as active selectors, rather than passive receivers of ready-made varieties.

It is a mistake to consider this as a rejection of science. It is a withdrawal from the commercial seed system. If it is true that scientific plant breeders are working for farmers and not for seed companies, they might find organized farmer groups another outlet for their scientific achievements. That would require the development of participatory plant breeding methods.

PARTICIPATORY PLANT BREEDING

Certain trends have made the world ripe for adoption of participatory plant breeding methods.

- The shielding of crops from environmental stress in high-input systems is facing increasing economic and ecological problems[4]. Scientists are changing their attitudes, and a new paradigm is being formulated. Instead of modifying the environment to suit the requirement of high yielding varieties, the varieties need to be modified to suit the environment[5].

- The claim that modern varieties can be made broadly adapted and be superior across most farming environments within an ecogeographic region is being challenged. A number of recently published reports find varieties with specific local adaptation to perform better when varieties are exposed to local stress environments (Evans, 1993; Ceccarelli, 1996).

- If relevant diversity exists in a locale, the combined action of natural and artificial selection within a local environment may be an efficient breeding method. Experiments show that this may work also in a fertilizer-intensive system (Allard, 1988; Soliman and Allard, 1991).

- In recent years farmer groups working with local seeds have been organized all over the world. They are not primarily conservers of old seeds. They want their seeds to be improved, in an evolutionary, slow and steady way, and under their own control.

- Finally, participatory methods have been developed in order to facilitate the involvement of farmers together with scientists as active and equal partners in research to generate relevant farm technology (Mettrich, 1993). Such methods can be applied also to plant breeding (Sperling *et al.*, 1993).

To my knowledge, farmer attitudes to germplasm never include prejudice against modern varieties or any other form of exotic seeds. Commercial seeds often diffuse into areas where the traditional seed supply system is still predominant. Farmers try them with an open mind and adopt or reject them according to their own criteria. If grown and multiplied in the villages, diversity will start to appear within them and local reselection will be possible. In that way commercial varieties eventually might become like landraces.

It is also commonly observed that farmers change and exchange seeds. A traditional farming system rarely functions as an environment for the static preservation of old landraces.

I have never come across a community where seed management is uniform. Often practices range from neglect to very simple mass selection, but with a few scattered individuals who devote an exceptional amount of effort to the maintenance or improvement of seed quality. These

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4 See Pingali (1993) for review of economic problems of high-input rice farming, and IRRI (1994) for summary of yield decline data and hypotheses of causal soil environment problems.

5 This plant breeding perspective of the new paradigm is discussed by Ceccarelli (1996). The soil science perspective of the same paradigm is formulated in this way: "Rely more on biological processes to optimize nutrient cycling, minimize external inputs and maximize the efficiency of their use. Efficient nutrient management, therefore, is the basis for the second paradigm" (Sanchez 1994).

exceptional persons, very often women, may be the source of good seeds for others in the community.

Once such a community is organized for seed management and improvement, it becomes possible for it to establish links to scientific institutions. According to what I have gathered in a number of community visits, there is nothing in traditional attitudes that would make people reluctant to join a participatory breeding scheme -- if it provides them with a wider selection base and prospects of progress through on-farm evolutionary breeding.

Community resources for participatory approaches to seed management and breeding are not limited to indigenous culture and traditional practices. The educational status and experiences of modern farmers may also be turned into a resource for community action. In the Philippine group, a number of the members were high school graduates and a few had a university degree. And moreover, most of them had a couple of decades' experience with modern input-intensive farming. Seed activities opened their minds towards the traditional societies, towards themselves and towards the modern world. The traditional societies supplied them with their seeds, and through the seeds, they learned to appreciate the values and achievements of these societies. They discovered their own potential, and saw that the outside world could bring more than technology packets: it could bring knowledge and ideas to be exploited and further developed by themselves.

IN CONCLUSION: USING BIODIVERSITY

Institutional plant breeding depends to a large extent on the recycling of a limited gene pool (Kannenberg, 1987). The genebank collections serve as sources of genes for resistance to diseases and pests and little else[6]. This limited use of germplasm collections may in the long run pose a serious threat the genetic heritage kept in genebanks. Who will keep paying for the maintenance of enormous numbers of seed samples that are hardly requested by anybody? Localized evolutionary breeding, however, will need the landraces with their specific adaptation and could, potentially, increase the demand on the genebanks tremendously.

Genebanks are organized to serve scientific plant breeding. In recent years, genebanks are also being used to supply seeds for re-establishment of landraces that have been lost from disaster areas. This is done or planned for areas in Cambodia, Eritrea, Ethiopia, Somalia and Rwanda. But otherwise, local communities are not yet established as *bona fide* users of genebank materials. If farmers are organized and linked up to scientific institutions, it would be possible to establish a channel for return of relevant germplasm from genebanks to farm communities.

To some degree the direct return of landraces to areas from where they were originally collected and to other areas with similar agroenvironmental conditions may be warranted. However, it might be more useful if genebank materials are made available in the form of enhanced and enriched populations. Scientific institutions can synthesize such populations, but adaptation and selection should take place in farmers' fields.

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6 "The wealth of genetic variation in adaptive responses to soil and climatic conditions conserved in the world's gene banks is little known and less used relative to that in resistance to pests and diseases, but it may yet prove to be the most important genetic resource of all" (Evans 1993:168).

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DISCUSSION

LOEVINSOHN: A question to John Witcombe. I wonder why you have used only released varieties in your participatory selection scheme, rather than including a range, possibly also including local checks or near local (i.e. varieties found locally or nearby) so as to make a wider pool available from which farmers might select?

WITCOMBE: When we formulated the project, we had a process which is called a 'search process' in which we defined all possible sources of germplasm to try with the farmers and that included failed cultivars, cultivars which had been rejected from the coordinated projects, even though we felt they had farmer desirable attributes, advanced lines from plant breeders, pre-released cultivars and released cultivars. But what actually happened is that as we went into the search process, we found that there was a huge diversity of choice amongst the released material that was unexploited. We saw the advantages of going with released material because, if you start there first and get something which farmers prefer which is released, then your uptake part, the effectiveness of your research is so much greater. If that procedure fails, or if we want to build on the research, our second route has been to go to participatory plant breeding as the route of choice. For example, in the maize where we have had very little success with released cultivars, (although 'Shweta' which is released in Uttar Pradesh has been adopted by our farmers), we have gone to creating specifically a composite which includes local landraces and farmer preferred cultivars-- very broadly based.

GHILDYAL: Dr. Witcombe, you are working in a rainfed environment and this environment is not uniform. Over even a 100 m distance, the environment changes, the water regime and soils change. Therefore, the lack of adoption you mention may be due to the very varying environments.

WITCOMBE: The recommended cultivars in the area are all dwarf, high yielding cultivars. The rainfed cultivars which are recommended are of late maturity. All of the material which has succeeded are recommendations from outside of the states in which we are working, and the reason why there is no adoption has been because the farmer have not been exposed to those cultivars. It is a lack of popularization--which is a failure of the release system. When a cultivar is released in one state, for example in Orissa, which is the case of Kalinga 3, there is no formal mechanism for ensuring that it is tested in other states. We were the first people to test Kalinga 3 in Gujarat and Madhya Pradesh more than one decade after it was popular in Orissa.

RILEY: I have a question for Trygve Berg. When he referred to the barley work that was conducted in California, which was conducted, as I understand it, under natural selection conditions, to what extent would the results be applicable to what we are talking about in terms of farmers' selection of landraces, where farmers are the predominant entity in shaping the nature of landraces? Could extrapolation of that natural selection experiment perhaps lead to some erroneous conclusions?

BERG: One of the first scientists to analyze this material was Suneson who published his paper in 1956 and proposed 'evolutionary plant breeding'. What he claimed was that the natural selection which had occurred had not only established material with a high degree of stability and disease resistance, and a reasonably high yield, but also established a base for line selection of improved materials, and therefore he wanted to exploit this.

The base for the success and the evolutionary progress of this material was, of course, wide diversity. I am not sure that this wide diversity, which can bring about such progress, is present in all the landraces which farmers have. I don't think it is, but we don't know enough about it. I think scientists can contribute a lot to create diverse materials from which selection, both natural and artificial selection, can be made under local conditions.

GUPTA: The process of taking advanced lines of segregating populations to farmers can serve two purposes. One is the selection itself, and the second is to use it as a heuristic tool to help unfold the criteria which people use....These criteria may not be revealed in response to questions about the varieties that they have been using for ages.

The second point relates to parallel processing--where farmers can be brought to station and can be exposed to far greater choices than you can ever share with the farmers in their fields, because of the constraints of what you can take to farmers' fields....As farmers make selections in their fields and on-station, so scientists will make their selections. And the two can be compared to see if consistent characters are being selected for or whether different genetic qualities are being advanced in each. That would be a useful approach.

SAHAI: A question to Dr. Sperling. You mentioned this model--'division of labor' you called it-- and what the inputs are that farmers could provide and what the inputs are that breeders can provide. Is this model actually working anywhere?

SPERLING: The 'division of labor model' is one that has been most fully developed in Rwanda, but also tested, with beans, in Zaire and Tanzania and with agroforestry species in Burundi. I want to mention that the model changes, even with the same crop, when taken to different sites, so that models have to be adapted to specific situations. If we consider the general principle of saying that, as the breeders' function we should offer the farmers a wide array, that is diverse, and then set up the mechanisms for farmers themselves to select and target these varieties then we could say that this general division or principle is being experimented upon in many crops and sites: e.g. cassava in Colombia, pearl millet in India, barley in Syria.

SINHA: I've restrained myself from commenting earlier, but I think this discussion has some important implications for plant breeding in India.

I think it is important that we consider some of the historical developments of plant breeding. One of the first phases was when there were shortages and there was a need for wider adaptability, particularly in the areas of assured inputs. What we have heard today are examples drawn largely from rainfed and upland conditions where there has not been such a large impact of selections or release of new varieties. In areas of assured input, however, there have been important gains. It is also now realized that local selection of regional specificity is going to be far more important--not that farmers have not done it in this country. There is a farmer I happened to visit last year, Mr. Rana, who also happens to be a graduate of St. Christopher's College, who took to farming. He has himself selected a variety of wheat, which is being sold, which gives eight tons--as against the six or seven tons from commercial varieties. He has also selected varieties of cotton out of material being provided---so this kind of effort is going on.

A second, important point made by L. Sperling, was about the selection of crops, here beans, for certain conditions, like under bananas, etc, in intercropped situations. Most of our plant breeders were trained in Britain where single crop cultivation was a normal practice. When they came back, they essentially devoted their time to those situations to which the had been exposed. It is true that selection for intercropping and multiple cropping systems has not been effective and that this is an important, required aspect of tropical agriculture....

There is now a lot of consciousness regarding the need for location-specific selection and we have started by giving 10 to 15 pre-released varieties to the Sone Command Area [Bihar]. However, the mechanisms as such need to be changed at the governmental level....

DIAGNOSTIC METHODS FOR BREEDING PEARL MILLET WITH FARMERS IN RAJASTHAN

E. Weltzien R., M.L. Whitaker, and M. Dhamotharan[1]

ABSTRACT

The role of local farmers in ICRISAT's pearl millet improvement project for Rajasthan has changed: from unidentified suppliers of local germplasm to the base material of a formal breeding program, to active collaborators in selection and variety development. On-farm trials, designed to expose farmers to a wide range of diversity for traits that the local landraces do not possess, provided the starting point for this change in farmers' roles.

Farmers' evaluations of this new diversity have provided insight into their preferences for specific traits and their production objectives, thus allowing the breeding program to focus on improving traits of primary interest for farmers in the target region. Farmers from different regions, and farmers representing different social groups prefer different traits and place different emphasis on yield stability versus maximizing yield in favorable years.

Interested farmers have selected among a wider range of advanced experimental varieties in on-station trials. Their selections reflect the needs of their communities and production conditions.

Farmers' traditional strategies for seed selection and preservation vary among individuals within a village and across regions. Farmers are exploiting the variability generated by the natural outcrossing between the local landraces and the experimental cultivars. An initial on-station evaluation of the effect of this selection indicates that farmers are selecting effectively for improved productivity.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R.Br.) is the primary cereal crop and staple food in the driest, hottest regions of India. In the state of Rajasthan, it is grown on 4-6 million ha annually, which represents approximately 45% of the area planted to this crop in India and approximately 20% of the world acreage. In Rajasthan, productivity of pearl millet has increased only marginally over the past decades, and adoption of modern cultivars is very low. In contrast, modern cultivars of pearl millet are widely grown in better endowed environments in India, and have contributed

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[1] We thank the Department of Watershed Development of the State Government of Rajasthan and the German Agency for Technical Cooperation (GTZ) for their financial support; the Social Work and Research Center, Tilonia, Ajmer District, the Watershed and Soil Conservation office, Jodhpur, the Central Arid Zone Research Institute, Jodhpur and the URMUL Trust for Rural Development, Bikaner district for their interest and support in providing local contacts and insights; the local investigators and all participating farmers of Udaipur Khurd, Nunwa, Aagolaie and Kichiyasar villages for their untiring efforts and openness.

to significant increases in productivity (Jansen, 1989). This situation suggests that specifically targeted crop improvement efforts are required for the harsh environments in Rajasthan. The research presented here is part of a collaborative effort with local and national institutions to identify and develop technologies to improve the productivity of this farming system.

This paper describes the experiences of the ongoing pearl millet improvement program in Rajasthan, with emphasis on diagnostic methods developed for focusing the target of the breeding program on farmers' needs, some lessons learned from applying these methods, and future directions in methods and research.

BACKGROUND

Pearl millet in the farming systems of Rajasthan

The dry environments of Rajasthan are a good example of variable stress environments in the semi-arid tropics. In the pearl millet growing areas, mean annual rainfall ranges from <250 mm in the west to >500 mm in the east. Annual fluctuations in rainfall are large and pearl millet grain yields of 100 kg/ha or less are not uncommon in western Rajasthan (Sharma and Pareek, 1993; Gupta *et al.*, 1994).

Pearl millet is the staple cereal in western and central Rajasthan and, in the west, up to 80% of the gross cropped area is sown to pearl millet. It is usually sown in crop mixtures with short season legumes. Livestock are an important part of the farming system. Pearl millet and legume residues are valuable fodder sources, and farm yard manure is the primary fertility amendment used by farmers.

Breeding for marginal environments

During the Green Revolution era, plant breeders worldwide focussed their efforts on improving varietal performance under favorable growing conditions in which water and nutrients were available to the crop when required. Improved disease resistance was regarded as a key component of yield stability. Three assumptions underlay this approach: (1) that genetic gains could be achieved most efficiently under favorable conditions; (2) that poor soil fertility conditions would be generally overcome through the amendment of mineral fertilizers; and (3) that the genetic gains achieved under favorable conditions would also be beneficial under less favorable, stressed, or marginal growing conditions (Blum, 1985).

Farmers' experiences and research results of the past 10-15 years suggest that the latter two assumptions do not generally hold true, and that specifically targeted efforts are required to address the needs of farmers cultivating crops under marginal conditions characterized by abiotic stresses such as heat and drought (Matlon, 1987; Weltzien and Fischbeck, 1990; Weltzien and Witcombe, 1989; Ceccarelli, 1994; Haugerud and Collinson, 1990).

Selection theory indicates that genetic gains under low productivity conditions are expected to be highest when selection is practiced in the target environments (Jinks and Connolly, 1973; Simmonds, 1991). Results from breeding programs designed to target marginal conditions show that expectations for genetic gains for grain yield under such conditions are high, and individual programs have begun to show good progress (Weltzien, 1986; Ceccarelli, 1994; Richards, 1989; Atlin and Frey, 1990; Bidinger *et al.*, 1994). In these breeding programs, changes in the breeding strategy involved the use of appropriate base material for selection with good adaptation to the major stress factors, and the use of selection sites in the target region under marginal conditions. Critical to the choice of selection site and its management, as well as for the choice of appropriate base materials, is a good understanding of the environmental conditions under which the crop is expected to perform.

Successful breeding programs need well defined targets or goals. These goals must be consistent with farmers' needs and production strategies. For farmers in marginal environments, grain yield is usually not the only component of productivity. The stover is frequently used as feed for livestock, and thus stover yield may become an important determinant of crop productivity. In marginal environments, growing conditions, thus total biomass yield, particularly grain yield, vary greatly from year to year. Farmers may pursue different strategies to cope with this situation, e.g., maximizing grain or stover yield over years, or ensuring a minimum level of grain yield even under the most adverse conditions. An understanding of their strategies is required for targeting a breeding program to their needs.

In environments with frequent crop failures, farmers may be as concerned about crop survival and adaptive traits as they are about final productivity. By identifying traits which farmers consider important, the researcher can gain important insight into adaptation and acceptability.

Thus, for the appropriate choice of selection sites, the choice of appropriate base material, and for defining the goals of a breeding program for marginal environments, an understanding of the environmental conditions, farmers' needs and production strategies is required. Diagnostic methods for addressing these questions are described in this paper.

DIAGNOSTIC METHODS

Farming systems research (FSR) and on-farm research (OFR) methods have developed in response to the failure of much single commodity-focused research to meet the needs of complex farming systems, particularly in situations where farmers' needs are not well understood by researchers and where there are strong interactions between different sub-systems or components of the whole farm enterprise. FSR methods allow scientists from a range of disciplines to gain insight into the major processes and constraints contributing to productivity of individual components of a farming system. In FSR and OFR, commodity-focused researchers of different disciplines evaluate technology with the participation of farmers in the context of the whole farming system, i.e., taking into account the interactions between sub-systems. (Shaner et al, 1982; Norman and Collinson, 1986; Byerlee and Tripp, 1988; Norman, 1992).

Methodology for diagnostic research and farmer-researcher interactions has recently seen a large diversification with the adaptation of participatory approaches for rural development as a tool for agricultural research (Chambers *et al.*, 1989; Haverkort *et al.*, 1991). The advantages of participatory approaches to diagnostic research are generally seen in the speed with which reliable results can be obtained and in their open format, which allows for farmers' input of issues, topics and considerations, which are not anticipated by the researchers.

For research on pearl millet improvement, the diagnostic methods were driven by the need to understand the environmental conditions for pearl millet growth, to identify farmers' preferences for individual traits and trait complexes, and to understand interactions between livestock and crops, as these may affect farmers' requirements for pearl millet. These methods include analysis of secondary data on production environments to define target domains; on-farm farmer-managed trials to elicit farmers' trait preferences; surveys of farmers' seed production practices and on-station evaluations of breeding material by farmers; and surveys and informal discussions to understand the interactions between environment, crops, and livestock. An interdisciplinary team including an ICRISAT breeder, socio-economist, and agronomist, contact persons from government organizations (GO's) and non-governmental organizations (NGO's), and farmers participated in the diagnostic studies.

Identification of target domain, village sites, and farmers for on-farm diagnostic research

The research target is farmers for whom pearl millet production is important, in areas where local varieties still predominate and yields are low. The target region, shown in Fig. 1, is the western and central areas of Rajasthan, where pearl millet is the primary crop and staple cereal.

Choice of districts

Within the target region, four target districts were chosen to span variability in agro-environments, i.e., differences in rainfall patterns, soil types and crop-livestock systems: Ajmer, Jodhpur, Bikaner, Barmer. From Ajmer to Jodhpur to Bikaner and Barmer:

- Rainfall levels and reliability decrease from 432 mm seasonal rainfall in Ajmer to 304 at Jodhpur, 228 mm at Bikaner and 239 mm at Barmer (van Oosterom *et al.* 1995);
- Soils become increasingly higher in sand content and lower in clay content;
- Average pearl millet yields fall from approximately 400 kg/ha at Ajmer to below 100 kg/ha at Barmer;
- There is less experience or familiarity with modern varieties (MV's) of pearl millet (Kelley *et al.* 1996);
- Milch animals become less important, while sheep and goats are important in all the four districts.

Selection of villages

Local organizations (GO's or NGO's) in the target districts were identified to act as local links between ICRISAT researchers and farmers in the on-farm trials. The criteria for choosing local organizations were: interest of the organization in the research; experience/interest of the organization in the agricultural development of their target groups; and quality of their existing relationships with potential villages. NGO's were identified in Ajmer[2] and Bikaner[3] districts; two GO were identified in Jodhpur[4] district. Initially no suitable organization was identified in Barmer district; a year later an NGO[5] in Barmer was identified. Each local organization nominated individuals to serve as 'contact persons' for the collaboration.

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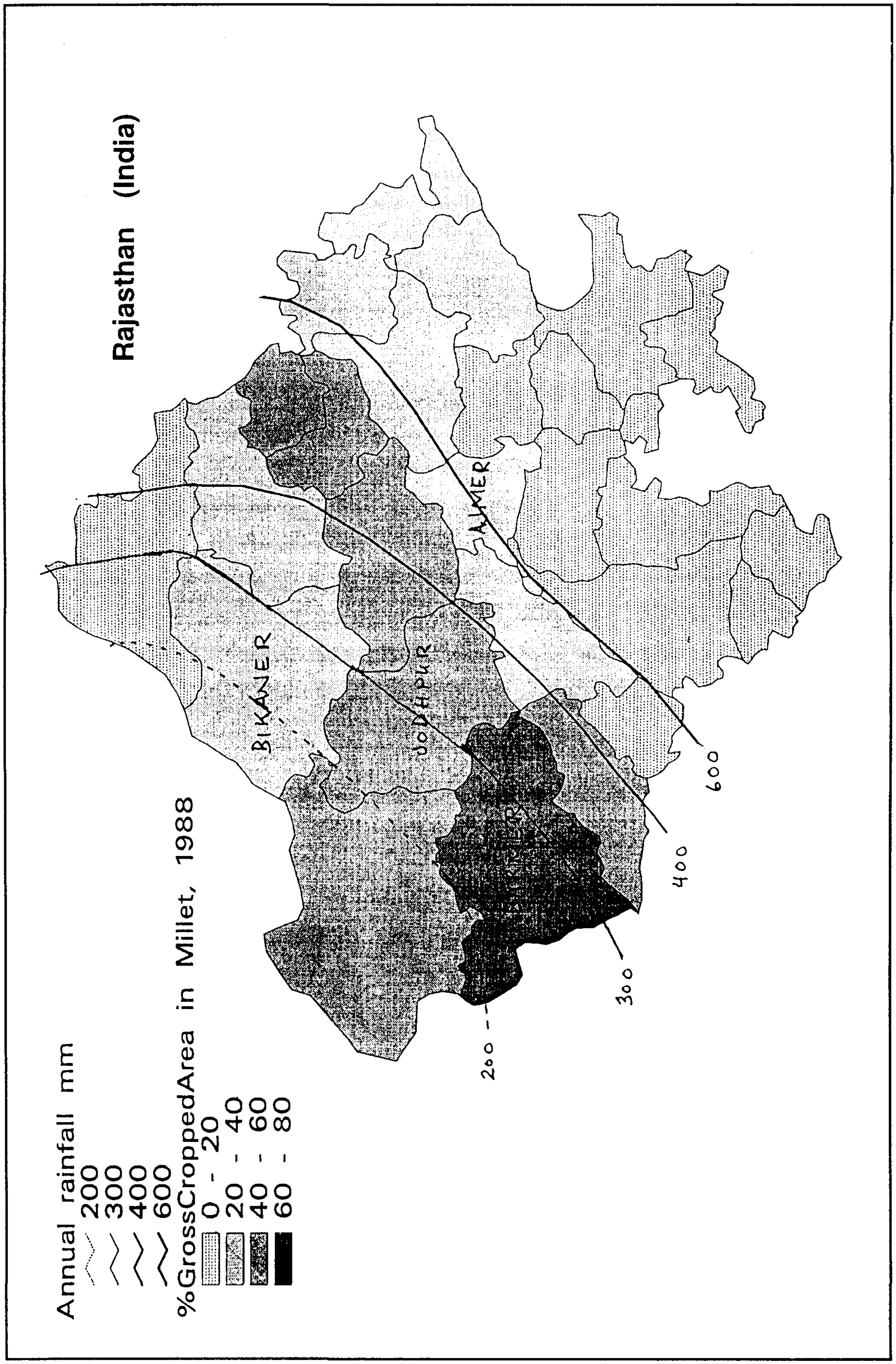
[2] Social Work and Research Center (SWRC), Tilonia, Ajmer District

[3] URMUL Trust, Lunkaransar and Nokha, Bikaner District

[4] Department of Watershed Development and Soil Conservation, Regional Office Jodhpur and Central Arid Zone Research Institute (CAZRI), Division of Economics, Jodhpur

[5] Society for Uplift of Rural Economy (SURE), Barmer and Bhadka, Barmer District

Figure 1: Distribution of pearl millet (% gross cropped area, on a district basis) and rainfall isohytes in Rajasthan and on-farm trial locations



Selection of village sites was done jointly by ICRISAT researchers and the contact persons. The criteria for choosing village sites were: (1) village ties to the local organization which would enable our work to build on existing trust of local farmers; (2) villages where pearl millet was important in the local farming systems and farm household incomes; (3) villages which are representative of the district in terms of agro-environmental conditions and socio-economic conditions, e.g., don't have extremely unusual soils or occupations; (4) villages where there are no social/political hindrances to effective researcher-farmer interaction. These are not easy criteria to evaluate through secondary data. Visits to potential villages with members of the collaborating organization and informal discussions with village farmers were used to evaluate appropriateness.

Village investigators and participating farmers

Once a village was chosen, ICRISAT researchers and the contact persons jointly identified one or two villagers as potential local investigators. The role of the village investigators was to monitor the on-farm trials and collect information from participating farmers during the crop season. The criteria for choosing investigators were: (1) one male and one female investigator in each village; (2) must be able to read and write sufficiently for project needs; (3) must have good relationships with village farmers and be able to interact positively with farmers of any caste; (4) must be interested and serious about the work. ICRISAT economists, with the assistance of the contact persons, conducted a three-day training workshop for village investigators to explain project goals and methods, and to train them in basic survey techniques. Based on their performance in the training program, investigators were employed.

To choose participating farmers for the on-farm trials, ICRISAT economists and the local contact persons visited each village with the investigators before the beginning of the rainy season. First, a meeting of farmers was held to explain the objectives of the trials and the way trials would be conducted.

Initial choice of farmers was done through a village census, in which farm households and their resources were identified (land, livestock, farm resources). The criteria for choosing participating farmers were: (1) to span the range of household resources, i.e., landholdings; (2) to include both men and women farmers; (3) to choose farmers with a serious interest in the research, i.e., a preference for experimenters and farmers interested in seed production.

In selecting villages and farmers, we have relied heavily on the knowledge of the local collaborating organizations. We are now developing some simple techniques for initial village characterization which provide rapid information to support village selection and to stratify village households in economic or social terms.

On-farm trials

Choice of pearl millet varieties for on-farm testing

Three contrasting varieties were chosen by ICRISAT researchers for the on-farm trials in 1992 and 1993. For the 1994 trials, four varieties were chosen. They were chosen to represent the widest possible range of variability of traits of potential interest to farmers, including different maturities, tillering potential, panicle and grain size. We preferred to distribute seed of open-pollinated hybrids rather than single-cross hybrids because farmers expressed interest in using the harvested grain as seed for the next season.

Methodology for on-farm trials

Thirty farmers participated at each location during 1992 and 1993. During 1994, 20 farmers in each village participated, to allow us to cover a greater number of villages. Each participant was given one of the experimental cultivars. For actual distribution of seeds, a lottery method was used. Each participating farmer was asked to take a piece of paper on which the name of a cultivar was written. This method helped to avoid consequences of imposing choice of seed on farmers.

Farmers were asked to sow the experimental cultivar near their own cultivar and to manage the two cultivars as similarly as possible, so that they could observe the relative performance on their fields. The plot size thus was also the farmers' choice, and varied with planting density and the crop mixture used. This is similar to the strip tests conducted by breeding firms, during the final stages of variety testing. The field location was chosen by the participating farmer.

Throughout the growing season, the village investigators monitored trials and collected information from participating farm households, including structured questionnaires on farm household resources, cropping history, crop and livestock management, crop management in relation to environmental stresses, changes in crop management over time, and management of the season's experiment.

Evaluation of on-farm trials

Three methods were used for eliciting farmers' trait preferences:

- Individual comparisons of experimental cultivars with farmers' own cultivar;
- Group interviews to compare a range of experimental cultivars;
- Farmers' descriptions of an ideal variety.

Individual interviews, group discussions, and formal questionnaires were used to improve our understanding of the environmental conditions for pearl millet production.

Individual comparisons

Before flowering, researchers and farmers visited each field and discussed field management and early growth of the experimental cultivar relative to the farmers' own cultivar. Prior to harvest, plots were visited again to discuss in detail farmers' perceptions of differences between the experimental and their own cultivar. Individual assessments while viewing the standing crop indicated what characteristics farmers use to distinguish between the cultivars. For each distinguishing trait, farmers were asked to rank the two cultivars, as well as on their overall preference. Researchers probed into reasons for preferences.

We thus obtained lists of traits that farmers used to distinguish between the two cultivars. This gives an indication for which traits the varieties differ, which traits farmers consider important, and which traits they look for when examining new genetic variability. This was particularly important during the first years, when we tried to understand what the main issues for varietal selection are. During the past year, we started to improve our understanding of farmers' opinions on tradeoffs between traits, like high tillering and panicle size, or early maturity and high biomass yield in good years. This involves more structured discussions on these specific topics.

The results of these discussions are certainly influenced by the particular genotype under evaluation and by the growing conditions in the experimental field. To try to overcome the first limitation, we discussed with each farmer the most important characteristics of an ideal variety. Furthermore, interested farmers were invited to the research station to examine a broader range of experimental cultivars (see below).

After harvest, farmers measured grain and fodder yields and evaluated grain and fodder quality of the experimental varieties in comparison to their own. Initially we used semi-structured interviews with individuals to understand the components of quality assessment for fodder and grain. Because responses were very uniform, we started in 1994 to evaluate the traits in group discussions in which all the farmers who grew one experimental variety formed a group (see below).

In the on-farm trials, each farmer was given only one experimental variety to grow. This minimizes risk to the farmer. With only one variety, the farmer observes keenly its behavior and characters relative to his/her own variety. We encouraged farmers to also visit each others' fields so that they would see the range of diversity in plant traits represented by the three/four experimental cultivars. But this seldom happened even when the fields were close. On the other hand, this approach has provided rich information on the growth and behavior of the cultivars in farmers' fields, as well as on farmers' trait preferences.

In the on-farm trials, researchers have made the initial choices of traits for farmers to evaluate. In the future, farmers could be involved at an earlier stage in defining the traits and trait complexes of potential interest to them for on-farm evaluation.

<u>Group assessments</u>

With different groups of three to six farmers each, representing farmers' participating in the experiments, non-participating farmers, and women farmers, we conducted group interviews to compare all experimental cultivars with each other and with the local cultivar at the end of the season. Groups usually toured a cluster of fields to see all experimental cultivars under similar growing conditions. Farmers collected three to four representative plants from each cultivar to have specimens available during the discussions.

Discussions were structured so that farmers were first encouraged to talk about differences between the local cultivars and the experimental cultivars. For each trait they mentioned, a picture was drawn on a card. The cards were then used to construct a matrix ranking table. Farmers ranked the three experimental cultivars for each of the characteristics they had mentioned. Usually these discussions led to other topics, such as crop management, crop utilization and seed selection.

In conducting these group discussions, care had to be taken to keep the groups small enough to be able to listen to the opinion's of individuals. In larger groups, there was a tendency for strong personalities to dominate the discussions. For the same reason, women group discussions had to conducted separately.

We also started using group discussions for the postharvest evaluation of yields and quality parameters for grain and straw in 1994. In this case, groups of farmers who had grown the same variety were formed, men and women separately.

The advantage of group discussion was that it frequently lead to discussions between farmers on debatable issues, and the researcher assumed more of an observing role. This allowed the researcher to gain a better understanding of the background for certain differences in preferences for traits, less driven by his/her own preconceptions on the issue under discussion.

One difficulty with organizing group discussion in the western part of Rajasthan is that farmers do not normally live in closed villages, but rather in hamlets near their fields. It can thus be very time consuming to arrange group meetings, and to conduct the field tour to look at each experimental cultivar under similar growing conditions. To overcome this limitation and to encourage visits to each other's fields, we had formed clusters of farmers, whose fields were close to each other. Within each cluster, all the three/four varieties were distributed randomly. However, with the high chance for crop failure, the frequent need for replanting and the wide range of soil fertility conditions in any small area, only a few clusters were successful.

Ideal cultivar

During the individual and the group assessments, farmers were asked to describe the characteristics of an ideal cultivar, thus ranking the individual traits that they had mentioned before. This was usually followed by discussions of the reasons for this ranking. The discussion of an ideal variety gave farmers the opportunity to mention traits that were not exhibited by the experimental or farmers' own cultivar, and to mention preferred trait combinations and rankings of traits. However, it was not always easy to keep farmers' imagination within the biological limits of the harsh environmental conditions of western Rajasthan.

Characterization of the production environment for pearl millet

The expression of individual traits of a crop cultivar depends not only on the cultivar's genetic composition but also the environmental conditions where the cultivar is grown. The growing conditions have important direct effects on a cultivar's growth and performance, but more importantly the expression of many productivity related traits depends on the interactions between genetic and environmental factors. These interactions are usually unpredictable, and thus an important part of formulating goals for a breeding program is the identification of key environmental factors and production constraints. Three areas were targeted through individual structured interviews and informal group discussions: farmers' fertility management, i.e., crop mixtures and rotations, fallowing practices, and fertility inputs; management of seasonal drought stresses, i.e., crop mixtures and response farming; and management of crop-livestock interactions.

Farmers' selection practices

We have experimented with farmers' participation in the selection among experimental cultivars and in varietal mixtures with the aim to complement formal variety evaluation with their opinions, and to confirm previous results on preferences by exposing farmers to a wider range of genotypes than what is possible in off-station conditions. We have begun to study farmers' practices for seed production, the type of selection they use, and the selection criteria they employ using in-depth informal surveys. Formal surveys conducted previous to this research also gave indications for criteria used for adoption of new cultivars (Kelley *et al.* 1996).

Farmers' selection in on-station trial

Farmers visited one replication of a trial evaluating the most advanced breeding materials resulting from the collaborative breeding programs with the Central Arid Zone Research Institute (CAZRI) at Jodhpur, and Rajasthan Agricultural University at Fatehpur-Shekhawati and at Jaipur

(Durgapura). Included in this experiment were appropriate controls and unimproved local varieties. Farmers were given ten numbered labels each. They were asked to attach the labels to the ten best rows they could find in the trial, considering the needs of their local area. Farmers were told to tie only one label per row. Each plot had four rows, and was accessible from both ends. Farmers thus had the opportunity to select the same genotype more than once.

Crucial for the success of these efforts is the identification of farmers who have a keen interest in seed issues and selection for their own local area and social group. We invited farmers from the villages where we were conducting on-farm trials, while conducting the final evaluations. The local investigators were encouraged to invite also farmers who are not growing trials of their own, but have an interest in seed issues. Care was taken to invite women groups separately.

Before showing farmers the trial, we held a discussion with the whole group on management practices on the station and the rainfall pattern during the season. Then groups of four to six farmers looked at the whole experiment before making their selections. We then discussed the range of variability that they saw, which traits might be useful, which ones problematic, and their considerations in making the selections. Care was taken to let participants express their personal opinion.

At the end of the farmers' visit to the station, we invited every participant to select one variety from the demonstration of approximately 20 advanced and released varieties. They received seed of the selected variety at the beginning of the following season.

We evaluated farmers selections in the trial by grouping the entries according to their predominant traits. i.e., earliness, tillering, panicle size, and then comparing the frequencies with which each group was selected. Differences between preference patterns for farmers from different agro-ecological zones, and between men and women were consistent with previous results, but often more pronounced.

Potential weaknesses of evaluating farmers' selections in on-station trials are: the trials are grown under different conditions than farmers' own; and farmers only see the varieties at one time in the season. Specific differences may not be clearly visible at the time of the farmers' visit, e.g., early maturity or synchrony of tillering, if the visit occurs late in the season, or grain and stover yield of all entries if the flowering range in the trial is large and the visit occurs earlier in the season.

Advantages of farmers' selection in on-station conditions are that farmers can be exposed to a much larger range of variability under uniform growing conditions than in the on-farm trials, with no risk of crop failure for the participating farmer. Farmers who decide to participate in the visit to the research station are usually keen experimenters and are prepared to spend time interacting with the researchers. Thus discussions are fruitful and informative. The fact that farmers choose their own variety for on-farm evaluation is advantageous, because it allows an earlier involvement of farmers in the process of varietal evaluation.

Selection in variety mixtures

Groups of two to four farmers were asked to tag the ten best individual plants. Each farmer did his/her selection individually in a plot grown to a mixture of experimental varieties. Each farmer was asked to cut the panicles from the three best plants and bring them for a follow-up discussion. Farmers were first asked to describe the most important features of their selections individually. This was followed by a discussion on the reasons for these choices.

The advantages of this method of using farmers' selections to understand preferences for specific traits is that it can be conducted at small stations or experimental farms that do not have the equipment and infrastructure necessary to grow large varietal trials under uniform conditions. They can thus be conducted in the area where the farmers live, and under management conditions that are more similar to their own practices. Farmers need to spend less time to participate in the exercise. This is particularly important for involving women and poor farmers. A further advantage of this method is that it is possible to let farmers cut selected panicles and bring them for the group discussion, because this leads to intensive interaction among the participants on the advantages and disadvantages of certain types of plants and traits.

The disadvantage of this method is that the genotype of each individual is not always identifiable, and it is thus not directly possible to give participants seeds of their selections for further testing in on-farm trials. Furthermore farmers do not get information on specific cultivars during the course of the interview.

Understanding farmers' methods of seed selection

Through semi-structured interviews in villages where farmers have participated in trials, we sought information about indigenous methods of seed production and selection. The interviews are mainly held with farmers who are locally considered as experts for seed selection and production. Topics addressed during the interviews include the traits used for selection under different conditions, factors affecting the decision to select in the standing crop or on the threshing floor, the storage of seed and food grain, and the movement of seed in and out of individual farms. During the interview process, much effort is spent to interact with individuals with specific knowledge and experiences of these issues. These studies are ongoing.

The advantages of these unstructured interviews is that they do provide in-depth information on what farmers regard as the main issues in relation to the topic of seed selection and production. The results are thus more likely to present a complete overview of important issues and trends as farmers view them. The results should be less limited by the researchers' own concepts and priorities.

Surveys on causes for non-adoption of modern cultivars

In an initial study, we used formal, structured, pretested questionnaires to understand farmers' perceptions of the merits of available released varieties, with specific emphasis on understanding issues related to stover yield and quality (Kelley *et al.*; 1996). The survey did give indications that the available modern cultivars did not have the necessary adaptation to the harsh growing conditions of western Rajasthan, and that stover yield and quality are important criteria for adoption or non-adoption of new cultivars.

However, the results of this survey were mainly limited by the fact that farmers in the marginal areas of pearl millet cultivation had not been exposed to the wide range of variability available among newly released pearl millet cultivars and pre-released experimental cultivars. Farmers could thus not consider the whole range of available variability while expressing their preferences and concerns. Furthermore the commitment of the individual farmer during the interview was less serious because the interviews were not conducted in the context of a commitment for further collaboration.

FUTURE DIRECTIONS

Evaluating varietal preferences

In a special project we are looking at how to target different groups within villages (based i.e., on gender, wealth or caste); and at alternative techniques for farmer evaluation of genetic material to provide information on varietal preferences. This will include:

- Different ways to characterize villages
- Different ways to select farmers
- Different ways to select cultivars for farmer evaluation, i.e., demonstrations of a wide range of plant types, preferably grown under conditions close to that of farmers' fields (perhaps on NGO land or perhaps in villages on common land or on land of large farmers).
- Different ways for farmers to evaluate material

Evaluating farmers' selection

We are initiating a project on the opportunities and prospects for diversifying the genetic base of the local varieties of pearl millet that farmers in Rajasthan are maintaining and using for their own breeding efforts. The work will utilize participatory diagnostic methods developed by the ongoing study. How successful are farmers in improving their seed stocks? Is introduced variability improving farmers chances for improving productivity of their own seed stocks? When crop failures occur, how are seed stocks replenished? What are the implications for research aimed at introducing improved genotypes and increasing genotypic diversity as well as productivity? What opportunities for farmer participation in the formal process of variety development could be most useful?

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DECENTRALIZED BREEDING AND SELECTION: TOOL TO LINK DIVERSITY AND DEVELOPMENT

K. W. Riley

ABSTRACT

Much of the increased food production in recent years has been based on the breeding of varieties of major crops possessing geographically wide adaptation to favorable or uniform agricultural environments. At the same time, the disappearance of traditional crop landraces from these areas has formed the rationale for attempting to collect and conserve ex situ these crop genetic resources in genebanks around the world. Although improved varieties and production practices have had less impact in marginal agricultural areas, where complex agricultural systems and high levels of crop diversity have been maintained, increased population pressures and related economic changes are making such traditional systems difficult to sustain.

Recently, renewed interest has focussed on the feasibility of sustained improvement of crop production in marginal or diverse environments through the exploitation of specific adaptation based on locally-adapted germplasm. Such methods have also been suggested as a way to maintain farmer management in conserving high levels of genetic diversity in situ. Nevertheless, there are a number of specific, institutional and conceptual issues that must be explored before such methods can be expected to be more widely practiced as a crop improvement and conservation tool. This paper reviews the research, observations and concepts that argue for the development of decentralized breeding and selection and examines some of the issues that will need to be addressed at the international, national, community and local farmer levels.

INTRODUCTION

Cultivation and selection of crop plants and their wild relatives in farms and communities in different parts of the world has produced the vast array of diversity known as crop genetic resources. Part of this diversity has been reselected and bred into modern high yielding varieties (HYVs), but the majority of global agriculture still depends on landraces (Wood and Lenné, 1993). These landraces are adapted to a range of environments and are used to meet the needs for food, clothing, fuel and shelter of many of the world's people.

Agricultural scientists have been successful in developing HYVs in many of the major crops by breeding for traits such as some dwarf stature photo insensitivity, less tillering and higher grain to straw ratios -- characteristics that enabled crops to make use of higher levels of fertilizer, improved irrigation and pest control. As our ability to produce such favorable environments spread to many areas of the world, so did the HYVs, along with rapid increases in yield.

The new high yielding technologies, however, have been much less beneficial to those farmers who could not afford the external inputs needed, such as fertilizer, irrigation or new seeds, or where environments are not amenable to change (Byerlee and Hussain, 1993). This has led to claims that the diverse and risk-prone areas are poorly served by the transfer of technology approach (Chambers and Pretty, 1994). Farming communities in such marginal areas, however, have been shown to maintain high levels of crop diversity as a component of indigenous agricultural systems (Altieri *et al.*, 1987; Brush, 1993).

The hills of Nepal and the low rainfall farming areas of the Fertile Crescent in Syria and Jordan are examples of marginal areas where new agricultural technologies have made less impact, and where high levels of crop landrace diversity are maintained *in situ.* Using published information of Ceccarelli and co-workers on barley from the Fertile Crescent and drawing on the experiences of the author and colleagues when working on barley and finger millet with the National Hill Crop Improvement Programme in Nepal, this paper argues that a strategy of decentralized breeding, and selection for specific adaptation with participation of farmers, can be used to increase crop production and conserve crop genetic resources in marginal areas. In such areas, sustained improvement of crop production is an important component of development.

ENVIRONMENTAL DIVERSITY IN MARGINAL AREAS

In the low rainfed areas of Syria and Jordan, barley yields have remained low. Important abiotic stresses include high temperatures and hot winds during grain filling. The frequency, timing, intensity and duration of these stresses vary from year to year, but low yields are predictable and crop failures occur once or twice in five years. Barley is used as an animal feed for small ruminants in a variety of ways; in good years, straw and grain are harvested and stable grazed, while in bad years, the crop is fully grazed before stem elongation in an attempt to save the animals by sacrificing the crop (Ceccarelli, 1994). Under such conditions, fertilizer used is not economic as risk of failure is too high. Irrigation sources are being depleted and available water is generally only used for more profitable crops. Under such conditions, landraces predominate and non-landraces have made little impact.

The hills and valleys of the mid-mountains of Nepal possess an enormous range of agricultural environments, ranging from humid sub-tropical in valley bottoms below 1000 m above sea level, to arid temperate conditions at the limits of agriculture up to 3500 m above sea level. Farms are generally small, averaging less than a hectare, but contain a variety of land types and complex farming systems. Terracing is common on the steeper slopes, while fields on lower slopes are bunded, with access to limited irrigation for part of the year. Soils are generally freely drained and low in fertility but high livestock populations on these farms enable high amounts of compost to be applied, particularly close to buildings in the upper terraces. Soil nutrients then move downward with the rains, fertilizing the crops in the lower terraces (Riley, 1991).

In such environments, more than 150 distinct crops species and varieties are cultivated in a single village (Mateo and Hawtin, 1990) while Bhattarai *et al.* (1990) list 46 different cultivated crop species grown in Nepal's mid hills. Finger millet occupies a variety of niches in the rainfed farming systems of the mid hills growing as a summer crop between April and November. It is found either as a sole crop or in association with maize or legumes. Barley is most common in the higher elevation areas and can be found in the mid hills as a winter crop. Both crops are grown by a diversity of ethnic groups, both those of Tibetan-Burmese origins and those who speak Indo-Aryan dialects (Bista, 1991). The crops are used in a variety of ways. The grains form a variety of staple foods, and in some areas are important for making beer or feeding livestock, and sold to a limited extent in local markets. The straw of both crops is an important source of livestock feed and residues are returned to the soil as compost. As population pressure increases, farming systems are becoming more complex and intensive. For example, where maize and millet were formerly grown in separate fields, millet is now transplanted and relayed into maize. Rice wheat systems are replacing rice-fallow. In such a diversity of cropping systems, landraces predominate.

Farmers in both Nepal and Syria require stability of production to meet their needs in the areas of high environmental diversity. In the case of barley in Syria, this environmental diversity is temporal and comes in the form of a variety of abiotic stresses that change from season to season. In Nepal it is spatial, occurring in a range of micro-environments. Environmental diversity, in which cultural and agricultural diversity have evolved, appears to be the common factor which indicates the continuation of landraces in these areas.

FARMERS' MANAGEMENT AND LANDRACE DIVERSITY

Landraces are populations, developed and maintained by farmers or in farming communities as discrete entities, from planting to harvest and through storage and exchange to the next planting. The diversity contained in these landraces is dynamic and is evolving to enable farmers to meet changing needs (Hodgkin *et al.,* 1993; IPGRI, 1994).

As our understanding of farmers' management of landraces increases, it is becoming clearer that farmers' selection is dominant over natural selection in shaping the diversity within and among landraces. As stated by Harlan (1975), this practice (human selection) provides a new order of selection pressure. The population becomes an array of deliberately chosen components.

It is clear that farmers select their crop plants as they decide which individuals will be allowed to produce the next generation. In simple mass selection, farmers take the second step in breeding, that is in deciding how individuals that they have selected will be mated to each other. Thus, landraces may be a product of farmer selection as well as farmer breeding.

Diversity of landrace populations can be fairly readily observed at three levels: 1) diversity of landraces among regions; 2) among landraces in a village or farm; and 3) diversity of components within a landrace. A further level is the study of the genetic diversity within the components.

As the following examples using barley and finger millet illustrate, farmers' management has played an important role in shaping the diversity of landraces in those two self-pollinating crops.

Barley landrace diversity in the Near East

Weltzien (1988), found that much of the within landrace diversity among Syrian and Jordanian landraces could be accounted for in 10 regional groupings associated with specific geographical environmental and agronomic factors, indicating that adaptive processes are operating in agricultural systems. A high proportion of the total variation (65%) was found to exist within landraces. This variability was felt to be sufficient to allow successful selection for production related traits (Weltzien, 1988). Variation in disease reaction to a number of barley diseases was also identified in the pure line selections made from the collection sites. The finding that a small number of the progeny lines possessed resistance to stripe rust (*Puccinia striiformis*) is of particular interest (van Leur *et al.* 1989). Stripe rust is not known to occur in the Middle East, and genes for resistance for this disease would not have had any selection advantage in these landrace populations. Thus, landraces may posses potential or cryptic variation that can be maintained and used in crop improvement strategies.

Barley landrace diversity in the Nepal

Nepal is another center of diversity for barley (Witcombe, 1975). High variability has been found among both hulled and hulless 4 and 6-row barley growing in different parts of Nepal from the Terai (lowland) to the high Himalaya zones (Witcombe and Gilani, 1979; Murphy and Witcombe, 1981; Konishi, 1986). Greater variation was found to occur at the higher elevations (Takahashi *et al.*, 1968). The observations of the scientists in the National Hill Crops Improvement Programme (Riley *et al.*, 1989; Upreti *et al.*, 1989) made during a series of Rapid Rural Appraisal Treks in general agreed with these earlier reports, except that barley was no longer found growing in the Terai. The adoption of new wheat varieties which displaced barley in these fairly level productive lands, was thought to be the reason for the disappearance of barley from the Terai. Observations made during these treks can be used to help understand the structure of diversity of landraces of barley and finger millet.

Much of the variability among landraces is associated with landraces which are adapted to specific cropping patterns (Figure 1). A further important two-year rotation, which extends above the limits for maize up to 3000 m on rainfed lands, is a barley-potato-radish system. Generally, we found that only one landrace of hulless (usually called *uwa*) and one landrace of hulled barley were grown on a farm or in a community. Within landrace components were examined either as single plants in the farmers' fields, or characterized as single plant progenies at Kabre Research Station in the Eastern hills, 1750 m.a.s.l. and at Jumla Research Station in the Western hills 2300 m.a.s.l. While very high variation was found among components in the landraces from rainfed conditions, barley landraces from the irrigated barley-buckwheat and the barley-rice systems were found to possess low within-landraces variation. As a consequence, while very high genetic gains from selection have been achieved from selecting among single plant progenies of rainfed landraces (Lohani, 1973a and b; Malla and Singh, 1981), the gains from selecting within irrigated barley landraces have been modest (Gautam, 1991).

The differences in within-landraces variation between the irrigated and rainfed types can be explained by different adaptation requirements and farmers' selection. Rainfed conditions are highly variable, both spatially (among fields within a village) due to elevation or fertilization, and temporally across years, due to variable winter rainfall, or unexpected cold weather. Farmers deliberately maintained a number of variable components in their rainfed barley landraces, including difference in spike density, awn characters, row number (4 and 6-row) and kernel color within the same populations. In contrast, much greater environmental uniformity existed under irrigated conditions, which could explain why several landraces of both hulled and hulless barley from irrigated locations possessed low component (or within landrace) variability.

While Nepalese farmers are able to select barleys for many adaptive traits, there is still room for improvement. Nepalese barley landraces are generally poor for lodging resistance and stripe rust resistance. In farmers' fields, which often are fertilized heavily with compost, lodging before ripening reduces grain quality and yield. Farmers realize that landraces possessing straw with good fodder quality are often weak and lodge. Farmers are prepared to forfeit some grain yield and quality in the interest of better quality straw. Grain yield is not always the most important trait. There are often negative correlations among traits that make selection for improvement slow and difficult.

Stripe rust (sindure) has been reported as a problem in barley for a long time. In about 1 year in 10, an epidemic of stripe rust will seriously affect barley production (Upreti, 1989). Why then have farmers not selected more successfully for stripe rust resistance? One possible reason is suggested by Wood and Lenné (1993) that landrace mixtures prevented sufficient inoculum build up so that farmers were not able to locate resistant plants during the normal rust years-- thus

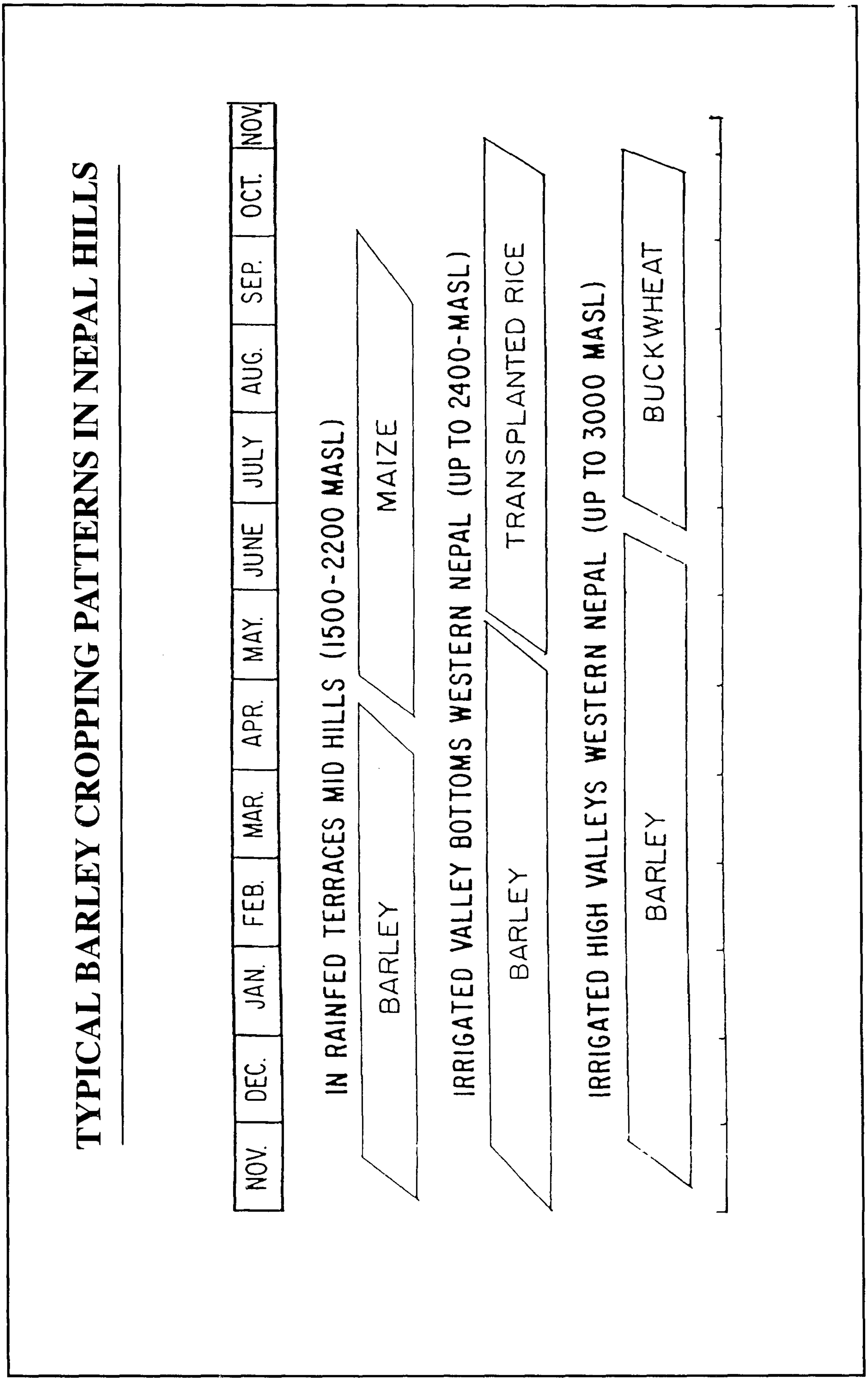


Figure 1: Some cropping patterns with barley in Nepal hills and mountains

allowing the occasional epidemic to wipe out all plants. This idea is reinforced by the identification of partial resistance to stripe rust in more uniform barley landraces growing in irrigated fields in the Marpha areas (Riley *et al.*, 1989). It is likely that formal research procedures for improving correlated traits and horizontal resistance to stripe rust could be successfully applied to improvement of these landrace populations.

Finger millet landrace variability in Nepal

Although recent studies (Hilu, 1993) using RFLP have indicated that cultivated finger millet possesses a very narrow genetic base, finger millet landraces in Nepal have been found to exhibit high morphological variation (Baniya *et al.*, 1993). No detailed studies on the structure of this diversity have been undertaken, but a Rapid Rural Appraisal into the importance, utilization and farming systems was made in three villages in each of nine zones across Nepal (Riley *et al.*, 1993; Shakya *et al.*, 1991). The study found that farmers within a village maintain high numbers of landraces, averaging 27 in villages in the mid hills in the east and central parts of the country. Each landrace had a different name relating to the shape of head or other morphological or agronomic trait. We found that landraces had been developed for adaptation to very specific niches. Landraces of varying maturities were used to spread out the harvest season, reducing labor peak demand and enabling fresh fodder to be supplied to livestock over long periods. Other landraces were specifically adapted to relay cropping with maize. In contrast to the rainfed barley landraces, millet landraces possessed very specific adaptation to a certain altitude or level of soil fertilizers. Other landraces had evolved with qualities suitable for specific food preparations or for good beer-making quality, or for good threshing or seed storage characteristics.

These landraces appear to be evolving as agricultural systems change. Several of the landraces were described as either 'old' or newly introduced. The ability to yield well in intercropping or relay cropping conditions was a particularly important trait sought in new landraces. Farmers were observed to engage in active seed exchange when they traveled to other villages. New types introduced to a village were tested by farmers before being widely used. Two improved varieties had been adopted by farmers in some areas. These varieties were included in the portfolio of landraces that they maintained. Okhale -1 is a single head progeny selection of a local landrace from the Eastern mid hills and released by the National Hill Crops Improvement Programme. Farmers in the Western mid hills have now adopted this variety as they value its high fodder production. PES 176 is an introduction from India. It was found to be a fairly high yielding, early variety. Although it is susceptible to blast disease, it is now grown by farmers in the Far Western hills where rainfall and disease incidence is lower. Although compost is exclusively used for the transplanted crop under maize, farmers have found that chemical nitrogen fertilizer can be used to hasten development of millet seedlings in the nursery. Some landraces have been found by farmers to be particularly responsive to nitrogen at the seedling stage. In the Far Western mid hills where rainfall is lower, and in the high hills where low temperatures limit millet growth, numbers of landraces average only five per village. Although finger millet is a tropical crop, landraces were found up to 2600 m where they possess extreme adaptation to cold temperatures.

In the lowland terai, millet has been largely replaced by intensive maize, rice and wheat systems. However, in the hills of Nepal, the number of farmers' landraces appears to be increasing. An attempt was made to estimate the across-region differences in Nepalese landraces based on their local name and preliminary description provided by farmers (maturity, yield and any particular characteristics) (Table 1). Some mis-classifications in this table are likely. For example, *Dalle* means 'fisted', in Nepali and describes a tightly closed head type. A variety with this name was described in the Eastern mid hills as late maturing with heads that were difficult to thresh, good grain yield, low straw yield best making good quality fodder. The landrace with the same name in the Western mid hills was described as having medium maturity, medium straw and grain yield, and may therefore be a different landrace. On the other hand, the same landrace may be called

Table 1: Names of some finger millet landraces found in different parts of Nepal *

Name	High Hills			Mid Hills			Terai		
	Eastern	Western	Mid/Far Western	Eastern	Western	Mid/Far Western	Eastern	Western	Mid/Far** Western
MudkeQ	✓						✓		
Nang Katwa	✓			✓			✓		
Balu Nala		✓							
Krei		✓							
Kanchiodo		✓							
Kalo Kodo			✓	✓					
Rato Kodo			✓						
Jangali				✓					
Tiltile				✓					
Lure				✓					
Dalle				✓	✓		✓	✓	
Pandur				✓					
Seto Kodo				✓					
Bagare				✓					
Juake				✓					
Mudke				✓					
Karante					✓				
Nala					✓				
Baghunge					✓				
Okhale-1					✓				
Archaule					✓				
Urchho					✓				
Balukodo					✓				
Kalobhunde					✓				
Ramjali					✓				
Bhachuwa					✓				
Seto Urchho					✓				
Thulo Kodo						✓			
Shano Kode						✓			
PES 176						✓			
Jalare						✓			
Kali						✓			
Lokhare						✓			
Pongdur							✓		
Ashauge							✓		
Jhapre					✓		✓	✓	
Thulo Kodo							✓		
Barbatel							✓		

* Adapted from Shakya *et al.*, 1991 ** Two unnamed landraces were reported from this area

different names in different local languages. Allowing for these mis-classifications, most landraces were found to be specifically adapted within one zone. This indicates that finger millet landraces are specifically differentiated across the different regions in Nepal.

Visual comparisons of single head progenies from landraces grown in breeding nurseries at Kabre Research Station suggest that moderate to high within landrace variation exists. Moderate advance through selection of such variability for grain yield, earliness, and blast disease resistance can be expected (Baniya *et al.*, 1992).

From the above case studies, it is clear that the structure of landrace diversity in these marginal conditions has been shaped by farmers for good performance, adaptation and stability in a variety of specific situations. How then can landraces be improved to meet farmers' needs, and also maintain the wealth of genetic diversity represented in these landraces?

GENOTYPE BY ENVIRONMENT INTERACTIONS AND STABILITY

Two statements made more than 30 years ago have formed the basis of breeders' philosophy for developing stable and widely adapted varieties.

1) "A variety can achieve stability either by population buffering ... where several genotypes comprise the variety each adapted to a specific environment, or a homozygous line can possess individual buffering or homeostasis which enables it to perform consistently over environments" (Comstock and Moll, 1963).

2) Plant breeders therefore attempt to "develop varieties which minimize unfavorable genotype by environment interactions, that is varieties which are able to control their developmental processes in such a way as to give high and consistent performance" (Allard and Bradshaw, 1964).

In the more productive environments, varieties with high and consistent performance have been developed for most of the major crops and many of these varieties have directly contributed to increased production (Ceccarelli, 1994). However, the lack of progress or impact of improved varieties in marginal conditions leads to an examination of the reasons for the lack of adoption of such varieties in areas, such as the low rainfall barley areas of Syria and Jordan, and the hills of Nepal.

Adaptation and stability are different

It has often been assumed that a variety which is broadly adapted across a wide geographic area is also stable in performing well across years (Schutz and Bernard, 1967). Breeders, seed agencies and extension workers value broad adaptation in a variety as it can be widely recommended. In productive environments, year to year fluctuations can be minimized. However, a farmer in a marginal area values a stable variety which can produce reliable yields on her farm in both good and bad years. Binswanger (1980) has shown that, in the semi-arid tropics, stability and adaptability may be independent traits. Stability is more time consuming to measure than is adaptability. While measurements of adaptability can be made by testing a variety across sites in a single year, assessment of stability takes several years. Thus, selection for wide geographic adaptation may have replaced selection for stability in improved varieties.

Heritability is not lower in marginal conditions

Heritability measures the degree to which the environment affects a certain trait. When heritability is high, improvement from selection is more rapid. For many years, breeders argued that heritabilities in stressed or poor environments are lower than in good environments (Blum, 1988). However, Ceccarelli (1994) recently reviewed data from several sources to show that heritability in low yielding environments is not lower than in high yielding environments. Methods of making improved heritability estimates as suggested by Ceccarelli (1994) would help to achieve more rapid gains from selection in marginal areas.

Genotype by environment interaction and direct selection

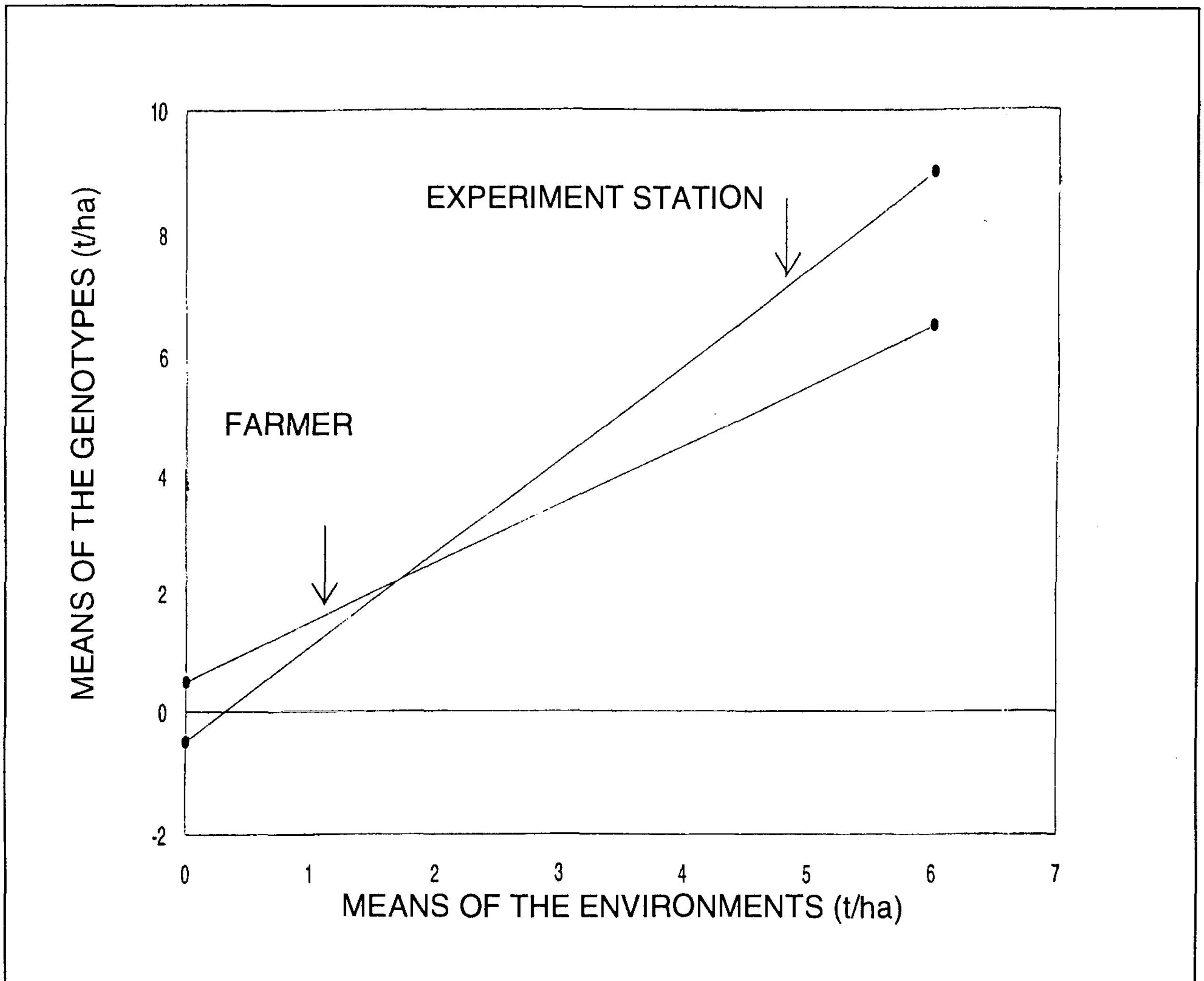
Because genotypes perform differently to each other in different environments (G x E interaction), it is clear that greatest response to selection occurs when selection is conducted in the environment where the future varieties will be grown. However, breeders have argued that correlated responses exist. In other words, a line that performs better than other lines in a good environment in a research station will also perform better than other lines under stress (Rajaram *et al.,* 1984). Using modeling and actual data, Simmonds (1991) and Ceccarelli (1994) have shown that a 'cross over' G x E interaction can occur when varieties are compared across highly stressed and favorable conditions. This is shown in Figure 2 (Ceccarelli 1994). In this hypothetical example, a variety selected in the experimental station under good conditions possesses a higher mean yield over locations, but performs worse than the variety selected in the farmers' fields in marginal environments where grain yield is less than 2 kg/ha.

Simmonds (1991) and Ceccarelli (1994) therefore advocate selection for specific or local adaptation. Such selection would use rather than minimize G x E interactions and seek to locate varieties, or landraces that could perform better at a single site. The advantages of such a selection scheme are shown in Table 2 using actual data from the 1991 Finger Millet Advanced Observation Trial carried out at three sites in the mid hills (Kabre, Khumaltar and Lumle) and one site in the Terai (Rampur). All entries are selections from landraces. When the highest yielding entry selected was from each site (for specific selection), the average improvement over the local check was more than three times higher when compared with Acc 2906-9 which produced the highest mean yield over all four sites (selection for wide adaptation). While this data confound environmental and genotype effects, they do indicate that more rapid gains can be expected from selecting for adaptation at specific sites.

Table 2: Phenotypic gains from selection comparing selection of the highest yielding entry at each site (underlined) with selection of the entry with the highest mean yield over all sites (double underlined) (1991 Finger Millet Advanced Observation Nursery, Nepal)

Replicated plot grain yields (kg/ha)					
	Location				
Entry	Kabre	Khumaltar	Lumle	Rampur	Mean
Acc 2906 - 9	2075	4180	2540	10000	4699
Acc 2442 - 1	1774	5860	2330	3500	3379
Acc 2905	3682	610	3430	4000	2931
Acc 2909 - 4	2930	2250	4660	3000	3210
Local check	2669	3490	3070	7000	4057
Gain or loss (kg/ha) compared with Local Check					
Selection for:					
Specific Adaptation	+ 1013	+ 2370	+ 1590	+ 3000	+ 1993
Wide Adaptation	- 594	+ 690	- 530	+ 3000	+ 642

Figure 2: Hypothetical GxE interaction between experimental station and farmers' fields



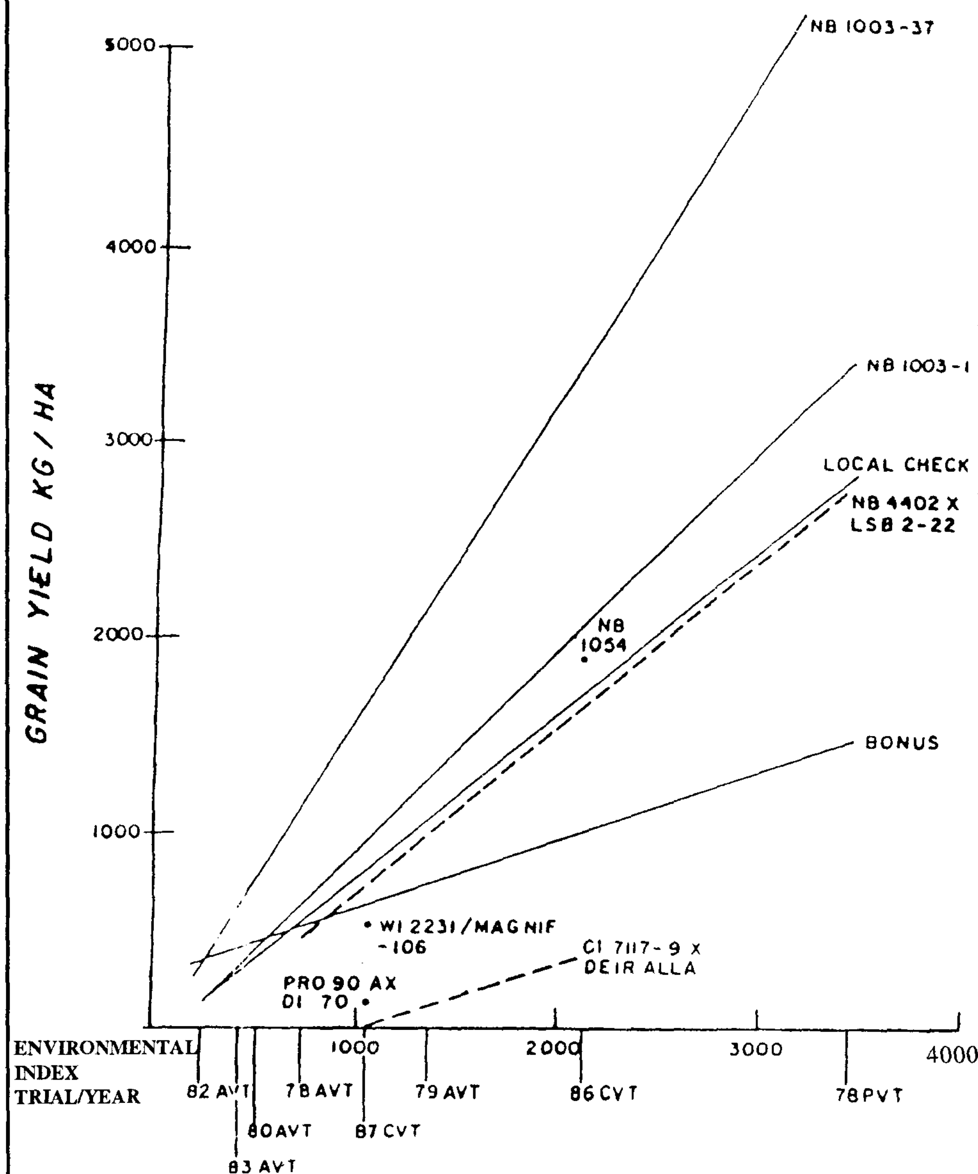
Source: Ceccarelli, 1994

Improving landraces for stability

In farmers' fields in Syria and in the hills of Nepal, landraces generally out perform modern varieties. In both countries, landrace improvement programs have achieved initial rapid improvement by selecting the best single head progenies. Gains of 12-16% per year have been realized in Syria (Ceccarelli, 1994), and 30-35% in a single year by selecting finger millet and barley single head progenies in Nepal (Baniya *et al.*, 1992). In the longer term, crosses among landraces and between landraces and parents with specific traits should be undertaken.

A better understanding is needed about the genetic structures of a landrace and how that structure confers stability. Maintaining the stability of landraces through careful recombination of landrace components to maintain an 'architecture of genotypes' will be required. An example from Nepal illustrates the rapid gains from selection, and the problem of stability in varieties derived from single head selections in barley landraces. Figure 3 shows the stability in grain yield of two barley varieties, selected in 1976 by Dr. Lohani, derived from landraces and tested at Kabre Research Station for ten years. Single plant selections (NB 1003-37 and NB 1003-1)

Figure 3: Stability of barley genotypes at Kabre



KABRE 1978 - 1988

ELEV. 1740 M. A. S. L.
RAINFALL 1900 MM
SOIL PH 4.7 - 5

VARIETY	MAT DAYS	STRIPE RUST (1988)	YIELD MEAN	B	R2
LOCAL CHECK	152	100S	984	0.84	0.07
BONUS	161	20 MR	680	0.36	0.25
NB 1003 - 37	159	100S	1988	1.60	0.93
NB 1003 - 11	159	100S	1584	1.35	0.88
NB 4402 X LSB 2 - 22	162	MS	1541	2 Environments	
NB 1054	152	100S	1794	1 " "	
WI 2231 / MAGNIF	150	60S	565	" " "	
PRO 90 A X DI 70	155	80S	142	" " "	
CL 7117 - 9 X DEIR ALLA	152	60S	335	2 " "	
14 TH IBON - 96	158	5R	000	1 " "	
LSD (0.05) (First 4 Varieties)			791		

are compared with a number of introduced barley lines. While the mean of NB 1003-37 is approximately double that of the local check, it is not stable in performance across years at Kabre, and performed no better than Bonus (an introduced variety) in the worst years, when stripe rust was severe. Although Bonus generally performs poorly at Kabre, it possesses stripe rust resistance, which enabled it to perform as well as the susceptible local landraces during stripe rust epidemics. Improved genetic diversity in landraces through the use of a combination of selected landrace genotypes, along with introducing specific traits such as stripe rust resistance can be expected to improve the long term stability and performance of barley landraces in Nepal.

Theoretically and experimentally, breeding and selection of landraces for specific adaptation has been shown to result in high expected improvement in marginal conditions. If such improvement is to benefit the farmer, closer farmer involvement is necessary than has been the case up to now.

FARMER INVOLVEMENT IN LANDRACE IMPROVEMENT

1) Traditional, indigenous and modern systems

Indigenous agricultural systems in which landraces are maintained are in a state of dynamic change. These systems can be characterized as outward looking, dynamic, improvement seeking and evolving. Traditional systems, in contrast, would be characterized as inward looking, static and equilibrium seeking. Indigenous systems, in order to evolve and survive must be able to maintain what is 'good' in traditional systems, and at the same time adapt technology from the modern or non-traditional systems that is appropriate, affordable and available (Gill, 1991). If the above terminology is accepted, we should aim at helping the farmer develop indigenous landraces which are maintained using indigenous knowledge. In a program of landrace improvement, the focus of both farmers and researchers would be on the indigenous systems as shown in Figure 4. This will require an understanding on the part of researchers of farmers' indigenous systems. Researchers must also better understand how landraces are maintained and improved as components of those systems. Farmers would be required to understand test, and incorporate the 'appropriate' part of modern technology that could be used in indigenous systems.

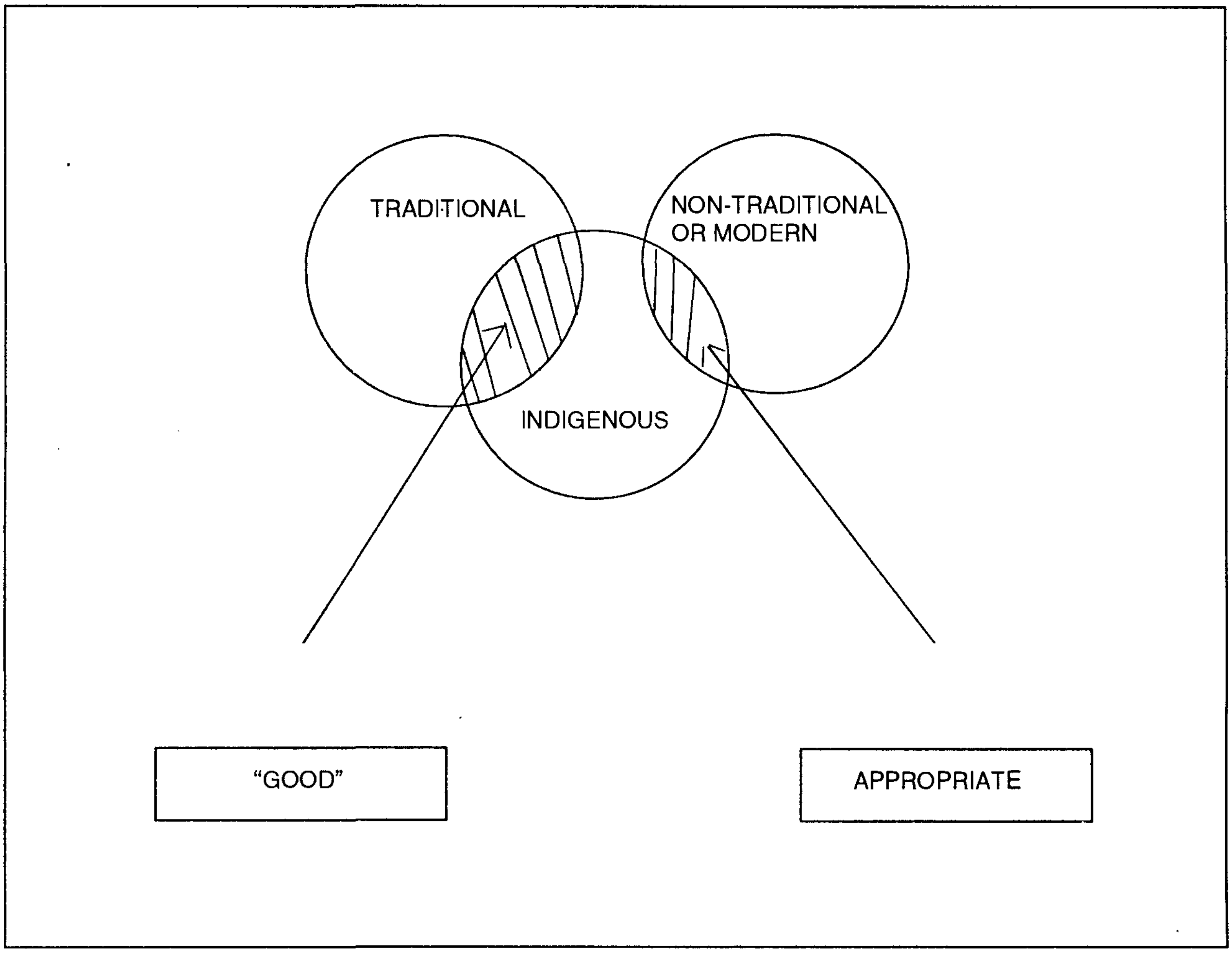
2) Selection of the appropriate traits

This paper has focussed on breeding and selecting for improved grain yields. However, traits other than yield may be most important for improvement, such as earliness or disease resistance, that are frequently negatively correlated with yield. Farmers' close involvement particularly with the selection process will be necessary to ensure that appropriate variability is incorporated into the landraces that will be selected by farmers.

3) Maintenance and monitoring of genetic diversity

Breeding and selection for specific adaption in landraces would maintain high levels of diversity in farmers' fields. Close participation between researchers and farmers will also be needed to locate diversity and ensure that it is maintained. Documentation and updating of farmers' knowledge will be important, with confirmation as needed, possibly using molecular markers or isozymes to assess the location and farmers' maintenance of genetic diversity.

Figure 4: Interrelationships between traditional, indigenous, and non-traditional systems



Adapted from Gill, 1991

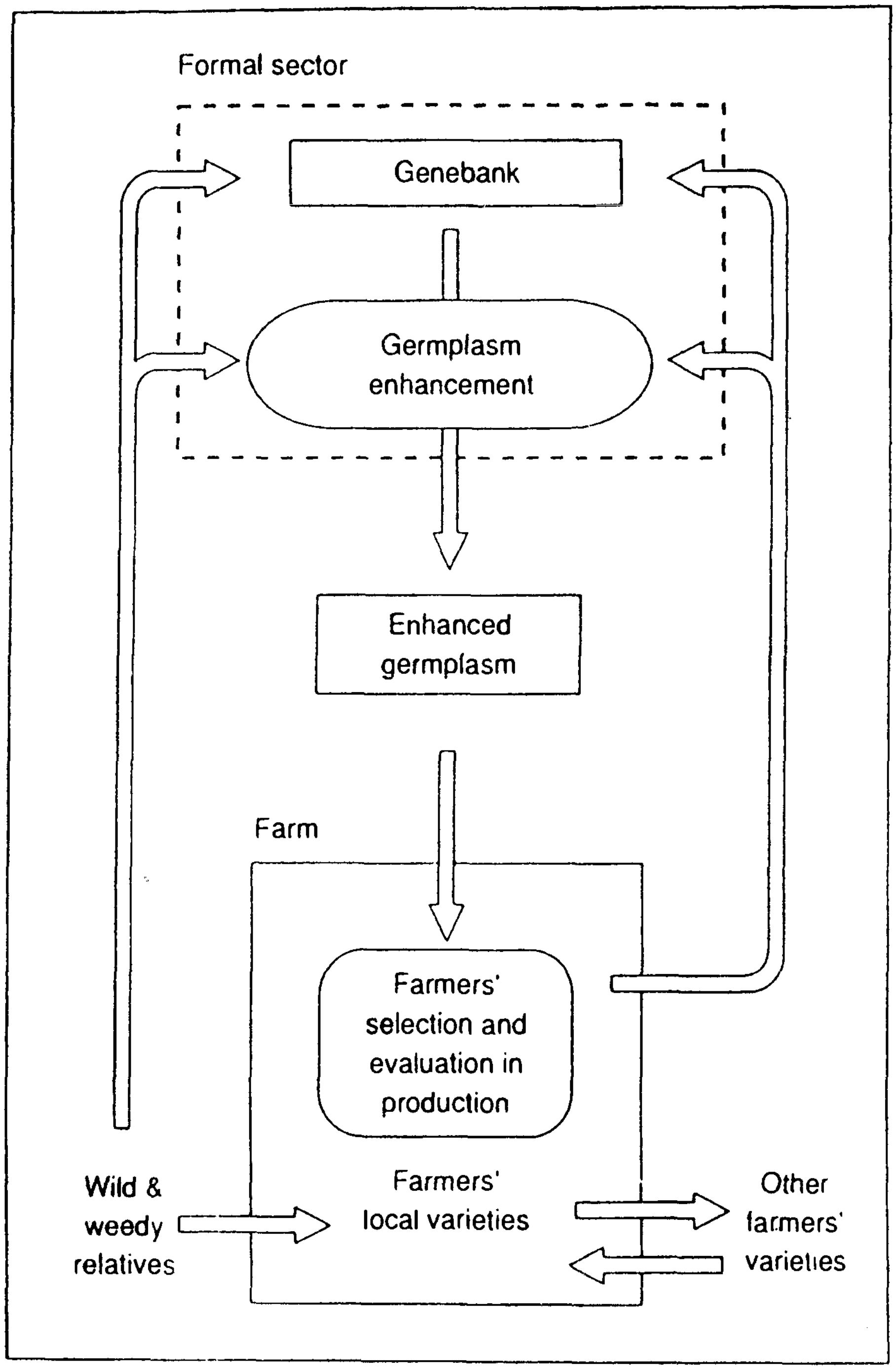
4) Some possible components in a program of decentralized breeding and selection

In general, an integrated program of plant breeding and selection such as that proposed by Mooney (1992) (Figure 5) will bring agricultural scientists together with farmers to develop productive landraces possessing specific adaptation and stability for the traits desired by farmers. In marginal areas, such as those described above, genetic diversity will be a necessary feature of these landraces. Scientist from international centers, national programs and non-governmental organizations (NGOs) can contribute to such a program. Selection for specific adaptation of the landrace components, and combining these components into a stable, productive landrace must be carried out by farmers, under farmers' conditions. The formal sector can contribute to the breeding and improved selection of these landraces in a number of ways.

- Participatory appraisal with farmers, researchers and NGOs to understand farming systems, observe the structure and variation in landraces and identify the traits for which landraces might be improved;

- Improved experimental design adapted to farmers' conditions, aimed at enabling farmers to identify desirable genotypes;

Figure 5: Model for an integrated system of plant breeding and selection



In an integrated system of plant breeding, the formal sector would produce enhanced genetic material using advanced techniques and drawing upon a worldwide collection of genetic resources. Final selection and evaluation of locally adapted varieties would be carried out by farmers, integrated with production. There would also be an important two-way exchange of information between plant breeding stations and local communities.

Source: Mooney, 1992

- Methods for selecting for correlated traits, such as improvement of both lodging resistance and straw quality;

- Improved methods of selection. Mass selection may maintain variability but low progress from selection for quantitative traits (such as yield) is expected (Allard, 1966). Single plant selection followed by recombination, assembly of selected lines, or simple recurrent selection (Allard, 1966) in cross pollinated crops, and index selection for several correlated traits could all be applicable in certain situations;

- Enhancing the genepool in which farmers select. Introductions, random mating to break linkages will be needed, or intensive screening to increase the frequency of desirable variation in the material available for farmers to select;

- Laboratory screening to identify genes for traits that are needed, and incorporation of desirable genes using biotechnology can be carried out prior to returning the components to farmers to select and combine into landraces;

- Farmers' systems of seed exchange of landraces, or landrace components must be strengthened. The formal sector can help farmers with technology and methods to exchange weed-free and disease-free seed, possessing good germination;

- Link farmers in different farm communities in different regions and countries to enable them to exchange germplasm and knowledge;

- Provide favorable policy environments to encourage and empower farmers for diversity management.

CONCLUSION

Although implementing such a program would require extensive re-training and a re-orientation in national and international programs, the difficulty in starting such programs should not be over-estimated. Many NGOs are already involved in grassroots activities with farmers aimed at increased use and maintenance of indigenous genetic resources (Cooper, Velle and Hobbelink 1992). Other organizations in Nepal, such as Lumle and Pakhribas Agriculture Research Centres, are already including farmers in the selection of breeding materials (R.J. Kardka, 1990, personal communication).

Breeding and selection for specific adaptation in marginal environments will complement and augment the diversity of landraces that farmers already maintain. While a program will be primarily focussed on improved and stable production, the maintenance of genetic resources *in situ* will be an important output that must be conducted as an integrated part of this program.

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ADDRESSING DIVERSITY THROUGH FARMER PARTICIPATORY VARIETY TESTING AND DISSEMINATION APPROACH: A CASE STUDY OF *CHAITE* RICE IN THE WESTERN HILLS OF NEPAL

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ABSTRACT

Promising Chaite (spring rice) rice varieties were randomly distributed among rice growers of 20 villages in the Western Hills of Nepal in 1991 through the Informal Research and Development (IRD) program of Lumle Agricultural Research Centre (LARC). The objective was to enhance decentralized selection of exotic varieties to specific niches and to meet the needs of farmers and thereby strengthen the varietal diversification process.

A survey conducted during June 1993 showed that all rice entries included in the study were adopted (at different locations) but that the varietal choice varied between the locations, indicating the need for varietal diversification.

Some 37% of respondents were growing the rice entries distributed through the IRD program and a further 57% were aware of these varieties and have asked for seed from the grower farmers. Pre-released varieties of Chaite rice were found spreading in the villages, with food-balance and food-surplus farmers contributing most to the process. The farmers' network of information and seed exchange can be a very strong and cost-effective means of disseminating varieties and hence should be used in the process along with other grassroot-level institutions. Farmers use a combination of criteria such as early maturity, medium to tall plant height, easy threshability with high yield, good cooking quality and taste while assessing a rice variety. The major contribution of the IRD program has been the development of locally adapted varieties through the farmer participatory approach. It offers the benefit of new genetic material to the farmers 5-6 years in advance of the formal system and helps promote genetic diversity through farmer-to-farmer seed exchange. It has also influenced the outreach research programs, helping to reorient them onto a farmer participatory tract.

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INTRODUCTION

The farming systems of the Nepalese hills are complex and there is an interdependence among crops, livestock and forest resources of the system. Superimposed upon this is great variation in topography and socio-economic factors, which has resulted in a diversity of farming systems. In order to address this diversity, any one variety or technology cannot necessarily be recommended for general production and this situation requires the generation of a basket of technologies to offer choice for the diverse conditions (Joshi and Sthapit, 1990). In fact, developing technology through informal experimentation and the integration of new knowledge have always been an integral part of Nepalese hill farming systems. The majority of hill farmers are smallholders and agricultural practices are based on indigenous knowledge and resources, as a consequence helping to maintain diversity in the system. Diversification is aimed at minimizing risk and meeting the family needs, as the farmers of this category have a very low risk-bearing capacity (CSS, 1990).

The formal research system in Nepal is organized along commodity-based programs. The research approaches used are conventional and, in the case of food crops, it generally takes more than ten years for a promising variety to reach the stage of Farmers' Field Trial (FFT) and Minikit. The formal research system is aiming for a few widely adapted crop varieties. Such varieties are generated in a limited number of research stations and under optimum growing environments through researcher-designed and managed experiments which may not be representative of the majority of domains in the country. Farmers cooperating in such experiments are little involved, if at all, providing mostly the labor and ranking varieties in a standing crop (Kadayat *et al.*, 1991). The active role of farmers in technology generation, evaluation, selection and dissemination process is largely ignored (Haverkort, 1991), so is the diversity of farming systems. Low uptake of technologies developed through formal research is due to the lack of considering indigenous knowledge and socio-economic issues while generating new technologies.

Agricultural research in Nepal is relatively new. However, some of the achievements of modern agricultural development, such as the four-fold increase in the area under winter planted wheat, are noteworthy (Regmi, 1986). Yet the benefits of the majority of recent advances in agricultural technology are mainly limited to accessible areas. Disparity in the realization of the benefits of new technologies in Nepal does not only stem from the gap between smallholders and landlords, but also from the difference in the physiography of the country, infrastructure and institutional development, and level of education of farmers. Nevertheless the issues of equity and remote areas have not been properly addressed by the formal research system so as to ensure that the gap between rich and poor does not increase.

The concept and evolution of Informal Research and Development

The Informal Research and Development (IRD) was started in 1989/90 to complement the formal varietal screening program. The idea is to make new genetic materials available to all the categories of farmers in a simpler way so as to address the diversity of hill farming systems and to assist the farmer participatory variety testing and dissemination process (see Joshi and Sthapit, 1990). The objectives of the program are to allow farmers to test and choose crop varieties according to their own needs, preferences and circumstances-- without the interventions of researchers-- and to help disseminate promising technologies through a farmer-to-farmer network while varieties are still at their most vigorous and potential stage. The approach also takes into account the indigenous knowledge systems and available resources of hill farming systems. Although the case study presented in this report is on *Chaite*[2] rice, the IRD program covers almost all the mandate crop commodities of LARC, including some livestock technologies.

Methods of Informal Research and Development

The IRD program is conducted in different parts of the Research Command Area (RCA) of LARC, based on the suitability of crop species, need for diversification and the potential of the crop. The following steps are generally followed:

1) The promising lines from advanced varietal trials or released varieties are selected and multiplied.
2) Seed packets of 250-500 g, depending on the crop species, are prepared, along with a printed response card with information on the objective of IRD, name of the crop and variety, seed rate, recommended domain and date of planting. The response card also seeks information on the performance, preference, seed retention and reasons for liking/disliking a particular crop variety.
3) The number of varieties distributed in a village depends upon the nature of the crop, availability of seed material and the diversity of the system.
4) Seed packets are distributed in two ways. One, through the extension network of different districts; another by distributing materials during visits, *Samuhik Bhraman*, monitoring tours, or through campaigns and surveys by LARC staff. IRD sets are distributed free of cost and on a random basis. The names and addresses of farmers to whom distributions are made are recorded in order to facilitate subsequent monitoring.
5) While distributing crop varieties, farmers are asked to decide themselves upon the exact terrace, aspect, altitude and time of planting, and the risk involved is also borne by them (Sthapit *et al.*, 1991). In fact, farmers have complete freedom to set up the trials as appropriate to their own circumstances and methods, except that varieties should not be mixed either in the field or during or after post-harvest operations. The amounts of seed distributed are small and so the area under test ranges between 40-200 m^2 per farmer, which allows for evaluation of the genotype without threatening anyone's livelihood.
6) Farmers are not consciously selected while distributing the IRD packets, in order to avoid socio-economic bias. The locations for distributing IRD materials are largely governed by major recommendation domains.
7) The role of researchers/extensionists is to select appropriate materials, multiply and plan for distributing them and monitor crop varieties distributed under IRD.
8) The IRD program is considered as one of the major activities of Outreach Research and now is conducted jointly by outreach researchers and extensionists, with the help of outreach site-based recorders.
9) Regular monitoring was felt necessary both to know the suitability of technologies for farmers with varying level of resources, socio-economic and ethnic backgrounds and also to determine the effectiveness of the IRD program *per se.*
10) Varietal testing, selection, maintenance and dissemination activities are all done by the farmers.

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[2] *Chaite* rice is the rice culture grown in lower altitude areas where there are assured irrigation facilities. It is seeded in February, transplanted in the Nepali month of *Chaite* (March/April) and harvested before mid July. The crop is also known as *Judi Dhan/Hiunde Dhan.*

11) As per the initial approach, it was envisaged that cooperator farmers would return the response card and, based on this, it would be easy to monitor the performance of crop varieties distributed under IRD. However, this did not work and now the approach has been modified, particularly for monitoring the farmers' point of view. Concerned researchers and extensionists are also now involved in monitoring the program.

Background to *Chaite* rice

Cultivation of spring-planted (February/March) *Chaite* rice in Nepal, in addition to main-season planted (June-July) rice, is relatively a new practice. The availability of early maturing and photo-insensitive rice varieties developed by the International Rice Research Institute (IRRI) and the improvement in irrigation facilities in the lower hills have increased the area of *Chaite* rice. *Chaite* rice has a high yield potential as it is less damaged by insect pests and diseases. It also utilizes production resources more efficiently as it receives more solar radiation than the summer-season rice crop. There is, however, a lack of varietal diversification, and the majority of area under the crop is grown to the single variety CH-45, which may be a potentially dangerous situation should there be any epidemic outbreaks of disease and/or insect pests (Joshi *et al.*, 1993; Sthapit *et al.*, 1990).

METHODOLOGY FOR MONITORING OF CHAITE RICE IRD

IRD on *Chaite* rice was initiated during the 1991 spring season, following the recommendation of the *Chaite* rice *Samuhik Bhraman* (Rapid Rural Appraisal) of 1990. A total of 1803 IRD packets of six early rice varieties were distributed covering 1803 household across the low hill area (<1000 masl) of the Western Development Region of Nepal (Subedi *et al.*, 1992)(Table 1). During 1992, a few packets of IR 44595 were also distributed in the same area. A survey was conducted during 1993 with the objective of studying the effectiveness of 1991/92 *Chaite* rice IRD program in generating and verifying technologies and also to identify the farmers' criteria for adopting of crop varieties so as to refine future programs.

Sampling frame and sample size

Initial monitoring of the performance of IRD varieties was conducted in 1992 covering 242 households (13.4% of the original 1803 household) from different locations. This formed the basis for the sampling frame for the 1993 study when 92 households were interviewed, taking a 35% (±5%) sample from 242 original households. A proportionate stratified random sample was used to identify the respondent households. For stratification purposes, the parameter selected was the variety of *Chaite* rice received by the respondent. Randomization was done within each stratum to select respondents.

Field work and analysis

A formal interview schedule was prepared for collecting information in 1993 and two agronomists, one socio-economist and one Junior Technician (JT) were involved in administering the interview schedule: at least two staff members were involved at each site. The combination of staff members was changed frequently in order to provide opportunities for idea exchange and interaction. It took approximately 20-30 minutes to complete one interview schedule. The field work was performed just before the harvest of the crop, from 22 June to 6 July 1993, and the entire exercise took ten days to complete. The raw data were entered onto the computer using SPSS Data Entry Module, and analysis was performed using SPSS/PC+.

Table 1: Details of *Chaite* rice varieties included in the 1991 IRD program

Name of variety	Status of variety	Number of households covered	Important characteristics as recorded in designed experiment
NR 10158-2B-2	Pre-released	181	Plant height 110 cm, yield potential 3.7 t/ha, straw yield 11.5 t/ha and crop duration of 114 days.
IR 28128	Pre-released	601	Short plant stature; 55-80 cm, fine grain; compact grain setting, good yield potential; 4.9 t/ha, straw yield 17.5 t/ha and crop duration of 150 days
IR 13155	Pre-released	434	Plant height 74-105 cm, yield potential 3.9-4 t/ha, medium grain type, difficult to thresh, straw yield 12 t/ha and crop duration of 130-141 days, good cooking quality
Palung-2	Released for main season planting	28	Tall growing, yield potential 3.5 t/ha, poor seed dormancy, crop duration of 134 days.
Chaite-4	Released	527	Dwarf variety with 54-77 cm height, yield potential 4.7 t/ha, fine grain type, relatively difficult to thresh, straw yield 13 t/ha and crop duration of 134-171 days.
IR 32419	Pre-released	32	Relatively dwarf with a plant height of 56-76 cm, yield potential 4.3 t/ha, straw yield 10 t/ha and crop duration of 140-171 days.

Limitations of the study

The time span within which the survey was conducted turned out to be insufficient to verify all the statements made by farmers. It was not possible to visit farmers' fields at most of the places after the interview, to verify their answers, to foster stronger links with them and to develop their confidence in the process. As the second year study is based on only 5.1% of total IRD sets distributed, the results should be interpreted cautiously.

FINDINGS

General background of the visited area

The study covered 20 Village Development Committees in six districts of the Research Command Area of LARC. All the sites were situated below 1000 masl, where there is potential for growing two to three crops per year.

Three types of land use systems are prevalent in the foot hills and river basins namely; *khet, bari* and *tars*. *Chaite* rice is solely grown on *khet* (bunded and irrigated terrace) land, however, it interacts with *bari* (unbunded terraces) and tar (unirrigated flat land) as the crop has to compete for several farm resources with other land use systems.

The surveyed area had a mixed ethnic composition with Brahmin/Chhetri (56.5%), Gurung/Magar (13%), Darai/Kumal (14.1%), Tamang (5.4%) and others (10.9%). About 26% of the respondents owned up to 10 *ropani* of land,[3] 32.6% had between 10-20 *ropani* of land and 33.6% had between 20-30 *ropani* of land, while only 7.6% had more than 30 *ropani* of land (Table 2). Irrespective of landholdings, 63% were within the food-surplus category, 22.8% in food-balance group, while 14.1% had food sufficiency for 3-8 months. All of the respondents of the food-deficit group had less than 20 *ropani* of land, while 33.3% of the food-balance farmers owned up to a maximum of 30 *ropani*, with only 12.1% of the food- balance group having over 30 *ropani* of land (Table 2). Information on the land tenure system revealed that, out of 92 respondents, 20 share-in land while 9 rent-out their lands.

Table 2: Food sufficiency level as influenced by size of landholding (# of respondents)

Food situation	Size of holding (*ropani*)				Total
	up to 10	10-20	20-30	>30	
Food surplus	10	17	24	7	58
Food balance (food lasts for one year)	5	9	7	-	21
Food last for 3-8 months	9	4	-	-	13
Total	24	30	31	7	92

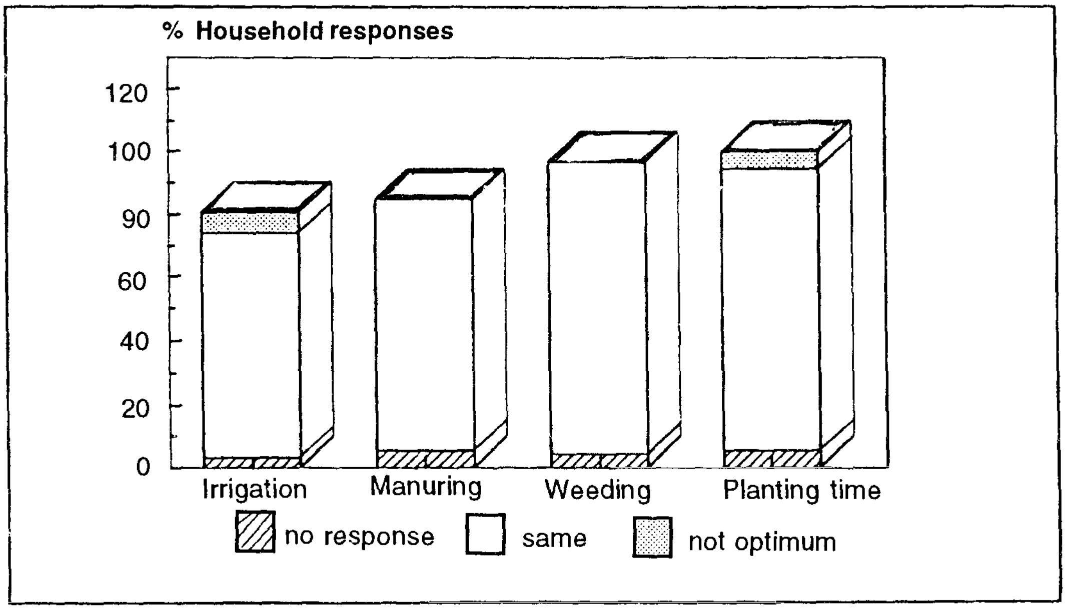
Information on the sources of income in relation to landholding was also collected. The major source of income reported by the respondents was the sale of agricultural commodities. The proportion of farmers deriving income from this source increased with the increase in size of holding. People with small landholdings were found to engage more in off-farm labor and other activities as compared to farmers with larger holdings.

Farmers attitude to IRD varieties for agronomic practices

The study investigated general crop husbandry practices adopted by the farmers for the existing *Chaite* rice varieties and for those distributed under the IRD program. The survey found that, in a majority of cases, the varieties distributed under the IRD program were treated in a more or less similar manner as the local varieties. Out of 92 respondents, 67% grew the IRD varieties on average fertility plots and on the same piece of land as was used for their local varieties. Seventy-nine percent of farmers applied the same level of organic and inorganic fertilizers. In 25% of cases, farmers grew IRD varieties on a better piece of land, while more organic manures and/or chemical fertilizers were applied only by 15% farmers. The majority of farmers (89%) planted the IRD materials at the optimum planting time and provided almost identical numbers of irrigation sessions both to local and IRD varieties (70.7%), while 19.6% of farmers provided above average irrigation. This pattern was similar for weeding and for the application of plant protection chemicals (Figure 1).

3 *Ropani* is a local unit of land measurement; one *ropani* is equivalent to 500m².

Figure 1: General husbandry practices adopted by the farmers for IRD varieties relative to local cultivars



However, it is common for farmers to screen the new/exotic varieties under adverse conditions (poor soil fertility, problematic soil or shady areas) during the first year of testing. As they gain confidence with the varieties, they treat them as they treat the local cultivars (Sthapit *et al.*, 1995). These findings show that the production environment of *Chaite* rice is less diverse than that of other crops.

Farmers perception of varietal performance

The majority of farmers reported that the plant height of IRD varieties is the same or less than that of existing varieties (Figure 2). Farmers observations are in agreement with the results of on-station experiments as the most widely grown Chaite rice variety, CH-45, is the tallest variety so far available. However, a few farmers also reported that new varieties were taller than CH-45 (Figure 2). Respondents were correct in their observation that new dwarf types of rices need a higher fertility status; improved varieties planted on poor sites did not perform well.

Responses collected for the maturity period of *Chaite* rice varieties show general agreement with the on-station results as most of the new entries are earlier or similar to CH-45 (Figure 3). In general, farmers need an early rice variety with a maturity period of around 150 days. Late varieties do not fit in a multiple cropping pattern, while early varieties suffer from rodents, birds and insect pest damage. The majority of respondents (65-100%) clearly identified that the IRD varieties (semi-dwarf varieties) were higher yielding as compared to farmers' locals. For example, some farmers harvested five *moori*[4] from one *ropani* of land where a local variety could have produced only two *moori.*

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[4] *Moori* is a local unit for volumetric measurement of food grains; one *moori* of rice is equivalent to 48.8 kg.

Figure 2: Farmers' perceptions of the plant height of IRD varieties relative to local cultivars

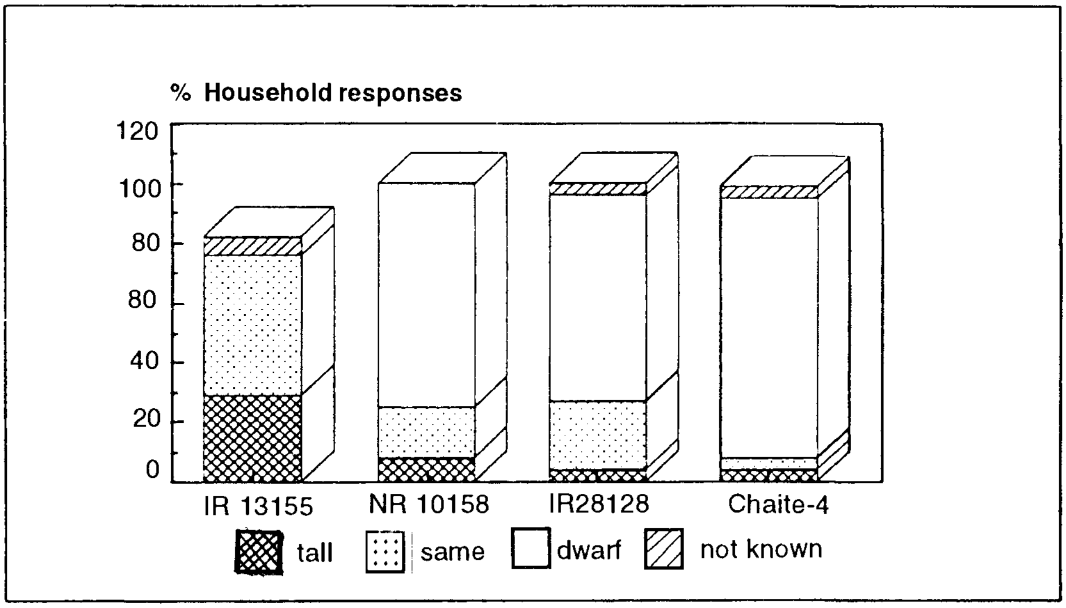
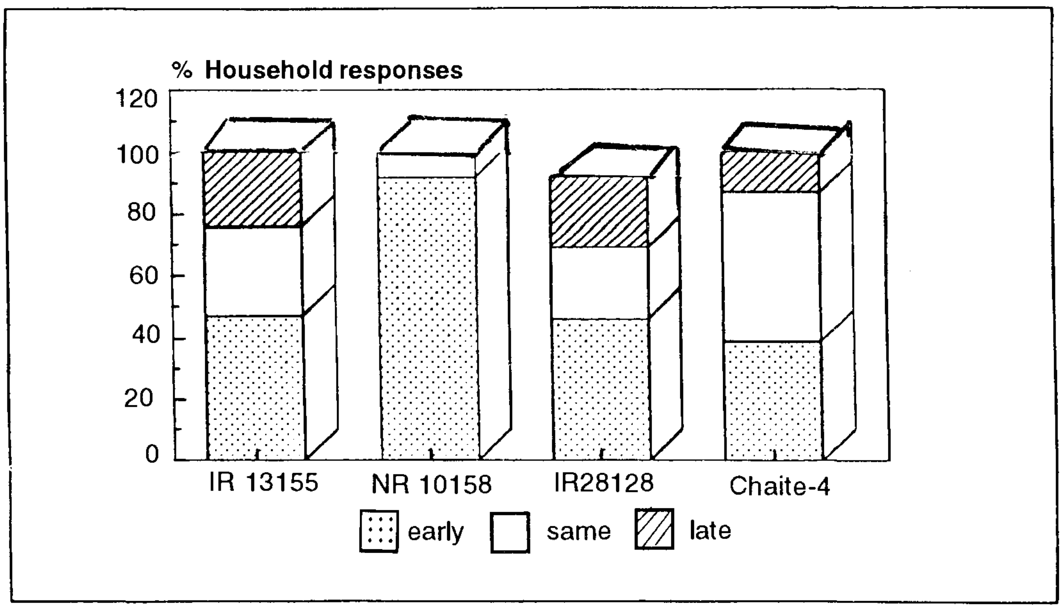
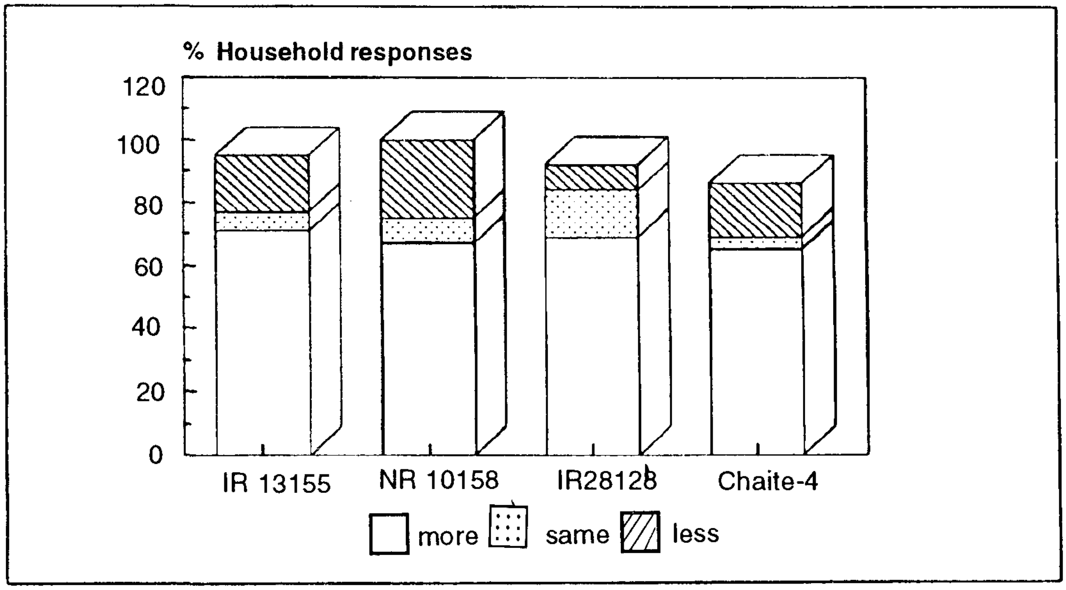


Figure 3: Maturity period of IRD varieties as perceived by respondents



Out of the 17 farmers who grew IR 13155, 12 (71%) reported that it was high yielding. Similarly, responses in favor of IR 10158, IR 28128, *Chaite*-4, and IR 44595 in terms of grain yield were 67, 69, 65 and 100 percent, respectively (Figure 4).

Figure 4: Grain yield of varieties as perceived by respondents



Post harvest characteristics, such as grain type, milling recovery, cooking quality, increase in volume of *Bhat* (cooked rice) on cooking, and quality of *Bhat* (less sticky and sustaining for long periods during hard work) are considered very important for a rice variety to be suitable for wide adoption. However, most of the respondents replied that they were not fully aware of the milling recovery and taste of cooked rice from the IRD varieties. This is not unusual as the evaluation of these parameters needs a large volume of rice for repeated testing and verification. Farmers also could not exactly recall the threshing problems associated with different *Chaite* rice varieties. The verification of this parameter is also limited due to the small amount that was grown.

Adoption level of *Chaite* rice varieties

The results of the study, based on 242 responses collected during the second year of growing rice entries from six districts, revealed that the preference level for *Chaite* rice variety varied, although all the entries were distributed across the locations (Table 3). Farmers' preference for tested *chaite* rice varieties and their willingness to continue to grow the same varieties in the following year were also studied. The willingness to continue the variety was cross-checked by asking whether they saved seed for the next season's planting. Based on the responses, particularly on the saving of seeds and willingness to grow the same variety again, responses were coded as 'adopted' or 'do not wish to continue growing the variety', i.e., rejection. Farmers who could not give a definite answer were classified as undecided. However, it was found that many farmers wanted to replace their existing early rice variety CH-45 because of its declining production potential. In most cases, new rice entries replaced existing varieties and new entries to some extent, while the overall increase in area under *Chaite* rice was quite low. This may be due to the need for diverse types of *Chaite* rice.

The study tried to identify the level of adoption of *Chaite* rice varieties after farmers had tested them for two years and were growing them for a third. Farmers' familiarity with the names of the rice varieties distributed under IRD program was considered one of the indicators for farmers' awareness. In the study, only 23% of the respondents could correctly recall the names of the improved *Chaite* rice varieties when they were compared with local cultivars. Of these, 18% were food-surplus farmers, about 5% were food-balance farmers, while there were none from the food-deficit group. The study found that 37% of farmers surveyed were still growing the IRD varieties during the third year, whereas 63% had discontinued or did not wish to continue to grow them.

The report of the *Samuhik Bhraman* on *Chaite* rice revealed that a total of 2590 ha of land were covered by the crop in the survey area and 98% of *Chaite* rice in the same area was covered by a single variety CH-45 (Sthapit *et al.*, 1990). An interesting finding is that the IRD has offered varietal choice to early rice growers. In a period of three years, at least four pre-released varieties have been adopted by the farmers, though to varying degrees. It would be highly unlikely in the formal system for farmers to get seeds of pre-released varieties before the minikit stage i.e. within 10 years from the time of crossing.

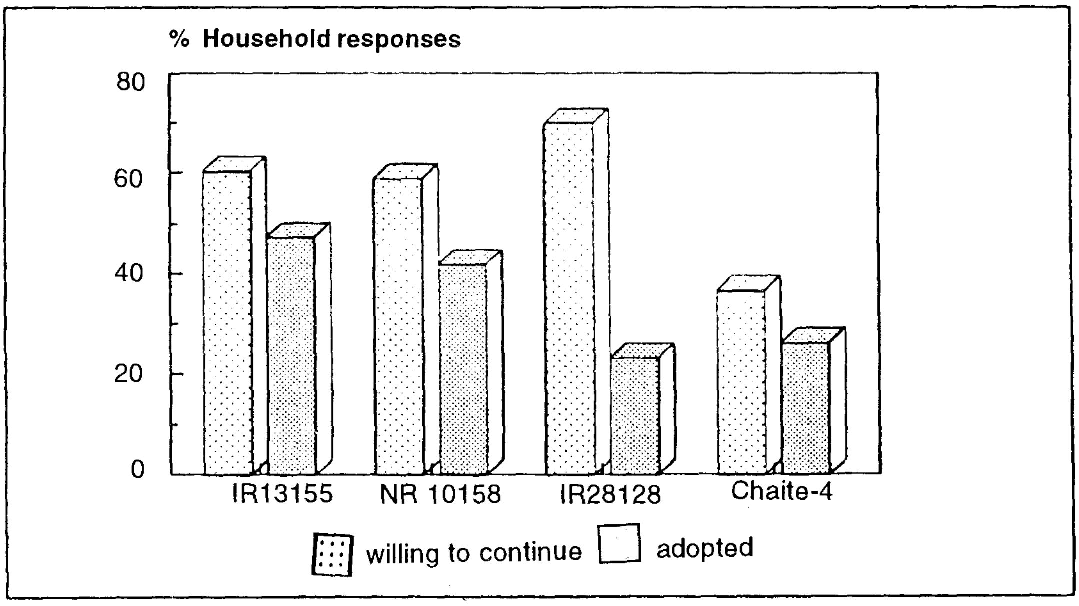
The study tried to correlate expressed willingness and actual adoption levels of farmers. Though 58% expressed their willingness to continue with the *Chaite* rice varieties during the second year, only 37% eventually adopted those varieties (Table 3). However, this is not unusual as the preference judgements of farmers were based on just one year of experience and they were interviewed when the second crop was still in the field; they were unaware of post-harvest characteristics. The survey revealed that three seasons testing is not enough to allow farmers to evaluate post-harvest parameters such as milling recovery, taste as *bhat* and other qualitative factors.

Table 3: Preference and adoption level of different *Chaite* rice varieties

Varieties	1992		1993	
	Number of households		Number of households	
	Surveyed	Willing to continue	Surveyed	Adopted
IR 13155	68	41	17	8
NR 10158	34	20	12	5
IR 28128	73	51	26	6
Chaite-4	55	20	23	6
IR 44595	8	8	4	4
Un-identified varieties	0	0	10	5
	238	140	92	34

In general, the gap between the percentage of households 'willing to continue' during the second year and those who have actually 'adopted' during the third year was similar in most cases, except for IR 28128 (Figure 5). The high level of rejection for IR 28128 was due to its poor cooking quality and taste, and low milling recovery because of high broken rice. In addition to these quality traits, the variety was a dwarf, which makes it difficult for carrying and threshing operations. The adoption level of the formally-released Chaite-4 is also low (Figure 5). Most of the deficiencies of Chaite-4 are similar to those of IR 28128. Farmers also reported that these varieties do not perform well at low fertility sites and are relatively late maturing.

Figure 5: Comparative study of farmers' preference (1992) and adoption level (1993) of *Chaite* rice varieties



IR13155 and NR 10158 had above 40% adoption which is clearly because of several relative advantages of growing these two varieties (Table 3). For example, NR 10158 is an early maturing variety and vegetable growers prefer this as it provides more time to grow winter vegetables. IR 13155 has good cooking qualities in addition its tall plant height and high yield. The reasons given for preferring varieties were mainly their early and uniform maturity, compact grain setting, long and attractive panicles, high tillering, non-lodging characteristics and tolerance to disease.

The study found that farmers are experimenting with different *Chaite* rice varieties and, as a result, varietal replacement is common. Some of interesting examples from the study are as follows. Khem Narayan Kafle of Dhanubase Syangja was impressed with the performance of IR-44595 and adopted it, replacing IR-28128. He felt IR 44595 variety was high yielding, with longer seed dormancy, long and slender grains and long panicles. Conversely, farmers of Jholuengephant Gorkha rejected IR-44595 for its very poor cooking quality and high percentage of broken rice, as long grain rices break when milled in local rice hullers. IR-28128 variety was preferred by Top Bahadur Kumal of Gorkha and Dil Kumar Malla of Manahare, Tanahun, while Karunakar Pokhrel and Hari Prasad Pokhrel of Ganeshpur dropped the same variety because of its short straw height, low straw yield, and late maturity. The straw height of *Chaite* rice is important not only from the straw yield point of view, but also to ease threshing and carrying operations. Dwarf varieties such as IR-28128 are preferred only in high fertility conditions, where lodging of local varieties is a problem.

Lok Nath Sapkota of Ganeshpur Syangja and Damodar Sharma Baral dropped *Chaite*-4 because of its poor threshability, poor heading and high sterility, while the same variety was adopted by the farmers of Sepabagaincha and Yampaphant. Damodar Sharma Baral was aware of the IR-13155 variety, which was also distributed in the same village and planned to acquire seeds and adopt it.

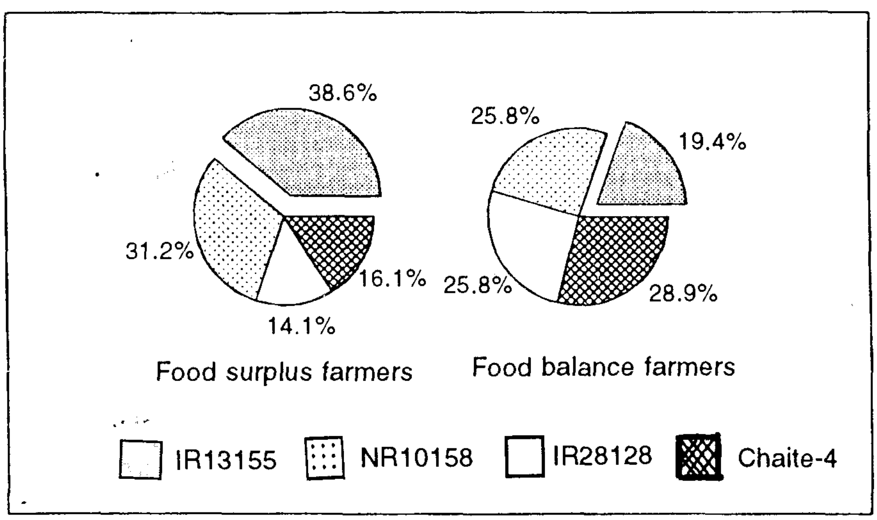
Laxmi Adhikari, a female farmer at Sepabagaincha, and Nar Bahadur Ale, Huwas, had adopted IR-13155, replacing their existing variety CH-45. They saw IR-13155 variety as higher yielding, having a maturity suitable for multiple cropping, safe from shattering and having a good cooking quality. The variety also replaced IR-28128 at Bhoteodar because of its high grain yield, tall plant height and good taste. However, the IR 13155 variety was initially not preferred by the farmers of Yampaphant where labor is constraining; it is difficult to thresh in spite of its high yield potential and good cooking qualities. Yet this variety was preferred by the farmers at Bhoteodar, Ganeshpur, Sepabagaincha, Huwas and near Damauli, the main reason being its high yield potential. Here farmers suggested that labor is not as important a constraint as land is and therefore they were willing to put some more labor on threshing IR 13155 to get some extra yield.

This information indicates the need for varietal diversification in *Chaite* rice, for which the IRD program strives. The high utility of IRD program is also demonstrated by these illustrations. The study revealed that farmers' choices of *Chaite* rice varieties varied within and between locations. This finding has clearly indicated that any one variety is highly unlikely to fulfil the diverse needs and preferences of farmers. The varying levels of adoption and rejection of *chaite* rice varieties also suggested the suitability of different rice varieties in different cropping patterns and socio-economic conditions. Rural people are local experts and keen observers (Prain, 1993) and they study carefully different components of any new technology before adopting it. This is particularly true in a subsistence farming situation where different traits influence the adoption of a particular variety significantly. When choosing different crop varieties, farmers have specific criteria in mind (Sthapit *et al*,, 1991) and are convinced only after thorough verification of them. The findings of this case study are very much in line with the observations of other researchers and this gives basic information needed in the research process.

Influence of socio-economic factors in varietal adoption

The adoption level of *Chaite* rice varieties was further analyzed on the basis of food-sufficiency level. Of the 29 farmers who were interested in continuing the IRD varieties, 48% were of the food balance group, 37% from the food surplus group and only 15% from food deficit group. While a higher percentage of early adopters comes from the food-surplus and food-balance groups, this cannot be generalized for other crops where production systems are more diverse than that of *Chaite* rice. It is noteworthy that rejection of IR 28128 and *Chaite*-4 was most common among surplus farmers as compared to IR 13155, unidentified varieties and IR 44595, whereas no clear trend was shown by the food-balance group (Figure 6).

Figure 6: Adoption level of different *Chaite* rice varieties across food sufficiency category



The varying level of adoption across food-sufficiency categories for different *Chaite* rice varieties indicates that any one variety cannot fulfil the varied requirements. IR 44595 had the highest level of adoption which was based on just one year of testing. Again, the sample was small and conclusions should be interpreted cautiously.

The association between landholding and adoption of *Chaite* rice varieties was similar to that of the food- sufficiency level. As the size of holding increased, farmers generally showed interest in testing new varieties, as they can bear more risk. The level of bearing such risk and eagerness to test new varieties was generally found to be low with the food-deficit group having landholdings of 10 *ropani* or less. Similar information was also obtained for the interaction between level of income and varietal adoption. However, no clear trends emerged from the interaction between family size and level of adoption.

The role of gender in variety selection and adoption

The study also tried to understand the role of gender in decision-making for varietal selection and adoption; it was found that the issue is very much influenced by the type of community. For example, in the Tamang community of Gorkha, women were found to have more say in the process while the opposite was true in case of Kumal community of same district in the neighboring village. A few common questions were asked both to male and female farmers; for example, the number of varieties to be distributed to each farmer under such IRD programs, the time of seed distribution, and any other suggestions which would help to improve the overall program of farmer participatory variety testing. The majority of farmers were in favor of having more than one variety. Irrespective of sex, 44% wished to have two varieties in the set, 25% preferred to have three, while 21% of farmers wanted only a single variety of *Chaite* rice at a time. The majority of female respondents expressed their willingness to test two to three varieties at a time. During discussions, it became clear that farmers wanted to compare their local *chaite* rice variety with at least two or more varieties, which would make the process of comparison easier. This multiple testing was felt necessary in case one variety failed, for whatever reason. This could be achieved by reducing the number of farmers per site and increasing the number of varieties per farmer.

The majority of respondents (95%) liked the idea of testing a small quantity seed of new *Chaite* rice varieties on their own farm. A total of 87% respondents expressed their willingness to participate in such a program, even if they encountered failures, as they believe that this type of program is an avenue for new technologies and new ideas. However 9% of the respondents were not willing to participate in this program, while 4% did not give any opinion.

Extension of *Chaite* rice varieties distributed under IRD

The effectiveness of IRD program in technology verification and dissemination process was also studied. Since IRD varieties are tested under farmers' real situations, selection of an unsuitable variety is less likely. There is a greater chance of adoption of varieties selected from an IRD set and the spread of such varieties through farmer-to-farmer network should be quicker as farmers' information networks are considered to be very strong. It was also supposed that farmers would know about the new *Chaite* rice varieties distributed in their villages. The study showed that about 57% of the farmers were aware of other *Chaite* rice varieties distributed in the village, 41% were not aware about other varieties, while about 2% did not respond. Interestingly, all the farmers who were aware of other varieties reported that they had asked for seed from their neighbors in order to try them the following year. This suggests that farmer-to-farmer seed exchange could be enhanced through this approach, particularly in case of self-pollinated crops.

Another indicator was used to assess the contribution of the IRD program to the variety dissemination system through a farmer-to-farmer seed exchange network. Women farmers play a particularly significant role in this. Varieties are disseminated both in the form of seed and seedlings. It is a custom to provide a gift of a certain breed of animal or seed of popular variety to relatives. This particularly can happen when a newly married daughter goes to her husband's house (Joshi, 1995). In the survey, it was found that when ladies visited their parents they were gifted seeds or seedlings of new *Chaite* rice varieties. This general trend of spread of seeds was further analyzed on the basis of the food supply situation. Surplus farmers were the main people who distributed seeds to other farmers, though some amount of seed was also distributed by food-balance and food-deficit farmers, but mainly within the same village (Figures 7 and 8).

Figure 7: General pattern of seed flow through IRD

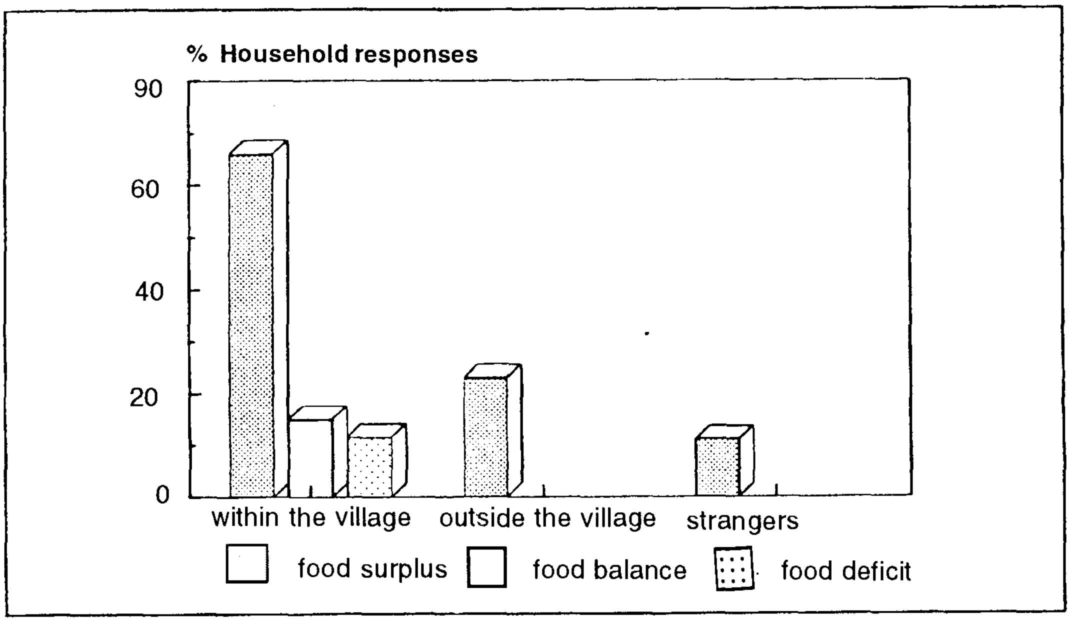
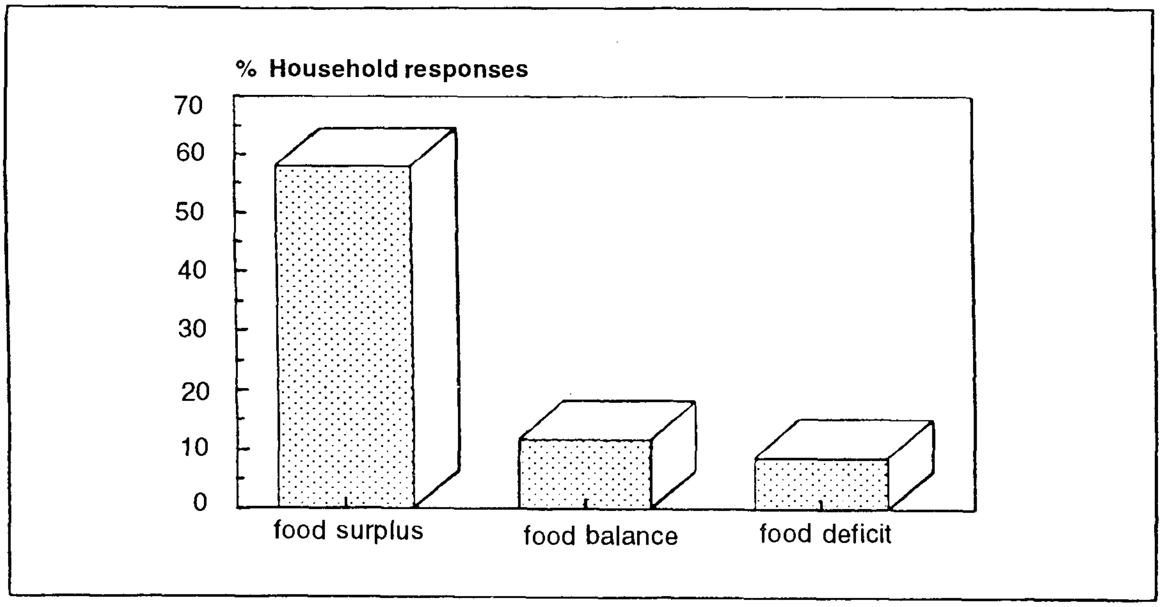


Figure 8: Distribution of IRD varieties by different food-sufficiency categories



These findings show that the IRD program is serving its objective of disseminating farmer-preferred rice entries through farmer-to-farmer networks and addressing the diverse needs of different categories of farmers. A number of new *Chaite* rice entries have spread to the area through this program, even in a limited area where CH-45 is still the predominant variety. Therefore, it has helped to promote genetic diversity.

Achievements of IRD

Initially, the IRD was conceived as a small-scale variety testing and dissemination program, complementary to the on-going research activities for arable crops. Gradually, the approach got wider acceptance in different disciplinary sections of LARC. Now the approach has already been institutionalized as one of the important tools for the outreach research programs for field crops, horticultural crops and livestock technologies. The most important contribution of this farmer participatory approach has been in influencing the outreach research approaches of LARC. It has been instrumental in identifying the complexity of the research outreach program. Previously, outreach programs conducted by LARC consisted principally of researcher-designed experiments. However, the IRD approach has been able to demonstrate the weakness of the formal system in that researcher-recommended varieties have not been doing as well as expected. The IRD approach is also accepted within the extension system and it no longer can be regarded as an informal system. It is interesting to note that some of the livestock species such as rabbit are also made available to the farmers through this approach. The usefulness of IRD program is well documented in different LARC publications (Gurung and Floyd, 1991; Gurung and Amatya, 1992; Kadayat *et al.*, 1991). The approach is considered as one of the strengths of LARC's research approaches.

Shortcomings of IRD

IRD materials are reported to perform well under only specific conditions as these are not bred and selected for wide adaptation. There may be a lack of adequate seed stock of some of the varieties spread through IRD as these may not have been promoted through the formal system (Kadayat *et al.*, 1991). IRD is also criticized because it may increase the chance of introduction of new diseases and pests in the area, as materials flow freely from one village to another and screening for disease tolerance by farmers is less likely. Again, long pedigree names of test entries are also difficult for farmers to remember and use in day-to-day operations. The main source of feedback to research and extension system from IRD is only in the form of monitoring large scale IRD in remote areas. There is still a lack of proper feedback to the formal system so that the technologies/varieties preferred by the farmers for different production environments can be promoted in a more organized manner. Again, because of the lack of a flexible seed regulatory system in the country, it is difficult to offer the benefit of farmer-preferred varieties to a large number of the farmers.

DISCUSSION

This case study has tried to analyze whether or not the IRD approach has addressed the issue of varietal diversification through the testing and identifying of relevant varieties for *Chaite* rice. The study found a number of pre-released varieties being spread in the village and replacing the existing variety, however, in a few instances, variety replacement was found even among the pre-released varieties as well. This information suggests that the approach is completely farmer participatory and that it is helping to promote varietal diversification on farm.

Varietal diversification is a sensible precaution for risk aversion in a rainfed and low external input agricultural system. Popular wisdom tells us that "betting on more than one horse reduces the risk" (Noordwijk and Andel, 1988). The study had clearly shown that varietal choice between the locations varied greatly, with choice largely being governed by the post-harvest qualities and utilities of *Chaite* rice. The IRD program has been successful in its objective of enhancing varietal diversification, as in a short period of three years, four pre-released varieties have been adopted by a considerable percentage of surveyed household.

Different characteristics of a particular variety, such as maturity period, straw height, grain quality, its adaptability to moderate or low fertility conditions, are the factors affecting adoption. Of the socio-economic factors, tenancy system, size of holding, and food-sufficiency level are important. Many agricultural scientists believe that science-based knowledge and local knowledge system must be optimized in the agricultural research and development process (Haverkort, 1991; McCall, 1987) to make the program successful.

Unlike most of other on-farm testing exercises, the IRD program is run on the basis of farmers' participation, e.g., in variety testing, selection, maintenance and dissemination. Selection of inappropriate varieties or technologies by an individual farmer is less likely as all cultural practices such as land preparation, time of planting, use of organic or inorganic fertilizers, irrigation, weed management, harvesting and threshing are done by the farmer, without giving any special consideration to the new varieties. This also increases the chances of adoption of technologies selected from an IRD set, and the farmers' network of information and seed exchange is very strong, cost-effective, and is more stable than government organized services. At the same time, grassroot-level institutions such as seed growers, vegetable growers' association and such other groups should be mobilized for the cause of IRD--due to its effectiveness.

The problem of the slow and hierarchical process of varietal dissemination can be overcome by IRD programs, as promising varieties of crops can be distributed to farmers from the F_7 stage onwards. This reduces almost by half the time otherwise required in a formal system, and is also a big saving in time and research effort.

The study of the different practices and treatments given by farmers to the cultivation of IRD varieties shows that there is not much difference between new varieties tested under IRD and local varieties in terms of manuring, time of planting and other cultural operations. Regarding the adoption level of *Chaite* rice varieties by farmers, it was noted that the actual adoption of the new technology depends upon numerous factors, and farmers are reluctant to adopt any new variety on a large scale in a short period of time. A minimum of four or five years was suggested to be appropriate for assessing the effectiveness of any such program.

CONCLUSIONS AND RECOMMENDATIONS

The IRD approach has contributed in developing locally adapted and suitable technologies through a decentralized technology testing process. Moreover, the IRD program operates on a minimum of staff time, the only involvement being planning, preparation and distribution of seed packets, and the monitoring of varieties. It began as a complementary process to the formal system and is enhancing the process of variety testing and dissemination through farmers' real participation. Based on these principles, the program should be cost-effective and sustainable.

1. Based on survey findings, IRD has been found as an effective tool for: (a) offering varietal choice to farmers: several pre-released *Chaite* rice varieties have spread in the study area through this approach; (b) on-farm level variety testing and dissemination, (c) decentralized selection. Farmers are participating in the testing of advanced rice lines and experimenting with them on their heterogeneous fields. Farmers are willing to participate in such a program; therefore the approach should be continued in future. IRD allows farmers to evaluate technologies under a range of abiotic and biotic stresses not normally well-represented in the formal research system.

2. Varietal adoption does not only depend on biological yield, but also on a number of equally important quality characteristics. Consideration should be given to all the factors when developing new crop varieties, including indigenous knowledge systems.

3. To develop IRD as a fully farmer participatory program, seed packets of different crop varieties should not be distributed. Instead, farmers should be given the opportunity to choose from among available varieties. Include two to three diverse types of varieties per farmer to make the process of comparison easier.

4. The objective of the IRD should be clearly stated to farmers before distributing the seed packets. Similarly, giving farmers a quick overview of the salient features of the crop varieties would help farmers choose the right type of material.

5. The farmers' network of information and seed exchange is stable and more cost-effective and should be strengthened. The spread of IRD varieties through the farmer-to-farmer network has been effective. Women farmers have been identified as the important agents in spreading the seeds from one village to another and therefore should be made more aware of this type of program. Women farmers should also be involved in variety testing and verification, as they are more aware of the post-harvest handling aspects of the crops.

6. Improved record keeping is needed of participating farmers so as to monitor the farmer-to-farmer exchange of seed and adoption or rejection of a particular variety.

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RICE GENETIC DIVERSITY: ITS SCOPE IN PARTICIPATORY RAINFED LOWLAND BREEDING

R. Thakur[1]

INTRODUCTION

The impact of the Green Revolution is hardly visible in about 14.9 million ha. of lowland ecosystems of rice in eastern India. Rice, the main staple food of the population, is grown under a wide range of ecological conditions: as an upland crop under great moisture scarcity to a deepwater crop, subject to water depths as high as three to four meters. There are many intermediate conditions between these two extremes. In the rainfed lowlands, flood and drought singly or in combination are the major abiotic stresses. So vast is this lowland rice-growing area in Eastern India that it is being increasingly realized at different levels of Indian administration that a large part of the agricultural answers have to come from the region itself. Other regions of the country have achieved fast agriculture growth, while this region has remained static. Better utilization of technology will only come through close analysis of the constraints to the generation and adoption of improved technology, including constraints within the policy realm.

Bihar is a typical eastern state, with the highest acreage under rice, 5.4 million ha, and showing only 1.2 t/ha average yields. The rainfed lowlands, including the flood-prone ecosystem constituting more than 50% of the total acreage, are characterized by dismally poor productivity. Most of the area is covered by traditional systems of cultivation, though scientists claim to have developed high yielding varietal technologies both at the national and state levels. Their adoption has been negligible as farmers prefer their own cultivars which are adapted to the varying conditions prevalent in the region. These cultivars have passed through innumerable selection cycles. High yielding varieties perform better where management is better, but virtually fail when conditions are adverse.

In this paper, we review the present scenario of high yielding varieties (HYVs) vis-à-vis the traditional genetically-diverse resources, their respective utilization, and describe an approach to develop adapted technologies to these rainfed lowlands and flood-prone ecosystems.

PRESENT SYSTEM OF VARIETAL DEVELOPMENT

Crop improvement projects and State Agricultural Universities have a mandate to release varieties with an appropriate package of practices. When a breeder develops a large number of advanced lines at the research station, such lines are initially evaluated and a few best are retained. An even narrower number of entries is promoted to advanced trials. Based on overall performance in yield and other desirable traits, a cultivar is identified for minikit testing, conducted by the State Department of Agriculture. Then again, based on an overall positive performance, the cultivar is named as a variety.

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[1] While unable to attend the conference, the author submitted the following paper.

Varietal technology developed through this process has mostly been adopted in the risk-free and homogeneous irrigated systems. For the risk-prone rainfed lowlands and deepwater ecosystems, the efficacy of this method appears doubtful. No variety so far developed through this method has been widely adopted. Despite such limitations, this methodology continues to be used and, based on average performance, varieties are being released. It is often assumed that there is a suitable resource base, land tenure system, climatic and infrastructural conditions to suit such component technology. Seldom it is noted that farmers' field conditions are often quite different from those on experimental stations, both in terms of practices and actual agro-ecologies. Farmers' conditions often include dynamic water regions, no insect/pest control, no soil amendments, local practices of cultivation, etc. Improved varieties, consequently, do not manifest their genetic superiority over local varieties under farmers' field conditions (Maurya *et al.*,1988; Saran *et al.*,1990).

LOCAL CULTIVAR ADOPTION IN BIHAR

Table 1 lists the popular local cultivars predominantly grown in different regions of the rainfed lowlands in Bihar. Many high yielding varieties have been released for the lowlands, but their adoption is limited to the favorable, irrigated locales. As we glance over the table, we see that one set of cultivars is popular in one region, another set in another region. No one cultivar is predominately grown in all regions. Farmers, through their experience, cultivate them in specific situations. Regional adaptability is very obvious. Their choice is mainly based on the average water regime, time of seeding and planting. We may analyze the land situation of a typical *Chaur* (lowlying land depression, mostly circular or striped in nature). They are deeper at the center and shallow at the periphery. Farmers plant suitable cultivars according to expected water stagnation. At the periphery of the *Chaur*, short duration varieties, even HYVs, are grown, then photosensitive, tall varieties which can withstand 40-100 cm water depth, and finally floating rices at the center. One can visualize the pattern of water in the *Chaur* from looking at the varietal composition. Farmers, however, in low rainfall years, such as 1992 onwards, have changed varietal composition; medium duration varieties, instead of photosensitive tall types, are planted now.

Farmers do not always consider the yield as the sole criterion on which to reject or select a cultivar. The variety must fit into their cropping system, should meet the household requirements and should have practices which farmers can easily afford to apply. The variation in yield due to management and environment should be minimal. In the rainfed lowlands, varieties invariably face drought and/or flood and must have an inherent ability to adapt. This inference has been drawn from the fact that numerous national demonstrations conducted in this environment have amply shown that a higher yield level can be achieved, yet, on practical basis, no farmers grow that variety the next year-- even though they may have realized a higher yield in the past. The reasons for their rejection possibly are (i) high level of management; (ii) necessity for irrigation water; and (iii) input application level, which in the demonstration may have been higher than that available to farmers. We also studied this aspect in our Farming Systems Research Project in a cluster of four representative villages from 1989-1994. This work might serve as a case study on which to plan further work to develop technology for this fragile ecosystem.

Table 1 : Traditional photosensitive popular cultivars of Bihar and their features

Traditional cultivars	Flowering date	Area of adoption	Adapti-bility	Special feature
Laldhari Kessore, Selha, Jhiggasar, Hathia Jhulan, Chengule, Kelasar T 141, No.52, Jalansar.	Ist to last week Oct.	South Bihar Plain of Bhagalpur region.	Regional	Hathia Jhulan had study stem broad leaf. All adapted to late planting.
Katarni, Kamod, Dehradun, Tulsimanjari.	2nd week Oct. to 1st week Nov.	-do-	-do-	Fine grain,highly tolerant to cold at flowering and drought tolerant. Adapted to late planting.
Bakol, Bakoi, Jaswa, BR 34, Herankel, Kalamkathi.	Ist to last week Oct.	North Bihar plain of Muzaffarpur region.	High	Jaswa has good grain quality. Bakol most predominant, sown in many districts of north Bihar.
Dhusari, Bakol, Kasaunjh, Parwapankh Akalbir, Malida.	-do-	North Bihar plain of Darbhanga Kosi region	Regional	Kasaunjh has short stature tolerant to soil deficiency/disease-pest resistant and cold tolerant at flowering.

TARGETING THE ENVIRONMENT

Classifying the environment in relation to the water regime (excess or no water) is difficult to do. There is great yearly variation in terms of flood or drought, rainfall pattern, and type of land depression; such matters complicate targeting for the rainfed lowland/ deepwater ecosystems. There is a high degree of dynamism. The same site may be drought prone if the rainfall is inadequate and or flood prone if the rainfall is heavy. This is main reason that HYVs, when grown in good weather, can yield over average but fail miserably when they face any kind of problem. Local landraces, on the other hand, are adapted to dynamic situations to a much greater degree. They possess adaptability to late sowing and planting, tolerate drought and/or flood and are thermo-sensitive, i.e. tolerance to cold at anthesis.

Therefore, we must target the environments based on the varietal choices of the farmers. A set of varieties was being grown in a specific type of environmental context, and that context, when analyzed, was shown to possess a high degree of variation. This indicates that varieties must have ability to adjust a great degree of variation. Bakol, a landrace, was growing in *Chauri* (lowland) as a transplanted crop and was directly sown in *Chaur* (deepwater). When there is likelihood of flood, it is directly sown or when there lack of flood, it is transplanted. Varieties possessing a narrow range of adaptability have no future in such an environment. Farmers have, in practice, researched this for years.

INTERVENTION AND TRIAL DESIGN

Keeping in view the existing farming systems, on-farm research and on-farm trials were planned as follows. Selected materials generated at the research station were first included in on-farm research trials and, based on their performance, a few were selected for on-farm trials which were conducted over a large number of sites. Farmers were partners in the planning and execution of the trials, which were designed to enable even semi-literate farmers to understand their implications.

ON-FARM RESEARCH TRIAL

Eight elite improved rice varieties, differing in maturity and height, along with the local cultivar Bakol were included in this trial (Table 2). The trial sites, one in each village, were selected in cooperation with farmers and the trials were conducted under farmers' management practices. There were three replications, with a plot size of 24 to 30 m^2 in a random block design (RBD). The rational of this research trial was two-fold: (i) to offer alternative varietal choices, and (ii) to verify the performance of improved cultures on-farm vis-à-vis on-station. Monitoring was arranged at the post-flowering period jointly with farmers. Based on the performance of entries along yield and maturity criteria, a few entries were selected for specific on-farm trials. This path of rice varietal evaluation, from on-station to on-farm research trial and then to on-farm trial, continued until 1994. Two cultivars, Sudha and TCA 48 in the photosensitive group, like the local Bakol and Rajshree in the earlier maturity group, were identified during the first year itself. They were included in the on-farm trial and, at the same time, remained in the research trial along with other entries (Table 2).

Table 2: Performance of rice varieties in on-farm research trial under rainfed lowland ecosystems of Bihar, India

Variety	Duration (days)	Height (cm.)	Average yield (kg/ha)						Remarks
			1989	1990	1991	1992	1993	1994	
			3*	3	4	2**	3	3	
TCA 48	185	155	2445	2345	3912	1836	3240	2680	Released as Vaidehi
PSQ 1209-2-3-2	150	140	-	-	-	-	3200	3350	
TCA-214	190	150	2039	-	-	-	-	-	Very late
Sudha	185	147	2358	2514	3418	1662	2630	2344	
Rajshree	145	130	2840	2737	4215	1772	3160	2604	Highly stable
Mansarowar	155	95	2004	-	-	-	-		
IET 7591	156	135	2139	2215	-	1334	2275	2968	
SBR 3013	165	120	2245	2380	-	-	-	-	
IET 7552	170	130	2168	1915	-	558	2386		
TCA 84-3	150	145	-	-	3146	1694	2837	2466	
SBR 1119-13-3-1	148	165	-	-	3736	1007	2938	2791	
SBR 38-150-2-4	136	140	-	-	3415	508	-	-	
Bakol (local)	175	160	2135	1832	3118	1262	2424	1779	
LSD at 5%	6.20	6.31	18.48	19.37	15.26	14.75	10.27	9.28	
C.V. %	10.62	13.34	10.72	13.22	10.55	15.22	16.18	19.61	

* No. of sites

** Unprecedented drought year

The trial design was simple: the test variety was grown with the local in a 500-1000 m^2 area under farmers' management practices. The sites, though not very uniform, were mostly on the peripheral portion of the *Chaur*. Altogether, 54 on-farm trials with Rajshree were conducted. Its performance was rated excellent (Table 3). In the drought years of 1990 and 1991, it did remarkably did better than the long duration Bakol, which faced severe drought in the absence of rain in September-October. Rajshree, because of its earlier maturity, was virtually unaffected.

Sudha was also tried in transplanted conditions against Bakol at 18 locations in three years. It did fairly well over the local but, due to drought in 1991, it also suffered like Bakol. It has, however, a superior grain quality. TCA 48 has now been found better both under transplanted and direct sown conditions. In the drought year, it was significantly superior to Bakol and was also found suitable for delayed sowing and planting. It has now been released as 'Vaidehi' (Thakur *et al.*, 1994.).

Table 3 : Results of on-farm trials on rice variety Rajshree conducted under the lowlands/shallow and deepwater ecosystems of Bihar, India

Village	No. of sites			Yield (kg/ha)		
	1990	1991	1992	1990	1991	1992
Choudharytola	3	3	7	2536(2132)*	2646(1945)	3048(1436)
Dhobgama	4	9	4	3615(1638)	3817(1639)	3140(1238)
Bakhtiyarpur	3	4	3	3415(2241)	3618(1932)	3845(1537)
Gwalatola	2	9	3	3517(1948)	4435(1614)	3937(1008)

* Yield of local variety in parentheses.

IMPLICATIONS

The on-farm data have implications for looking at the two-way linkage between on-farm and on-station research. The rainfed lowlands, which constitute more than 50% of the rice area in the state, serve as a glaring example where research priorities at the station have had little relevance for actual on-farm situations, both at the state and national levels. Dwarf varieties, responsive to fertilizer application and record yields, are screened and released-- but they do not match the existing adverse conditions. Mansarowar and Saiivahan varieties, released centrally, consequently failed in our on-farm research trials. Rajshree, a tall variety, was found successful because it is adapted to late sowing and planting and is tolerant to drought as well. It has, however, been released on the basis of its stable yield at the research station and, being a spontaneous mutant from the farmers' variety, possibly has adaptation to adverse situations. Criteria such as duration and to some extent tolerance to submergence and drought are assessed for the rainfed lowlands at the research station but adaptation to delayed sowing/planting, which is the number one problem, is never assessed while selecting a cultivar. At the Eastern India Lowland Breeder's Workshop, held at Bhubneshwar, the author shared his experience of working in farmers' fields, which led to the setting up of screening trials for the aforesaid problems in the eastern Indian states (Thakur and Mishra, 1992).

Rajshree, with about a month earlier maturity than the local, does shows the possibility of developing lines of this duration as envisaged by Choudhury (1982). At present, durations of more than 150 days are the only ones considered. TCA 48, released as Vaidehi, is again a local selection and has advantages over the local Bakol.

VARIETAL RELEASE METHODOLOGY

The State Agriculture Universities and Coordinated Crop Improvement Projects have the mandate to release varieties based on the overall performance of the cultivar at experimental stations and also in minikit testing. Varieties developed through this process have mostly been adopted in the risk-free situations, as mentioned earlier. The rainfed ecosystems have various niches and vary from region to region; varietal adoption is consequently not uniform. For example, varieties suitable for the deepwater *Chaur* lands of Bihar do not match the requirements in adjoining states like West Bengal and Uttar Pradesh, and *vice versa.* Farmers, in fact, grow different varieties in different regions. A few varieties, therefore, will not serve the purpose. Release of numerous varieties, rather than a few, has been proposed earlier (Jain and Banerjee, 1982). Therefore, varietal release procedures need to be modified for risk-prone environments.

The performance of TCA 48 in farmers' fields under adverse conditions has led its release as Vaidehi, which also has a stable yield at the research station (Thakur *et al.*, 1994). This is a selection from a local cultivar. Pureline selection, though abandoned with the advent of modern varieties and better technical know-how, still has relevance in rainfed ecologies. Jaladhi I and Savita in West Bengal, Kamini and Vaidehi in Bihar have recently been released and have gained popularity in their respective regions. Release will ensure pure seed production and eventually lead to stability in production. This breeding methodology was earlier been suggested, after reviewing the results of the hybridization program (Thakur and Mishra, 1992; Thakur, 1995). In a short period of time, it will have a visible impact on the production scenario. However, hybridization has a long-term use in variety release and will ultimately serve to develop varieties adapted to the harsh and dynamic environments (dynamic in respect to water regime, disease/ pest pressure and soil deficiencies). North Bihar which used to be largely flood-prone has now become drought-prone for the last four years due to less precipitation. Farmers have started searching for medium duration rather than long duration cultivars for the upper part of the lowlying *Chaur* lands. The solution lies in breeding strategies done within the system context, not in isolation but in cooperation and active participation of farmers as partners. We now realize the harsh realities when the HYVs, considered as solutions to all problems, failed to perform. Innovative farmers' techniques, their indigenous knowledge and their overall their active participation in the technology generation is very essential. The participatory approach, advocated earlier, has been found practically useful in identifying farmers-preferred cultivars (Thakur and Singh, 1992, Thakur *et al.*, 1993, Joshi and Witcombe, 1995, Loevinsohn and Sperling, 1995).

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DISCUSSION

[Editors' note: One presentation in this session was not submitted in paper form. As it raised issues not addressed elsewhere, we give a snapshot of its content in order to make the subsequent discussion intelligible.

A. Joshi and J. Witcombe present results from a project focusing on participatory varietal rice selection in three Indian States: Gujarat, Madhya Pradesh and Rajasthan. They describe the stages of: identifying farmers' preferences; an India-wide search process which seeks released cultivars with characteristics matching these preferences; and farmer participatory varietal trials. They argue that the reliability of the formal, organized yield trials is low and that many of the recommended cultivars are suitable only for high input systems. However, there are suitable released within India which because of poor popularization and poor definition of recommendation domains don't reach appropriate farmers. They conclude with recommendations to decentralize both breeding and the varietal release system.]

GUPTA: I want to comment on the suggestion of re-orienting the multi-locational trials. Let us not throw out the baby with the bath water. Gao Chavan, a castor variety, was developed in Gujarat but released in Andhra Pradesh, and there are many such examples where the multi-location trials have made suitable choices possible. What should be mentioned is that within the multi-locational system, there should be the possibility to take trials to a greater number of locations. This would also mean that the number of lines to be advanced have to be segregated and advanced at different levels for different projections as you cannot take very large numbers of varieties because the seed requirements will increase enormously. So there are some practical ways in which the existing system can be modified-- rather then releasing the varieties and then taking them for zonal selection.

...Another point is that the incentives for breeding for localized diffusion present an institutional issue of great importance which cannot be de-linked from the entire discussion. Unless and until the research system recognizes breeders for a task which is to develop lines for localized diffusion, it is unlikely that breeders will allocate time and energy to achieve that goal. So farmer participatory breeding will remain a peripheral, cosmetic activity unless institutional change takes place and local adaptation becomes an important mainstream criterion.

WITCOMBE: I want to elaborate a bit on my suggestion for re-organization. Even though we tested Kalinga 3, now for over three years, and it is one of the most popular cultivars in India, if you look at it in terms of breeder seed production and probably even in terms of hectarage grown, it is still only released in Orissa. When we sent proposals to the State Release Committees in the three states in which we were working, all those State Committees have said that they will need more data, even though we have so much farmer participatory data, which is so convincing. Therefore, it seems to me absolutely essential that the material, once it is identified and has been popular with farmers in a particular area, must be put into the multi-locational trials in the appropriate zone to generate data to support NGOs who are working in farmer participatory research. Otherwise, the process will go on and on and I can see that it will take us another three years to get Kalinga 3 released in any of the States in which we are working.

SINHA: But you don't need to get it released again--once it has been released by The Central Varietal Release Committee and in a state. I can give examples, not one, but many. Variety C-306 was released only for Haryana; today it grows in all parts of the country. There is no restriction.

WITCOMBE: You are absolutely correct in what you are saying, but in practice, not having official release is a disadvantage, the reason being that the KVK's [adaptive research/demonstration centers] are not willing to take up varieties which are not released in that state. The varieties are also not recommended by the State Agricultural University in their package of practices and we are not able to get the varieties to be taken up by the State Seed Corporations because, again, they are not recommended cultivars. So what you are saying is legally correct but, in practice, release is required.

OOSTERHOUT: I think we should be really careful not to repeat what happened with the Green Revolution: the HYV was given as the answer for all problems. In the same way, this farmer participatory breeding is not the answer for all problems. As there should be a basket of choices for farmers, let there be a basket of choices for breeders. And that brings me to the next point. A lot of breeders are quite stuck because they have been taught in a certain way: they have to produce the product and there is a lot of legislation to restrict them.

What I would like to see coming out of this workshop is some sort of training program or awareness program for breeders, because a lot of breeders are really stuck....Let us be open and creative and not think that there is only one solution.

SPERLING: I found it interesting that IPGRI is interested in decentralized selection and you have also spoken about re-introducing varieties. Has IPGRI ever thought about decentralized selection <u>in order to reintroduce</u> varieties, for instance, in cases like the Zimbabwean drought described this morning or in extreme cases of disruption like Rwanda or Cambodia? What kinds of mechanisms do you have for reintroducing varieties?

RILEY: I think that is a very important mechanism which I tried to present in my talk. Genebanks need to be more involved with breeders in a decentralized way. There have been many instances, as you know, where in emergencies, genebanks have been very involved in bringing material to a particular area where there has been tremendous erosion.

What we are trying to focus on here is that when we talk about *in situ* conservation, there is an opportunity for farmers to maintain a large amount of variation that they have been maintaining traditionally. There must be mechanisms to enable them to do that better. The paper tried to focus particularly on what breeders can do to change. One of the many components would be in re-introducing material that was lost and that is where national systems have to be very much involved with the breeders so that the process works. I think it can work best on a national basis.

KOTHARI: India, as many other countries, is going very much into private sector breeding, rather than public sector. Given also our concerns about site-specific breeding and selection, etc., --which are necessarily less profitable than wide adaptability selection--what is the scenario we are going into? Are we going into a situation where, in fact, we are going to lose more diversity or do you think private sector breeding could also fit into this kind of scenario of increasing diversity?

SINHA: Well, only last week, I had a meeting with the industry in Hyderabad, some 20 companies. It now seems very clear that the target of the private industry in this country is essentially the hybrids. In the hybrids, also, the first target is the vegetable crops and then come maize, sorghum, pearl millet and there will soon be an effort in rice. The public sector as such will have a major concern for all those crops which are self-pollinated; whether it is wheat or rice or sorghum or Bajra. The public sector will have to remain seriously involved, otherwise the country will come into great difficulty....One would not expect that the private sector would help farmers' participation in selection.

GUPTA: Another view is that the number of varieties marketed by the National Seed Corporation or State Seed Corporation in the last twenty years has been well perceived. If you look at genetic growth, the contribution of the public sector is singularly important and is continuing.... That is a matter of fact. At the same time, the regulatory framework for release, for testing of the material developed by small seed companies is very unfavorable. The small companies have to pay the same testing fee as the large multinational corporations. So, if you really wish the small private sector to be competitive and to generate varieties, then the regulatory framework has to be altered. It is not now feasible for small companies to come and play a major role.

SATHEESH: I wonder whether in the context of diversity, the question of public sector seed corporations or private sector is relevant at all because I think that both of them work toward one goal---anti-diversity. There was some suggestion that the private sector will ultimately look at consumer preferences and will make something for their preferences, but everyone knows that the private sector manipulates consumers. So I think that if biodiversity is the goal, then the seed producers will have to be the people themselves and the communities themselves and no national corporation, whether public or private sector or multinational.

FARMERS PARTICIPATORY HIGH ALTITUDE RICE BREEDING IN NEPAL: PROVIDING CHOICE AND UTILIZING FARMERS' EXPERTISE

B.R. Sthapit, K.D. Joshi, and J.R. Witcombe[1]

ABSTRACT

High altitude rice is constrained by chilling injury and Sheath Brown Rot (ShBR) diseases. The modified-bulk method of breeding supplemented by farmer participatory breeding (FPB) is adapted to efficiently utilize limited resources, and farmers' expertise to provide selection choice. This study has been conducted by the Lumle Agricultural Research Centre (LARC) at Chhomrong (2000 m) and Ghandruk (2000 m) villages in the Western Hills of Nepal since 1993 with the objective of developing productive varieties adapted to local needs and preferences, and also enhancing genetic diversity on-farm. Selection of segregating lines in farmers' fields has been encouraged and their selected lines are multiplied and entered into the formal system to ease official release. The reasons for adopting an innovative approach as compared to a conventional method are described.

Promising F_5 bulk seed of selected lines was distributed to expert rice farmers for decentralized selection. Selection procedures, evaluation criteria of farmers and factors affecting their decisions were monitored. Selection methods of farmers which successfully resulted in the choice of different rice entries are discussed in this paper. Results were assessed by joint field visits, preference ranking, post-harvest evaluations, crop cut yield data and on-station trial data. Final adoption decisions were based upon multi-stage evaluations, including post-harvest by women farmers. Farmers selected Machhapuchhre-2, 3 and 4 from the Fuji 102 x Chhomrong Dhan and Himchuli-2 from K332 x NR10157-2B-2 crosses. Two populations of Machhapuchhre-3, selected independently by farmers of Chhomrong and Ghandruk, have promoted genetic diversity in farmers' fields. Both populations are the most preferred by farmers and are spreading quickly. Farmer-selected varieties also performed better in researcher-managed yield trials, with better resistance to ShBR disease and chilling. Preference ranking by farmers indicated that there is good agreement between farmers and breeders suggesting that expert farmers' selection is as reliable as breeders'. The success of this kind of program depends upon how well expert farmers can be identified and whether the problem is relevant to the farming community.

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INTRODUCTION

Chilling injury in rice is common in Nepal in high altitude areas (i.e. >1000 masl). Of 1.4 million hectares of rice in Nepal, 26% are grown in temperate areas (1000-2000 m) (Shahi and Heu, 1979), and spikelet sterility caused by chilling injury is a major constraint above 1500 m, limiting both the area of production and the length of the growing season (Sthapit and Shrestha, 1991). In Nepal, rice improvement programs have been less successful in high altitude areas to which limited research resources have been allocated by national and international programs. Of the 39 rice cultivars recommended so far by the National Rice Research Program (NRRP) only two, Chhomrong Dhan (CD) and Palung-2, have been released as chilling tolerant cultivars suitable for the high hills (>1500 m). Screening of internationally known cold tolerant materials at Lumle (1450 m) and Chhomrong (2000 m) has identified lines with good chilling tolerance during vegetative growth but which failed to produce grain because of incomplete panicle exsertion or spikelet sterility.

Nepal is rich in genetic diversity of chilling tolerant rice landraces (Nagamine, 1992) but the identification and utilization of local germplasm within the national breeding program has been limited (Sthapit, 1992). Since 1985, Lumle Agricultural Research Centre (LARC) has conducted a high altitude rice improvement program by evaluating local and exotic germplasm in farmers' fields at Chhomrong (2000m). As a result, in 1991, Chhomrong Dhan (CD) was released by National Variety Release and Registration Committee (VRRC) for the high hills of Nepal. Only CD shows reliable adaptation and good performance above 1500 m. About 25 years ago, this variety was introduced from India by a curious farmer at Ghandruk and Chhomrong (>1900 m) where rice was never grown before. Pure line selection of the local population for chilling tolerance and ShBR resistance was done by LARC.

The chilling tolerant rice participatory breeding program commenced with farmers in Chhomrong and Ghandruk in the rainy season of 1993. The idea to start such program sprang from discussions during a field visit to Chhomrong by Dr. J.R. Witcombe and LARC rice breeders in October 1992. The reasons for adopting such an approach are many:

a) LARC did not have sufficient suitable land and resources to justify breeding on-station.

b) There were hundreds of F_4 lines that had been grown on rented land, and the requirement for rented land to grow and screen F_5 progenies in the next year was very large. It was felt that a farmer participatory approach, whereby F_5 bulk families harvested from the most promising F_4 rows were given to farmers for their evaluation in their fields, would be more resource-efficient and would lead to more relevant testing.

c) Rice varieties bred and released by NRRP in Nepal must pass through a highly centralized process of varietal testing, release and certification system taking 13 to 15 years to reach farmers' fields (Sthapit, 1995). Since 1966, Nepal has been slow in releasing rice varieties (i.e. 1.4 per year) for the 1.4 m ha area in rice ecosystems ranging from 80 m to 2600 masl with differences in moisture and temperature regimes.

d) Variations in altitude, soil type, soil moisture regime, water source, aspect, nature of terracing, and other management practices contribute to creating a mosaic of farming systems that is heterogenous and complex. Extreme agroecological diversity, specific ethnic preferences and complex production systems demand location-specific varieties. Research programs that address individual farmer's needs are impractical.

e) Adoption levels of improved rice in Nepal are very poor, ranging from 10 to 11% (Chemjong *et al.*, 1995 and LARC, 1995). In Nepal, and elsewhere, breeders fundamentally use wide adaptation and high yield as the principal selection criteria. Improved varieties do not always meet the farmers' needs. However, other criteria such as tallness, grain color, cooking and eating qualities of rice are used by farmers when making adoption decisions (LARC, 1995). Farmers' perceptions are not usually assessed at an early stage of evaluation (Sthapit, 1995).

f) Wide scale adoption of an 'improved variety' in high potential areas has the effect of reducing the gene pool on farmers' fields (Lohar *et al.*, 1995).

g) The initial success of informal systems of farmer experimentation has played an important part in consolidating the farmers' role in breeding (Sthapit *et al.*, 1989; Joshi and Sthapit, 1990).

Varietal selection is difficult for very heterogenous environments where farmers have a range of preferences and circumstances. A combination of traits is required for adaptation and various socioe-conomic criteria need to be considered to achieve adoption of a variety. This requires a research system that will deliver a wide range of rice varieties suitable for the diverse agro-ecological and socio-economic circumstances of farmers. Use of conventional selection approaches, concentrating on grain yield and wide adaptability, is not always possible in developing countries where research resources and trained manpower are limited.

This necessitated the re-orientation of LARC's high altitude rice improvement methodology to address two issues; resource availability and research appropriateness. Maurya *et al* (1988), Galt (1989), Joshi and Sthapit, (1990), Sperling *et al.* (1993) and Sthapit *et al.* (1994) considered alternative approaches to address these problems. Traditionally, the development of rice varieties has been a task of breeders and farmers are supposed to wait for finished products. However, at LARC, we thought that a joint venture between expert farmers and crop breeders for developing new varieties could be fruitful in terms of incorporating farmers' wisdom in identifying appropriate technology for their environment. The objective of the program has been to examine the practicability and success of adopting a farmer participatory approach to high altitude rice breeding as a means of minimizing resource use, utilizing farmers' knowledge, developing suitable varieties and enhancing the diversity of rice gene pools.

METHODS OF THE PARTICIPATORY VARIETAL SELECTION

In 1985, LARC started a high altitude breeding program with the objective of developing cold tolerant white grain rice with resistance to blast and ShBR diseases. An example of the scheme of this farmer participatory rice breeding program is given in Table 1. The approach emphasized farmers' selection of segregating materials from carefully chosen crosses from the on-going high altitude breeding program. An evolutionary approach was taken for the development of practical methods by using materials generated by the conventional modified bulk population method. There were no established FPB methods known to LARC breeders at the time which could have helped in the design of procedures that were practical and which were scientific enough to produce reliable results. There was an important element of risk.

Identification of site

High selection pressure was employed at Chhomrong (2000 m) for spikelet fertility and ShBR resistance during F_2-F_4 generations, while retaining variability in which farmers were interested.

Chhomrong (2000 m) village had been a high altitude rice testing site since 1985 and was considered a good site for natural screening of both cold air and water-induced spikelet sterility and ShBR disease caused by *Pseudomonas fuscovagainae* (Sthapit, 1992). This site was also selected because farmers were interested in improving the quality of their local rice and had been impressed by LARC's past farmer participatory research.

Table 1: The methods of farmer participatory breeding (FPB) for selected crosses and stages, and the level of participation between farmers and breeders in the program at Chhomrong and Ghandruk villages

Year	Generation and process	Level of participation	
		Formal system	Informal system
89	F_1 (Fuji 102/Chhomrong Dhan)	**Breeder**	**Breeder**
90	F_2 individual plant selection by breeders from large plot at Chhomrong (2000 m) and Lumle (1450 m)	**Breeder**	**Breeder**
91	F_3 family selection by breeders at 2000 m and 1450 m	**Breeder**	**Breeder**
92	F_4 families selection by breeders at 2000 m and 1450 m and bulk seed multiplication for FPBP	**Breeder**/farmer	**Breeder**/farmer
93	Best F_5 bulk seed of M-1 to M-5 and, H-1 given to farmers at Chhomrong and Ghandruk and farmers evaluate and select the best plants from given families; half of the seed given to LARC for testing	**Farmer**/breeder	**Farmer**/breeder
94	Farmers select F_6 bulk seed grown by farmers. Some new lines of M-6, M-7, H-1 and Nilgiri-1 given to farmers. Some single plant selections made by breeders. NRBN/NRCTN	**Farmer**/breeder	**Farmer***/breeder
95	F_7 bulk seed from farmers to be grown by breeders to make single plant harvests from 'true type' plants. IET/PYT	**Researcher**	**Farmer***/ Researcher
96	F_8 progeny rows grown from 94 and 95 single plants. Removal of 'off type' rows. Multiplication of farmer-selected families. CVT/FFT	**Researcher**	**Farmer***/ Researcher
97	F_9 breeder seed multiplication to give F_{10} seed. CVT/FFT	**Researcher**	**Farmer***
98	F_{10} breeder seed multiplication to give F_{11} seed. VRRC	**Researcher**	**Farmer***

NRBN = National Rice Blast Nursery
NRCTN = National Rice Cold Tolerance Nursery
IET = Initial Evaluation Trial
PYT = Preliminary Yield Trial
CVT = Coordinated Varietal Trial
FFT = Farmers' Field Trial
VRRC = Variety Release and Registration Committee
FPBP = Farmer Participatory Breeding Program
Asterisk (*) indicates probable source of biodiversity.
Bold faced indicates significant role in the selection process.

Identification of segregating materials

Two F_4 lines from the formal breeding program nursery were selected by the breeder for this study in 1992, and F_5 bulk rows were harvested. The selected F_5 bulk lines, from three crosses, were given local names for easy identification in discussions with farmers (Table 2). F_5 materials have significant genetic variation left in the bulk from which farmers can choose genotypes to meet their own needs and circumstances.

In 1993, a limited quantity (20-25 g) of seeds of F5 bulk were distributed to expert farmers[2] (Table 2). Additional F_5 bulk of Nilgiri-1, Himchuli-2 and Machhapuchhre-6 and M-7 was included in 1994. A total of ten farmers from Chhomrong and four from Ghandruk of Ghandruk Village Development Committee (VDC) were involved in the program. The number of farmers was limited due to the limitation of seed, but whenever possible, extra seed was distributed to farmers of adjoining or similar recommendation domains to test the extent of diffusion (Table 2). Table 3 gives the origins, species, sources and specific traits of the parents of the three crosses under study.

Table 2: Details of F_5 bulk of cold tolerance rice included in the participatory breeding program in the hills of Nepal in 1993 and 1994

Parentage[1]	Cross and pedigree	Vernacular name	Name and address of the cooperating household member[2]		Year of distribution
			Chhomrong	Other Sites	
Fuji 102 x CD	LR88001-1L-0C-0C	Machhapuchhre -1	Mr Ram Bahadur Gurung Ghandruk VDC-9*	Mr Man Kaji Gurung Ghandruk VDC-6*	1993, -
Fuji 102 x CD	LR88001-2L-0C-0C	Machhapuchhre -2	Mr Krishna Bahadur Gurung Ghandruk VDC-9*	Mr Jaya Bahadur Gurung Sabet VDC-7	1993, 1994
Fuji 102 x CD	LR88001-8C-0C-0L	Machhapuchhre -3	Mr Jaya Bahadur Gurung Ghandruk VDC-9*	Mr Rudra Bahadur Gurung Ghandruk VDC-6*	1993, 1994
Fuji 102 x CD	LR88001-8C-0C-0C	Machhapuchhre -4	Mr Chij Bahadur Gurung Ghandruk VDC-9*	Mr Purna Bahadur Gurung Ghandruk VDC-6*	1993, 1994
Fuji 102 x CD	LR88001-21C-0C-0C	Machhapuchhre-5	Mrs Ram Kumari Gurung Ghandruk VDC-9*	Mr Kajiman Gurung Ghandruk VDC-3*	1993, -
K332 x NR10157 -2B-2	LR8808-24C-0C-0C	Himchuli-1	Mr Mim Bahadur Gurung Ghandruk VDC-9*	Mr Bal Bhadra Paudel Dhikurpokhari VDC-5	1993, -
K332 x NR10157 -2B-2	LR8808-11C-0L-0L	Himchuli-2	Mr Him Bahadur Gurung Ghandruk VDC-9 *	Mr Dhananjay Devkota Lumle VDC-4	- 1994
Stejaree 45 x CD	LR89002-3L-0L-0L	Nilgiri-1	Mr Chitra Bahadur Gurung Ghandruk VDC-9*	Mr Jhajan Nath Devkota Lumle VDC-4	- 1994
Fuji 102 x CD	LR88001-2L-0L-0L-0L	Machhapuchhre-6	Mr Jau Bahadur Gurung Ghandruk VDC-9*	-	- 1994
Fuji 102 x CD	LR88001-1L-0L-0L-0L	Machhapuchhre-7	Mr Iswar Bahadur Gurung Ghandruk VDC-9*	-	- 1994

1 CD = Chhomrong Dhan

2 The participatory approach was used in Ghandruk VDC and only monitoring of variety was done in other villages to assess whether selection in different sites can be linked or not.

* Asterisk (*) indicates farmers participating in the rice breeding program.

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[2] Expert farmers are knowledgeable rice farmers as identified by the community.

Table 3: The important traits of parents, their origin, type and source (for the three crosses under study)

Genotype	Species	Origin	Source	Important traits reported
Fuji-102	Japonica	Japan	IRCTN	Cold tolerant, dwarf, white grain and good quality; Not released in Nepal.
Chhomrong	Japonica	Nepal	Local selection	Multiple resistance to cold, ShBR and Blast diseases, medium plant height, red grain; released in Nepal.
K-332	?	India	IRCTN	Cold tolerant, released in Kashmir, blast resistant
NR-10157-2B-2	Indica	Nepal	Breeding line	Early, cold tolerance, fine quality, not released in Nepal but sister line adopted by farmer
Stejaree-45	Japonica	Russia	IRCTN	Cold tolerant, coarse grain

IRCTN = International Rice Cold Tolerance Nursery

The identification of farmer-breeders

A total of 14 expert farmers from Chomrong and Ghandruk villages, who had considerable knowledge and skill in rice farming, and who were willing to participate in this study, were identified with the help of the local community. Four additional cooperating farmers from Lumle and Sabet villages were also selected, but FPB procedures were not followed.

Both male and female members of the same household were involved in this study to accommodate differences in gender knowledge and perceptions. Wives of male cooperating farmers were automatically selected for post-harvest evaluations. They are usually expert in evaluating harvesting, seed selection, milling, storage and cooking characteristics, whereas male farmers are more astute evaluators of threshing and yield potential.

Farmer participation

In the beginning (i.e., 1992), farmers were not very enthusiastic about the program and they were hesitant to participate in the conventional labor-intensive, researcher-managed trials to which they were so accustomed. However, farmers' participation increased as they perceived that the research was relevant to them. In October 1992, a small gathering of about 20 rice growers was organized to discuss the objectives of the program. The purpose was to develop rice varieties with white grain. White rice is highly preferred by the local community, and therefore, was used as a catching phrase to encourage them to get involved in rice breeding. At the meeting, the role of participating farmers and their knowledge of plant types and heritability of traits was also discussed.

Farmers' management

The farmers were asked to grow and manage the lines along their normal practices except that test entries were maintained separately in the field and store to avoid mixing. Farmers were allowed to assess and select as per their own criteria and objectives and the procedures were monitored and recorded by field staff. Seeding for nurseries and transplanting for all test and local varieties were done within a week. Sign-boards with the name of the variety and expert farmer were provided by the program to catch the attention of non-participating farmers.

Training in plant selection

In 1993, farmers were asked to make selections in the field. At the beginning of the selection, farmers were informed that progenies would segregate for grain color, plant height, maturity, etc., when two divergent varieties are crossed, and therefore, selection for desired traits should be done for two to three years from F_5 bulk seed until the trait is fixed. Breeders' knowledge of genetics and heritability was offered to farmers in order to complement farmers' indigenous knowledge of diverse environments. Farmers were encouraged to carry out their own selection, which enhances gene diversity at the farm-level. Farmers were asked to keep half of seed to grow the next year and to return half of the selected seed to LARC for on-station varietal testing.

Farmers' preference ranking

In 1993, farmers' plots were visited by a group of participating farmers and breeders but no preference ranking was done. In 1994, the on-farm and experimental plots at Chhomrong and Ghandruk villages were jointly monitored by participating farmers and other farmers from the villages with breeders, a socio-economist and affiliated researchers. Each farmer's plot was labelled with the farmer's name. At the outset, the breeder explained the purpose of the farmers' field day.

A total of 14 farmers from the village of 20 households visited individual plots, examining crop performance, inherent soil fertility and water sources. Representatives from six households could not participate in the field day, which took about three hours. After the field visit, farmers were individually asked to rank varieties from 1 (for excellent) to 7 (for worst) on the basis of their own criteria and knowledge. With the help of researchers, farmers listed the salient positive and negative characteristics of each variety using an open-format questionnaire. The extent of agreement among farmers, and also between male and female farmers based upon preference ranking, was also assessed by Kendall's W (Siegel, 1956), a measure of the concordance among multiple judges. Rank correlation was also done to measure agreement between breeders and farmers using Spearman's coefficient of rank correlation (Steel and Torrie, 1960).

On-farm yield measurement

Crop cuts from 1 m^2 plots were taken from fields of all participating farmers to measure grain yield. Measures were adjusted to account for 12% moisture content. Plant height (cm) and fresh straw yield at harvest were also recorded. At harvest time, the farmer's method of plant selection was observed.

On-station yield trials

In 1994, the farmer-selected variety Machhapuchhre-3 was included in the National Rice Cold Tolerance Nursery (NRCTN)[3] which had been selected by Rudra Bahadur Gurung from

[3] The NRCTN is the entry point of all introduced and breeding lines for temperate rice from which the elite entries are advanced to CVT and FFT. Varieties entries have to go through multilocational tests for five to six years before they are considered for release (Sthapit, 1995). The results of the CVT and FFTs grown across distinct agro-ecological zones are pooled, and varietal releases are based on the three-year overall performance of variety included in the FFT set. An overall good performer stands a good chance of being released. However, a cultivar which performs very well in one specific location, but overall is not near the top of the list, will never be released under the current system of cultivar evaluation and release.

Ghandruk-6 in 1993, and was considered best from the point of view of yield potential and resistance to cold and diseases. The objective of this was to assess the performance of the farmer-selected variety in comparison to varieties developed through the centralized breeding program and to verify the unconventional on-farm results with on-station data in order to satisfy the variety release regulations. A broader objective was to influence research policy itself.

The NRCTN was conducted at four sites during the summer of 1994: Chhomrong (2000 m) and Shera (1250 m), testing sites of LARC; Khumaltar Agricultural Farm (1350 m), and Kavre Agricultural Farm (1700 m). At LARC, 20 varieties supplied by NARC along with the farmer-selected M-3G, eight progenies of Fuji 102/CD and three local checks were assessed for variation in chilling tolerance and yield potential, using the standard evaluation system for rice (IRRI, 1988). Trials were designed in randomized complete block design (RCBD) with two replicates at Shera and Chhomrong, whereas in Kavre and Khumaltar nurseries were non-replicated with twenty entries.

The trials were researcher-managed with standard recommended agronomic practices. The nurseries were transplanted during mid-July 1994 with the application of 60-30-20 Kg NPK/ha except at Khumaltar where chemical fertilizer was applied 100-40-30 kg NPK/ha. Plot size varied from 1.2 to 4m^2. Data on agronomic traits and disease incidence related to chilling tolerance were measured. Yield data were not recorded in Khumaltar. Analyses of variance were used in replicated trials to evaluate the significance of differences between varieties for various traits using a randomized block design.

Post-harvest evaluations by women farmers

Post-harvest evaluation was done three months after the harvest. In 1994 season, this study was carried out only with those varieties for which farmers had retained seed for the next season. The questionnaire was designed after discussions with women farmers known for their seed selection skills, cooking and milling practices. Farmers milled and cooked the rice along local methods and their assessments were recorded. A total of seven questionnaires on post-harvest evaluations were completed.

Monitoring of varietal spread and rejection

Varietal spread was monitored with all cooperating farmers during 1993, 1994 and 1995. The reasons for adoption or rejection were also recorded.

RESULTS

Farmers' selection of site

The majority of participating farmers grew their crop in medium fertility conditions at altitudes ranging from 1400 to 2000 m. Four cases illustrate how farmers' decisions influenced site selection for variety evaluation. Him Bahadur Gurung from Chhomrong (2000 m) transplanted Himchuli-2 rice to a small plot where cold water first gets in from the channel and which used to cause severe tip sterility in his local rice. Him Bahadur aimed for risk aversion by experimenting in the worst plot for cold water tolerance. He has no plan to continue with Himchuli-2 as the performance of the variety was not good. Similarly, Rudra Bahadur Gurung from Ghandruk (2000 m) also tried M-3 first in the worst plot of his land which was situated at the corner of a high terrace, which received little sunlight and was exposed to cold water. He selected a few good plants from the plot and has expanded the area sown to the variety from 6 to 1250 m² over two years of testing. As an extreme case, Jhanan Nath Devkota of Lumle (1400 m) transplanted Nilgiri-1 to a plot where he never had seen a rice plant produce a single grain. The plot has an inlet of cold water from the mountain stream, which also brings animal manure to the terrace. It has been well-established that cold water in presence of high fertility induces high spikelet sterility (Sthapit, 1992). The variety yielded 3.3 t/ha at 12% moisture content estimated from a 2 m² crop cut. Mr. Devkota was excited at this unexpected result and immediately decided to expand use of the variety to better lands and over larger areas. However, at planting time, he changed his mind because of the high shattering, poor straw quality and taste. Another farmer, Dhananjay Devkota of Lumle, evaluated the variety under high fertility conditions to see whether Himchuli-2 (4.0 t/ha) could stand the conditions. He has 0.4 ha of highly fertile rice fields and local varieties such as Raksali (2.9 t/ha) and Kathe (2.0 t/ha), which are adapted at Lumle, are partially sterile under his conditions. Mankaji Gurung of Ghandruk (2000 m), experimented with M-1 under rainfed upland conditions as he has larger areas falling into this category.

The farmers' strategies illustrate that varietal selection under uniform on-station conditions cannot represent the very heterogeneous environments used by farmers. Decentralized selections of site, management, and variety have helped to generate useful information on the specific requirements of farmers--information which formal might find costly to access.

Crop performance

The results are based on the field performance of entries given to participating farmers in 1993 and 1994 in Chhomrong, Ghandruk and neighboring villages. In 1993, most entries included under the participatory program were cold tolerant; however, the performance of Himchuli-1 was not very satisfactory due to high panicle sterility and degeneration. Among Machhapuchhre lines, M-1 was very dwarf and was more sterile than Chhomrong Dhan. Farmers dropped M-1 and M-5 in the first year of testing. M-5 performed poorly and was unattractive to farmers. Performance of M-2 was average and farmers gave it another chance for evaluation. Over one year, testing of M-3 and M-4 appeared promising and farmers retained seed, including that of M-2, to verify further in the 1994 season.

In the 1994 season, the comparative performance of rice varieties was judged by preference ranking of groups of male and female farmers, and breeders. The overall performance of M-3 was best, followed by M-2 and M-4. Himchuli-2 was ranked worst (Table 4) because of high sterility and small panicle size.

The evaluation scores among male and female farmers in Chhomrong village showed significant agreement (Table 4). Agreement between breeders was higher than amongst farmers but this could be due to the small number of breeder judges. Agreement between breeders and farmers was high (0.82) which suggests that farmers participation in selection is as reliable as breeders, if expert farmers are carefully chosen.

Out of 14 farmers who participated in the program, two farmers at Ghandruk and three at Chhomrong retained seeds from the test lines (Table 2) for further testing and evaluation.

Table 4: Comparative performance of various farmer-selected and managed rice varieties in Chhomrong in 1994, as judged by the farmers' preference ranking at the stage near maturity

Variety	Preference ranking				
	Mean ♂ farmers' n=9	Mean ♀ farmers' n=5	All farmers' n=14	Researchers n=2 n=16	Overall
Machhapuchare-2	2	2	2	2	2
Machhapuchare-3	1	1	1	1	1
Machhapuchare-4	3	3	3	3	3
Machhapuchare-6	4	6	4	3	4
Machhapuchare-7	6	4	5	4	5
Himchuli-2	7	7	7	5	7
Nilgiri-12	5	5	6	4	6
Kendall's 'W'	0.81	0.83	0.67	0.96	0.77

Kendall's 'W' is measured on the scale 0 (no agreement) to 1 (perfect agreement)
Rank correlation (ρ) between male and female farmers, = 0.82, and breeders and farmers, ρ = 0.82.

Farmer-managed trial yield data

Table 5 shows grain yields and other agronomic traits measured from the 1 m^2 on-farm plots where farmers carried out their preference ranking. These figures cannot be statistically analyzed and interpreted as the data were based upon a single crop cut of small plots. However, there was good agreement between farmers perception of the variety and crop cut results. The most preferred farmer-selected variety, M-3, had a higher yield than the Chhomrong local. The local variety produced 4.1-6.4 t/ha in 1994 from crop cuts of ten adjacent fields. Yield levels of the other test varieties were lower than the local. Aside from grain yield, the plant height and straw yield of M-3 was also found superior to the locals.

Table 5: Grain yield and other agronomic traits measured from 1 m^2 (crop cut) from farmers' fields at Chhomrong (1700-2000 m), 1994

Variety	Grain yield (t/ha) at 12%mc	Plant height (cm)	Straw yield (t/ha) at harvest	Tiller No /plant
Machhapuchare-2	5.22 (6.35)*	116 (118)	20.0 (18)	8.0 (5)
Machhapuchare-3	**6.32 (5.06)**	**123 (110)**	**24.0 (17)**	**6.7 (4)**
Machhapuchare-4	3.55 (5.06)	114 (116)	11.2 (25)	5.6 (5)
Machhapuchare-6	3.14 (4.09)	100 (116)	5.0 (5)	5.2 (6)
Machhapuchare-7	3.23 (4.72)	111 (120)	16.0 (11)	6.0 (4)
Himchuli-2	1.43 (5.06)	117 (125)	20.0 (26)	4.0 (5)
Nilgiri-1	3.52 (5.06)	110 (106)	18.0 (18)	5.6 (5)
Mean	3.77 (5.05)	113 (116)	16.3 (17.1)	5.8 (4.8)

* Figures in parenthesis represent grain yield data of the Chhomrong local, grown adjacent to a test variety. n=1.

Farmers' methods of plant selection

Farmers used various criteria to select the best plants and gave some of their harvested seed to breeders for comparison with formally-screened varieties. There was variation in the methods of plant selection amongst farmers. At maturity, some farmers used grain color without consideration of plant height and maturity, a process which results in an unimpressive crop when working with segregating plants. Some farmers only bulked seeds of those plants which were similar in plant height, maturity time and grain color. Performance of these varieties was remarkably different in the field. Apart from grain color, farmers' criteria for selecting plants were long, compact and drooping panicles, good grain setting, and freedom from ShBR disease.

For example, Mim Bahadur Gurung of Chhomrong village selected intermediate plants from M-3 which had compact panicles and filled grains. He selected plants which still had their green flag leaves after maturity. He thought the straw quality of those plants would be better. He also compared the maturity of the plant with the local, grown alongside. Plants with medium height were selected by one farmer, Purna Bahadur Gurung from Ghandruk, who did negative selection of undesirable plants first: discarding either dwarf or too tall plants and diseased plants. He then selected panicles from white colored hills with high grain density and long panicles. He is a retired livestock field staff of LARC who has some knowledge of selection and heritability. Another farmer, Rudra Bahadur Gurung from Ghandruk, tested the M-3 in his worst plots and harvested the best tall plants; he then bulked seed to be grown in 1994 in his best field.

In summary, the major criteria for selecting the plants in the field were mainly grain color, yield potential, plant height, and maturity. Besides grain yield, farmers considered how densely the grain had set in a panicle, panicle length and tillering ability. The overall phenotype of any plant hill was considered for selecting or rejecting the entries. Farmers showed a willingness to spare time and care in selection, though the relative degree of care and time given by farmers were significantly higher in the second year of participation.

Monitoring of spread and biodiversity

Good varieties selected by farmers have spread within two years of introduction (Table 6). For example, Mim Bahadur Gurung of Chhomrong village got half of the seed from his friend Jai Bahadur Gurung, to whom LARC scientists originally gave the seed in 1993. Jai Bahadur Gurung could not select superior types from the same seed lot, whereas Mim Bahadur Gurung has selected M-3 (identified as M-3C) and has increased the area under it from 3 m^2 to 150 m^2 within a year. His plot was excellent as he put more care into it. This indicates that farmers' expertise in selection varies. Similarly, Rudra Bahadur Gurung from Ghandruk also selected M-3 (identified as M-3G), increased the area from 6 m^2 to 50 m^2 in 1994, and has sown a nursery for 1995 of about 1250 m^2. The variety occupied 2.5% of his total rice fields after first year of selection and 62.5% in the second--a significant rate of spread. Farmers of both villages come from the same ethnic group and agro-ecological background yet selected two different promising varieties, M-3C and M-3G, from the same F_5 bulk seed. This indicates that this F_5 bulk seed of Fuji 102 x CD cross has important genetic variations which farmers thought important to meet their particular needs. Therefore, they selected two populations independently. This type of decentralized selection in breeding lines has allowed farmers, who have grown only Chhomrong Dhan for the last 25-30 years, to maintain biodiversity in their own fields .

Table 6: The extent of adoption of new varieties (as measured by increased area) since the start of the farmers' participatory breeding program in Ghandruk VDC, 1993-95

Variety	Participating farmer	Area (m^2)			Total khet land area (m^2)
		1993	1994	1995	
Machhapuchare-1	Ram Bahadur Gurung, Ghandruk-9	8	0	0	1500
Machhapuchare-1	Mankaji Gurung, Ghandruk-6	3	0	0	2250
Machhapuchare-2	Krishna Bahadur Gurung, Ghandruk-9	8	12	50	3750
Machhapuchare-2	Jaya Bahadur Gurung, Dangsing-7	4	0	0	6000
Machhapuchare-3	Mim Bahadur Gurung, Ghandruk-9	-	3	150	2250
Machhapuchare-3	Jau Bahadur Gurung, Ghandruk-9	3	0	0	2250
Machhapuchare-3	Rudra Bahadur Gurung, Ghandruk-6	6	50	1250	2000
Machhapuchare-3	Rajendra Gurung, Ghandruk-9	-	3	0	500
Machhapuchare-4	Chij Bahadur Gurung, Ghandruk-9	6	8	80	2250
Machhapuchare-4	Purna Bahadur Gurung, Ghandruk-6	8	26	750	8750
Machhapuchare-5	Ram Kumari Gurung, Ghandruk-9	1	0	0	2000
Machhapuchare-5	Deu Kaji Gurung, Ghandruk-6	-	3	0	750
Machhapuchare-5	Kaji Man Gurung, Ghandruk-6	4	40	0	1500
Machhapuchare-6	Jau Bahadur Gurung, Ghandruk-9	-	6	0	2250
Machhapuchare-7	Iswar Bahadur Gurung, Ghandruk-9	-	6	0	2250
Himchuli-1	Min Bahadur Gurung, Ghandruk-9	3	0	0	1500
Himchuli-1	Balbhadra Paudel, Dhikurpokhari-5	10	0	0	7500
Himchuli-2	Him Bahadur Gurung, Ghandruk-9	-	5	0	1500
Himchuli-2	Dhananjay Devkota, Lumle-4	-	5	100	4000
Nilgiri-1	Chitra Bahadur Gurung, Ghandruk-9	-	9	0	2250
Nilgiri-1	Jhanan Nath Devkota, Lumle-4	-	6	6	1055

Farmers' perceptions

Table 7 summarizes some important comments made during field visits and farmer gatherings. These comments typically reflect the various levels of satisfaction found amongst participating farmers. Pitamber Shrestha, field-based staff at Chhomrong, shared his experience with his fellow research team members as follows:

> "In the beginning it was very difficult to find a participatory breeder-farmer, but now, the whole community is willing to offer their help. It is a nice feeling."

Post-harvest assessments by women farmers

Women farmers reported that they would like to make their decision on variety selection after the post-harvest evaluation. Table 8 shows that farmers used several qualitative criteria to assess the quality of rice. Varieties M-6 and M-7 had more negative attributes than M-2, M-3 and M-4. As a result, farmers showed willingness to expand the area under M-3, M-2 and M-4. In Chhomrong, consumers preferred white-grained rice over red-pericarped rice as it saves women time in milling (See Table 7, comment 2). A dry-flaky cooked rice goes well with curry and pulse soup as compared to a soggy rice. These traits associated with aroma, softness and ability to expand after cooking are the most desirable traits of good quality rice in Nepal. The post-harvest evaluation shows the ultimate criteria upon which farmers either reject or adopt the varieties. For example, Jhanan Nath Devkota from Lumle village was so impressed with Nilgiri-1 rice at first but refused to expand the area beyond his problem plots because of poor taste (Table 6).

Table 7: Farmer's perceptions of the cold tolerant rice varieties in Chhomrong, Ghandruk and Lumle, 1994

Comments of a group of male farmers in a group discussion at Chhomrong village, Kaski District, 7 October 1994.

> *"**Any rice variety that grows at this altitude is good.** We need a variety which yields more and gives more straw. **If variety has white grain color it is a bonus.** We will further select the plants to grow in larger plots next year."*

Comments of female farmers in a group discussion whilst visiting farmers plots:

> *"If we can change our local rice into white grain rice it will save a lot of our (women) time. **We spend one to two hours extra to dehusk rice until we get white grain.**"*

> *"Machhapuchare-3 has both more grain and more straw. It has long panicles and grains are plenty. It matures with the local one and the plant is taller. **If it tastes good, I would like to continue this variety.**"*

Comments of Rudra Bahadur Gurung, a male farmer, during a group discussion in Ghandruk village, Kaski District, 9 October 1994.

> *"**In the beginning I was not interested in involving myself but when LARC scientists told me that it has white grain then I became curious.** I first tried it in the worst parts of my land. I saw the tall plants producing really good panicles. I selected all best plants with white grain and a maturity time similar to our local variety. This year it looks really good and better than last year. Now I am happy to grow it in all my plots. I have no plan to share the seeds until I fulfill my requirements."*

Table 8: Post-harvest assessment[1] of various rice varieties measured relative to local check (i.e. Chhomrong Dhan) at Chhomrong Village in 1994

Traits[2]	M-2	M-3	M-4	M-6	MP-7	Chhomrong
Good/bad taste	+	+	+	+	+	-
Swelling/Non-swelling	+	=	+	-	+	+
Water-soaking/Non-soaking	+	+	+	-	+	+
Content/Non-content feeling	+	+	+	-	+	+
Aroma/Non-aromatic	+	-	-	-*	-	+
Dryness/Sogginess	+	+	+	-	+	-
Non-stickiness/Stickiness	+	+	+	-	+	-
Milling %	50.0	45.0	56.0	45.0	40.0	50.0
Broken rice %	1.9	5.0	1.3	5.0	5.0	1.8

1 + Better than local check, = equivalent to local check; - inferior to local check

2 Assessment was done by farmers after cooking by local methods. Underlined traits are preferred qualities for Chhomrong farmers.

Asterisk (*) indicates a peculiar aroma of rice which was not preferred by farmers.

In general, the milling percentage for all rice varieties was relatively poor, ranging from 40 to 56% by volume, with 1.3 to 5% broken rice. Farmers considered 50% milling recovery acceptable. M-4 had the highest milling recovery (56%) with the minimum percentage of broken rice. Purna Bahadur Gurung of Ghandruk was so impressed with the milling recovery of M-4 that he planted all seed which was not selected before. The experience of Chij Bahadur Gurung suggested that the variety M-4 was easier and quicker to mill by *Dhiki* (the local method of dehusking which requires two persons, normally women) as it has a very thin husk cover. The milling recovery of other cultivars was within the range of the local variety CD. It is interesting to note that the best panicles selected by farmers were kept for seed whereas the grains from the late tillers and small panicles were used for post-harvest evaluations. As a result, the milling percentage amongst the tested varieties was relatively low with a high percentage of broken rice. Therefore, farmers believed that the variety with a similar milling percentage to the check variety should have a better recovery if average or only good panicles were selected. Farmers showed reluctance to continue with the M-7 variety as its milling recovery was quite poor (40%). M-2, which performed at average in the field, was rejected by farmers because of the peculiar smell of the cooked rice.

On-station yield trial

The results of the on-station yield trials are presented in Table 9. At the Chhomrong site (2000 m), though M-3 performed at par with the check variety Chhomrong Dhan (p 0.05), M-3 was superior in terms of white grain quality. Both varieties showed good resistance to ShBR disease and chilling at anthesis. At Kavre site (1700 m), IR 52423-B-3-3-1-3 produced the highest grain yield (7.1 t/ha with poor straw yield) followed by progenies of Fuji 102/Chhomrong Dhan i.e. LR 88001-7L-0L-0L and LR 88001-21C-0L (6.8 t/ha) and M-3 (selected by farmers)(6.7 t/ha). The farmer-selected M-3 variety outyielded the check Chhomrong Dhan (5.4 t/ha)($p>0.05$). It also outyielded other superior local varieties known for better cold tolerance in Nepal. M-3 also had comparable incidence of ShBR and neck blast under natural inoculum pressure as compared to most breeder-selected varieties.

Table 9: Comparative performance of Machhapuchhre-3 with other rice varieties in the NRCTN during 1994 summer at Shera (1250 m), Kavre (1700 m) and Chhomrong (2000 m)

Variety	Grain yield (t/ha)			Days to 50% heading			Plant height (cm)			ShBR[1] (%)		
	1250 m	1700 m	2000 m	1250 m	1700 m	2000 m	1250 m	1700 m	2000 m	1250 m	1700 m	2000 m
M-3 (W)	5.2	6.7	4.3	96	118	156	120	136	119	11	10	2
CD (R)	6.1	5.4	4.9	91	105	147	130	116	127	4	12	5
Darmali (W)	1.9	5.0	0	111	123	180	137	116	129	5	4	2
Jumli Marshi (W)	1.6	6.0	2.7	90	145	131	119	109	141	13	36	12
BSV[2]	4.7±0.4	3.9±0.8	0.5±0.3	94±2.2	115±2.0	154±3.5	127±4.0	101±2.9	105±4.9	5.7±1.2	17.1±2.9	19.4±8.0
Mean	4.1±0.21	-	2.2±0.30	134±0.6	-	186±1.2	129±1.5	-	121±2.4	70±0.7	-	11.9±2.2
SEd	.1.03	-	.0.87	1.94	-	1.88	7.87	-	7.8	4.38	-	14.4

1 Bacterial Sheath Brown Rot disease incidence (%) at maturity
2 National Breeder Selected Variety (n = 10)
R = Red grain and W = White grain

At Khumaltar site (1350 m), study of agronomic traits for the farmer-selected variety M-3 scored 1 for chilling tolerance and phenotypic acceptability (data not shown). According to the standard evaluation system, rice varieties receiving a rating between 1 and 3 are considered desirable for parental sources and for commercial varieties (IRRI, 1988). At Shera site (1250 m), the yield performance of the farmer- selected variety was at par with the Chhomrong check and was found superior to other white grained local cultivars.

DISCUSSION

Results indicate that there are significant differences between farmers' and researchers' strategies for site selection for testing. It is a common practice in formal research system to select better and uniform pieces of fields for trials rather than to select representative target environments-- for which varieties are bred and screened. In contrast, farmers test the materials first under their worst land (stressed environments) for which they need a solution and then spread the variety to better fields. Ceccarelli (1989) has suggested that when the stress environment has a much lower yield potential, direct selection in the environment is the most efficient breeding strategy. This decentralized selection of segregating breeding lines in farmers' heterogeneous environments not only helps identify location-specific varieties but also eliminates the risk of releasing variety which may later be unacceptable to farmers.

Many workers have advocated decentralization of research policy (Maurya *et al*, 1988; Farrington, 1988; Galt, 1989; Tripp, 1989; Joshi and Sthapit, 1990; Sperling *et al.*, 1993; Sthapit *et al.*, 1994). It is well documented that the formal research system in developing countries is highly centralized and does not reflect the problems of resource-poor farmers. Poor adoption of officially released rice varieties in India (Maurya and Bottrall, 1987) and Nepal (LARC, 1995; Chemjong *et al.*, 1995) provides evidence of this. However, it has not yet been shown that farmer-selected varieties can be equally good in terms of yield and other desirable traits if breeder and farmer work jointly, using the formal varietal testing system. One of the farmer-selected rice varieties, M-3G, which had been selected initially by breeders for chilling tolerance and ShBR resistance by pedigree-bulk method, is now being multiplied and included in the 1994 national varietal testing system of the NARC. It is being promoted to IET as a promising entry. M-3 matches the characteristics of the local varieties but has better grain quality and chilling tolerance, and has been preferred by the farmers of Chhomrong and Ghandruk.

The area covered with the variety selected by expert farmers has been quite high; there have been promising results within a short period of three years. Morris *et al.*, (1992) has argued that the rate of adoption has long lag period, usually 5-6 years after the release of a variety. It is yet to be seen whether this variety will spread from farmer-to-farmer amongst a group of roughly homogenous farmers with similar circumstances. Results indicate that farmers wish to fulfil their requirements. However, some farmers have already started distributing seed to other farmers. Interestingly, the performance of the farmer-selected variety matched on-farm crop cut data and the results of researcher-managed on-station trials in diverse altitudes. With our experience in Chhomrong and Ghandruk, we anticipate that the variety will be widely spread among similar areas by the time the variety is released through the formal system due to the early farmer-to-farmer spread of the preferred variety. The slowness of the formal procedures and the system's capacity to generate only a few new varieties every year-- juxtaposed to the need of a basket of varieties to address farmers' needs in diverse and complex farming systems-- has encouraged the LARC to involve farmers at early stage of breeding (with a few carefully selected crosses). With the present FPB system, farmers are exposed to new material six to seven years earlier than in a conventional system, and the proposal for official release can be submitted three years earlier, even taking into account time needed to select for uniformity in farmers' cultivars. This approach in Nepal, therefore, will allow farmers to have increased access to breeding materials several years before normal varietal release, when the variety still has its full genetic potential (Galt, 1989), and its spill over effect will be greater than those released late by the formal system.

In the past, a large number of exotic cold tolerant rice varieties supplied through IRCTN and NRCTN were evaluated at Chhomrong and the majority of them failed to set grain in high altitude villages (Sthapit, 1992). In that context, these varieties developed jointly with farmers are far superior and are already spreading through farmer-to-farmer seed exchange. This has been possible not only due to the FPB system but also due to the identification and utilization of locally-selected Chhomrong Dhan as a cold tolerant donor, which was selected from a range of local germplasm. Hence, use of indigenous germplasm and farmers' wisdom in crop cultivation, supplemented by breeders' knowledge of heritability and genetics is turning out to be fruitful in selecting the right plant type to produce a population which is superior to the local cultivar. Utilization of genetic resources to meet farmers' production needs is a realistic way to encourage *in situ* conservation as indigenous genes are recombined with other useful gene pools within local environments. Though the concept is new, it is thought to be resource-efficient and problem-oriented as the role of farmers is not merely limited to providing land and supplying labor but is aimed at directly decentralizing the variety evaluation process. Breeding is not often the favored option for research managers of short-term research organizations like LARC, but now they have shown interest in farmer participatory breeding due its low cost and its rapid generation of an appropriate variety.

Farmers' methods of plant selection varied with the farmers' own expert knowledge and circumstances. Not all farmers were good at this exercise. Segregating lines of Machhapuchhre-3, which all had desired genetic recombinations, were given to three farmers, but only two farmers succeeded in identifying superior types, according to their own needs. Interviewing farmers who failed to identify superior types from the same F_5 seed revealed that they lacked knowledge of segregation and just concentrated on grain color for mass selection. Therefore, as Loevinsohn and Sperling (1995) suggest, a basis of collaboration can be found once the respective strengths of the two parties are recognized. This study found that expert farmers could be identified within a year of preliminary work and a program should be build on that.

Women farmers are particularly skillful in assessing post-harvest traits such as milling recovery, cooking and eating quality of rice. Expert women farmers for this purpose can be identified from a village workshop. Men farmers possess more skill in assessing the standing crops for yield potential, management requirements and threshing criteria. An anthropologic tool is required to help amass all this information. Breeders and field staff should also interact with farmers frequently and should stay in the village for considerable time so as to start to understand the indigenous knowledge system. If the success of these initial efforts is to be sustained, research management should ensure a congenial environment for field staff who work in difficult areas. This is often forgotten by policy makers or research managers who have tried to replicate successful and innovative approaches from elsewhere.

This study also reveals that farmers evaluate new varieties at different stages of crop growth, particularly at near maturity and also at threshing, milling and eating sessions. Monitoring indicated that farmers keep on changing their decisions depending upon the availability of new information. At present, farmers' involvement in formal variety testing is limited to preference ranking at maturity, however, the majority of farmers make their final decision (re: retaining or rejecting the variety) during milling, cooking and eating. For example, the area under M-4 was expanded due to its good milling recovery whereas M-2 was rejected due to its peculiar smell when cooked. M-3 was preferred at all stages but mainly because of its yield potential and straw height. Nilgiri-1 was first selected by a farmer in Lumle village who later changed his decision of expanding the variety to his remaining good fields because of the high shattering and poor taste. He wished to continue to grow it only in one plot where an inlet of cold stream water causes high sterility. Himchuli-2 was rejected by farmers at Chhomrong, Ghandruk and Lumle where rainfall is very high at the time of maturity and causes pre-germination before harvest. In contrast, Himchuli-2 was liked by farmers of Patlekhet village (1500-1700 m), where rainfall and humidity at maturity is less. In Lumle, the mother of Dhananjay Devkota selected non-sprouted panicles and planted them in a 100 m² plot to see whether the problem of sprouting would continue. There are several such examples which support the decentralization of selection and such findings can be fed to outreach or extension staff.

This study also found that high altitude farmers have their own way to assess eating and cooking qualities of rice. White grain rice with softness, content feeling and ability to expand after cooking are preferred traits. Whether these criteria can be related to standard grain quality testing procedures needs to be investigated in order find a method which can be used in breeding programs. The present varietal testing systems do not have mechanisms to consider farmers' relevant traits, such as post-harvest variety evaluation. Laboratory measurement of such grain quality traits is important as these are important criteria for selection or rejection of varieties by farmers. Grain quality is often not assessed in the formal varietal testing system of Nepal until it reaches the final stage of release (Sthapit, 1995).

Farmers participatory breeding is a controversial issue for plant breeders who feel their own role threatened. Major changes in researchers' attitudes appear likely when more productive results become available. A main concern in this approach is to screen for disease resistance and to resolve the seed certification problem. If small quantities of seed are given to farmers, susceptible material will be rejected-- if breeders and pathologists can give farmers some training in identifying the symptoms and selection procedures. Bacterial ShBR disease, which is prevalent in cool temperate rice growing environments of Nepal, can be screened naturally as resistance to ShBR is heritable and local landraces are good sources of resistance (Sthapit *et al.*, 1995). Fortunately, Chhomrong Dhan has durable resistance to ShBR disease. This may not be true with other diseases and, therefore, disease screening of F_3 and F_4 populations is essential to safeguard farmers from disease epidemics and also to avoid possible criticisms of such an innovative approach.

The cost-effectiveness of FPB could be greatly increased by distributing farmer-selected varieties outside of the project villages by making seed of identified cultivars widely available. Seed certification will be a problem because FPB method does not produce a pure line variety. However, this is possible to overcome in two ways: (a) introduction of the farmer-selected variety into the formal testing system, and (b) further selection for uniformity, using few extra resources. Both of these possibilities are being studied at present.

Decentralized selection is, of course, how farmers have traditionally developed landraces. Farmers are also curious researchers who are constantly in search of productive varieties for their specific niches. Publicly-funded research institutions cannot afford to conduct varietal testing for such heterogeneous environments, and farmers should be encouraged and trained to do informal research in order to solve their specific on-farm problems. LARC, which is working in a very difficult and diverse farming systems, has realized that the varietal identification process can be made more rapid and efficient by increasing the range of genetic variation submitted to selection.

Our experience suggests that farming communities have a clear understanding of the local production constraints and a range of preference and needs for a traditional crop, whereas formal research systems have a comparative advantage in terms of access to wide range of germplasm of different origins and of contrasting characteristics. Breeders working together with farmers have more chance of developing appropriate varieties, and still maintaining and enhancing biodiversity. Result suggests that biodiversity has been already promoted in participatory villages by allowing farmers to select populations of their choice, for example, two types of Machhapuchhre-3 (M-3G and M-3C) were generated from the same seed lot given to three different farmers. They are tall and intermediate Machhapuchhre-3 populations. Both M-3G and M-3C have good yield potential, cold tolerance and white grain color. The dilemma for breeders is then which variety to promote? How many similar varieties to multiply for seed? Can similar phenotypically-related varieties be certified?

Berg *et al.* (1991) have suggested that genetic diversity does not need to be expressed in real plant differences, and that it can persist as variation hidden in the genetic structure of the plant population. These materials, therefore, can be included in an informal research and development (IRD) program which will allow farmers to select varieties according to their own needs and circumstances-- without researchers' biases (Joshi and Sthapit, 1990). Such approaches in combination, will also provide researchers insights into a wide range of rural problems, which may assist them to design more realistic and output-oriented research in the future.

The decentralized selection of segregating material from a few carefully chosen crosses, drawing on the active participation of expert farmers, presents attractive prospects for fostering a more sustainable and productive agriculture, better adapted to local needs. This would consequently lead to identifying farmers' need-based technologies in a cost effective manner. A similar argument was also put forward by Loevinsohn and Sperling (1995). This new approach tried by LARC can be of considerable significance in developing other crop varieties suitable for diverse and complex situations. The prerequisites of the method are that objectives be clearly identified and that breeders be sufficiently flexible to learn and reciprocate with the farmers.

CONCLUSIONS AND RECOMMENDATIONS

1. Decentralized selection of segregating lines under diverse environments identifies location-specific varieties and eliminates the risk of releasing unacceptable varieties.

2. FPB promotes varietal diversity within a short period in participatory villages. Genetic diversity may persist as hidden variation when a number of farmers select plants from the farmer-selected variety.

3. Farmers' selection criteria are as reliable as breeders'. Machhapuchhre-3, a farmer-selected variety, performed better in researcher-managed multi-locational yield trials with respect to cold and disease resistance. The rate of varietal spread has been rapid.

4. There are many positive effects (as well as spill over effects) if farmers have quick access to new lines when the variety still has its full genetic potential.

5. Group field visits, preference ranking, and monitoring of adoption decisions are useful for assessing performance.

6. Farmers' methods of plant selection vary with expert knowledge and interest. Not all farmers are good for FPB. Training in plant selection is useful.

7. Farmer participation increases if the problem is relevant.

8. Adoption decisions change with new information. Multi-stage evaluations for grain color, grain and straw yield, milling, cooking and eating qualities are necessary.

9. The integration of farmer-selected lines into formal testing and IRD systems increases the cost-effectiveness of FPB.

10. The FPB method has been found successful and has been initiated for mid-hill fine quality rice breeding.

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PARTICIPATORY BREEDING, ON-FARM-SEED MANAGEMENT AND GENETIC RESOURCE CONSERVATION METHODOLOGY: A SUSTAINABLE AGRICULTURAL R & D MODEL[1]

D.M. Maurya[2]

ABSTRACT

This paper describes participatory breeding research in Uttar Pradesh which matches qualities of farmers' local cultivars with qualities of advanced breeding lines. Focusing on the multiple benefits of genetic diversity, it explores the practical implications of expanding such a program. Three areas of agricultural research and development are signalled: the plant breeding system, seed management structures and germplasm conservation programs.

INTRODUCTION

In spite of all our family welfare efforts at government and non-governmental levels, the population of India is still increasing at rate of 2.17%. In view of this fact, we have to increase the quantum of our food, feed, fibre and agro-product supply at a matching rate. There are two techniques to enhance the biological/agricultural production: first, by manipulations of the genetic materials (hereditary); second, through the manipulation of non-genetic (environmental and management) factors.

PARTICIPATORY PLANT BREEDING

Genetic enhancement

Plant and animal breeders always make efforts to have access to genetic variability, either naturally-occurring or created/induced. Out of the whole available, variable mass, they then rigorously search, isolate and pick out the more efficient genotypes (individual), which, when sown under real farming situations, ensure greater yields of fruits, grains, fibre, milk, meat, wool and or other products useful to men and their livestock. Even a slight genetic improvement in yield is important and remunerative as it continues to occur again and again in the progenies of the improved varieties (i.e. it is heritable).

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2 This paper is based on the experiences the author acquired and accumulated over 32 years as plant breeder, rice breeder, Head of Plant Breeding, Director Extension, Director of Research, Dean of Agriculture, and Project Leader of Farming System Research in the Department of Agriculture, Uttar Pradesh and in the two agricultural universities of Uttar Pradesh: the C.S.A. University, Kanpur and Narendra Dev University, Faizabad.

Contribution of plant breeding

Since independence, India has made tremendous progress in the field of agriculture: from an era of 'begging bowl', we have witnessed an era of 'self-sufficiency'. The progress in research is well reflected by increases in the production and productivity of various important crop commodities. Since Independence, the foodgrain production has increased almost three and a half times, from about 50 metric tons during 1950-51 to 181 metric tons in 1993-94, with all-time record production of 18.46 metric tons of oilseeds and 14.06 metric tons of pulses. Since 1951, the yield of wheat and potato has gone up seven times, maize four times, and rice, sugarcane, cotton and sorghum three times. We produced 138 metric tons of foodgrains in 1987-88, despite the worst drought year of the century.

Need to encompass the whole production system

Standard plant breeding has generally had the 'crop' as the center of focus. However, it is becoming clear that greater production with enhanced sustainability is possible only by examining the entire production system and modifying individual crops to better fit within the overall cropping pattern. Changes in plant maturities and plant architecture are common considerations. Such a perspective is also relevant for integrated nutrient and water management programs aimed at sustainable agriculture.

Plant breeding concept of 'best'- an illogical and naive issue

Using the modern concept of 'best', efforts are being made by plant breeders throughout world to evolve a genotype which will excel everywhere and all times: i.e., they aim for wide adaptation. However, no variety can perform in a consistently 'excellent' or 'best' manner under all growing/ farming area/contexts and over the long term, and still satisfy the needs of millers, traders and consumers equally. Thus, it is an illogical and naive concept to talk of the 'best variety'. Different varieties may be best in different locations, situations, and systems, through time and for different purposes. A variety may perform best in one farming situation but be the poorest in another. For example, a rice genotype best in deepwater zones can never be best under irrigated, well-managed areas or rainfed upland farming situations: these situations demand variable architectural requirements.

In fact, 'new and best' varieties are not perennially 'new and best'. These qualities are not fixed, they are subject to variation and change. A permanent and universal adoption is impossible. Disease resistance is never stable, cultivation practices may be modified over years. Storage and processing patterns may also change over time and space. Although plant breeders regularly register 'successes', many factors restrict the achievement to a specific time and spatial frame. It is very difficult to combine all desired attributes into a single genotype: resistance/tolerance for all diseases and insects, and abiotic factors; needed agronomic traits and qualities; features which will help meet farmers' future needs and aspirations.

Participatory plant breeding approach

The evidence from the Narendra Dev University of Agriculture and Technology (NDUAT) experiments strongly indicates that a participatory approach to agricultural research can allow rainfed lines to be selected which are generally compatible with the characteristics of traditional varieties, and which out-perform them on one or more criteria. The improved lines which have been 'matched' with farmers' traditional ones are not (as has been the case up to now) the official range of maturing periods, grain types, height and other traits to fit into various ecological niches. The assemblage of the traditional varieties, together with the baseline survey data and information collected through frequent unstructured conversations with farmers, has enabled the breeders to study the key agronomic characteristics of these local varieties in depth. This exercise has enabled us to select from amongst the advanced on-station lines those genotypes that match very closely the characteristics of the traditional varieties. We feel such a strategy offers the best chances for out-performing local varieties, for fitting new varieties into cropping systems and also for satisfying the local consumers' demands.

The rationale underlying this approach to selection is that, in rainfed conditions, farmers' goals, constraints and agro-ecological conditions are very heterogeneous. It would be a very expensive process for breeders to become as fully acquainted with this heterogeneity as farmers are, and impossible to replicate all those conditions at research centers. On-farm trials managed by farmers, are therefore crucial to the screening process. The approach, by recognizing the diverse varietal need within villages, and even differences within a single farm, reverses breeders' conventional aspirations to supply a single variety to as wide a 'recommendation domain' as possible. The underlying rationale and empirical evidence presented here argue strongly for a wider implementation of this participatory approach in rainfed areas. In comparison to other participatory methods available, this approach also represents a cost-effective use of scientists' time: their role is that of building-up a portfolio of varietal material broadly compatible with what farmers are known to prefer under rainfed conditions, matching it up with the characteristics of farmers' varieties, and then allowing farmers to make the selections under their own management conditions.

Sharing multiple options

Unlike other programs aiming, evolving and using a single finished product, offering a basket of half-baked technologies is the strength of our program. In offering a single 'best' technology, there is absolutely no option for a farmer to choose as per his/her needs and requirements. If the technology works, it is well and good. However, if it does not, it is rejected by farmers and then scientists have to go back to the experiment station and develop a fresh technology. There is evidence that a single technology has little chance of success under rainfed, complex, diverse, difficult and risk-prone village systems, especially in tropical monsoonal Asia. This 'single solution' approach slows down the whole process of improvement. In addition, a negative side of this conventional research is that if the technology is workable, its adoption will reduce the diverse, indigenous materials, methods and practices. Further, for a system to be sustainable, it must be resilient to stresses or other uncertainties. The traditional system has evolved with such characteristics so as to be resilient. The resilience rests on the diversity represented in the system, either in terms of the genetic variability in a given area or the diversity over time and space of farming operations. In our participatory approach, half-baked technologies with multiple options are used with the intention of generating and re-identifying appropriate technologies. In the process, different options percolate to variable niches existing in the village system. By offering sufficient options, the participatory contribution of farmers in experimentation is fully integrated and several breeding lines of different backgrounds may be retained by farmers to meet their preference and needs. Thus, local varieties are not replaced altogether by single released and notified varieties. This approach provides new and genetically efficient materials and, at the same time, ensures adequate genetic diversity.

Testing design

In the conventional on-station research system, the statistical tools and techniques like randomization, replication and local control are used to arrive at valid conclusions. However, when working with small resource-poor farmers in on-farm experimentation, it is difficult to test very many treatments with prescribed replications. To overcome this hurdle, we take different farmers in a village as a replication and different villages as multi-locations. Each farmer is given at most two to three new breeding lines along with one standard check and a farmer's own variety, used under normal farming conditions. The same treatments are replicated with at least three farmers in a village, making a cluster. Efforts are made to constitute such a farmer cluster, with areas contiguous so as to assume an analogy of a single experimental field. Different clusters of farmers receive different sets of breeding lines. Depending on the size of village, one to one and half dozen breeding lines are tested in each participatory village.

Self revolving technology through the establishment of village seedbank/on-farm conservation

Many tools, techniques and improved genetic materials reach small, poor farmers very late. Even if it reaches them, the farmers may not be able to purchase the costly seeds of new varieties. The Faizabad concept is laid out to solve this problem as follows. Genetic materials, seeds, plants, nurseries, calves, kids etc., are used as a treatments under experimentation and, sometimes, some of them prove to be judged better by farmers, according to their own household criteria. At the very outset of an experiment, farmers are persuaded and terms are defined to anticipate such a 'successful' case. To participate, farmers have to agree to voluntarily refund and contribute back a small portion of their produce to researchers to build-up a 'People's Seedbank' so that it can be shared by fellow farmers and households who may have important constraints. Thus, this system also has a in-built mechanism for very fast multiplication of improved materials.

This new theme enables even small, resource-poor farmers to get small quantities of seed well in advance as a test entry. Promising breeding lines, which match their local varieties, are tested on small, poor farmers' fields. After harvest, the farmer is requested to return back just double the seed quantity received, so that the next season other fellow farmers may have opportunity to test them, either in the same or other villages. This procedure is repeated with new farmers and the cycle continues. Thus, the seeds of potential breeding lines are revolved among the poorest farmers and the program is trying to assume a self-expanding, self-replicating, and sustainable form. In this way, a small quantity of seeds of promising breeding lines are gradually tested with a large number of farmers in the target group, without much dependence or burden on the experimental station (which has its own financial, human power, land, labor and other infrastructural limitations). Minimal investment and more relevant data are generated under this new research procedure. Most farmers are enthusiastically co-operating and participating in this mission.

A small quantity of seeds of the most promising lines can be spared easily from the research station and fed to this on-farm revolving (expanding and replicating) research system. Thus, this is not just a kind of program but also a model. A substantial amount of research as well as extension services might be rendered through this model program, involving the full participation of small resource-poor farmers who are mostly ignored, neglected and bypassed in the other models being used (Maurya, Bottral and Farrington, 1988).

SEED MANAGEMENT

Promoting few varieties: purely an administrative convenience, not a technical propriety

There are important problems which have been noted in the conventional approaches. There needs to be a critical review of the following: plant breeding research, germplasm assembly, choice of parents, matching designs, selection designs, choice of sites for raising segregating populations, testing designs, data generation and compilation, varietal release and notification procedures, seed production, seed certification, quality control, and seed distribution and marketing. The possibilities of introducing a more decentralized, participative approach across the board should be explored. However, such a change of approach could be within the framework of the Government of India's Seeds Act of 1966. At present, seed multiplication is not officially permitted unless the variety concerned has been notified by the central government on the advice of a technical committee. How to decentralize that process in the interest of rapid local dissemination, while at the same time ensuring that quality is maintained during the process of seed multiplication, is a complex and important question that deserves careful review. Certainly, the loss of 'line' characteristics resulting from the absence of seed multiplication support is a potential constraint to the effectiveness of locally-targeted selection procedures; this problem will have to be addressed properly if the needs and aspirations of rainfed, diverse, complex, difficult and risk-prone ecosystem farmers are to be met.

Promoting release and notification of a larger number of varieties

The expanding human population, necessitating greater food, fibre, fodder and sugar supplies, will be compelled to evolve efficient and high-yielding genotypes. The operational difficulty in handling seed production, certification, storage and distribution of seeds now restricts the number of varieties which can be handled. However, rather than relying on one or a few selected varieties, a mosaic of varieties needs to be put into channel so that at least some diversity may continue and no absolute danger may occur in the event of stress: for example, an outbreak of pests or diseases, or the occurrence of flood, drought, etc.

Concurrent program of release and germplasm enrichment

In the conventional breeding methodology, a large number of breeding lines are first generated and then, depending on the breeding objectives, a few lines are picked out which may attain commercial status. Thus, an in-built lacuna exists in the current conventional breeding method: huge numbers of breeding lines are not used---which consumes enormous manpower, energy, time and space. Certain lines may not attain commercial status for select reasons but they may be sources of valuable genes which could be further used in the breeding program. These need to be preserved and such materials should be passed on concurrently to the germplasm bank. Such a process may compensate for the huge loss regularly accruing in the breeding process.

Decentralization of seed corporations

The National Seed Corporation (NSC) and the State Seed Corporations can handle only a limited number of varieties of national and state importance. However, a larger number of varieties can be handled if NSC and State Seed Corporations are decentralized to divisional, regional, district or even block levels corporations. These would focus on producing seeds of local importance and requirements. Such a decentralized system should encourage the production of varieties with location specificity, generate local employment, promote genetic diversity and ensure a regional balance of seed production and seed availability.

Encouraging reputed and potential private seed companies to produce seed of locally-adapted varieties

The other way to promote a greater number of varieties and crops is through private seed companies. Located in different areas, and fast expanding, such companies should be encouraged through assistance and concessions to take-up seed production and distribution of locally-adapted varieties. Quality control can be exercised by seed certification agencies.

Simplifying varietal release and notification procedures with more say given to state units

In China, power has been decentralized to provincial and prefectural (district)-level seed companies. These seed companies have been empowered to release and notify specific varieties for their area. Seed issues are discussed at the national level only when there is inter-state movement of seed. Likewise, the state becomes involved in district-level varietal issues when inter-district seed movement occurs. Thus, the farmers in China are able to get seeds of appropriate and desired varieties with the help of local breeders and local seed companies.

GERMPLASM CONSERVATION

Genetic improvement not spontaneous and autonomous

Genetic improvement is not carried out in an isolated or spontaneous fashion; nor is it an autonomous activity. Rather, genetic improvement is performed through modification or alteration of already existing varieties. The process may include addition, elimination, reshuffling and synthesis of the traits dispersed in different cultivated and wild races/relatives through hybridization, mutation, or biotechnological techniques. Thus, plant breeding is an inter-dependent and overlapping evolutionary activity with characteristics of continuity.

A huge range of genetic variability in crop species - why?

During the prehistoric era, there was no organized research system and there was no application of mathematical and statistical tools to identify the best/potential yielders with good quality and adaptability within space and time. Prehistoric farmers chose their varieties through hit and miss, trial and error methods and keen observation of natural populations. They made selections out of curiosity or in quest for higher yield and other attributes from mixed and diverse populations which emerged from natural mutation (followed by hybridization, segregation, recombinations and accumulation of new recombinants variants). These farmers developed an astonishing range of crop variability. This diversity has proved necessary for the survival of the species during sudden drastic changes.

The raising of the crops in highly diverse, complex, risk-prone regions, over seasons, in different ecological situations, management systems, and variable climatic, edaphic and socio-economic conditions has also favored varietal wealth. Ever since species have evolved, there has been accumulated variation in crop populations, partly through natural selection and partly through artificial forces of human interventions (meeting the needs and preferences of cultivators, millers, traders and consumers). These forces have been responsible for the diversification of the genus/ species into various agro-eco-botanical groups, sub-groups, varieties, sub-varieties and land races.

Disservice done by plant breeding

We have seen the positive contribution of plant breeding. However, this is but one face; the other face of the plant breeding is negative and has rendered great disservice. The rapid and large scale adoption of one or a few high yielding cultivars has resulted into the rapid and fast replacement of locally-adapted varieties. Coupled with other factors like land degradation, deforestation, and land cleaning, these forces have caused serious genetic erosion, bringing genetic uniformity/homogeneity in large contiguous areas and thereby enhancing genetic vulnerability to biotic and abiotic stresses.

Narrow genetic base: fallacy of current plant breeding approach

Not only man has already lost part of the genetic resource base, but he is subjecting the production system to high risk by electing to use a narrow genetic base for many of the important crops (few varieties or multiple varieties with similar genetic backgrounds).

Basic raw materials for breeding

Landraces, traditionally grown primitive cultivars, and wild relatives of cultivated plants are the basic raw materials for present day crop improvement programs. They are also required to meet the aspirations of future generations who may need altogether new sources of genes for facing unforeseen challenges: pathogens, insects, other pests and abiotic stresses like salinity, drought, flood and unfavorable temperatures, and even the need to adapt to new machines and tools. These raw materials (genetic resources), which by themselves may be inferior, may contain some desirable and rare gene sources that can be transferred to widely adaptable and acceptable varieties.

Future human need unpredictable

Future human needs for breeding and crop diversification can not be predicted in advance. In the face of changing climate and global warming, new agricultural production systems are fast evolving and there may be novel future requirements for food, feedstuffs, industrial applications, unique ways of preservation, packaging, transport, storage, etc.

Biodiversity: the real base for improvement

Thus, biodiversity has now become fundamental as an input for technology development as well as for sustainable growth. The preservation and conservation of a large base of genetic resources has key implications for future development and genetic enhancement.

What is biodiversity?

Biodiversity includes the rich diversity of forms, right from the molecular unit (and the chemical and physical ones) to the individual organisms, and then on to the population, community, ecosystem, landscape and biospheric levels. It refers to the variety and variability among living organisms and the ecosystem complexes in which they occur. It is estimated that there exist 5-

10 million species of living forms on our earth. Some estimates place the number at about 30 million. But only less than 2 million of these forms have been identified and described. These include 300,000 species of green plants and fungi, 800,000 species of insects, 23,000 species of fishes, 3,000 amphibians, 6,300 reptiles, 8,700 birds 4,100 mammals and a few thousand species of micro-organisms.

Village ecosystem

The biodiversity in nature acts as an insurance during periods of emergency by reducing societal vulnerability. The combination of trees, grasses, crops, animals and ponds which we found in almost every village serves as an extraordinary, interactive and resilient system. Instead of destroying this complex and interrelated system, science should strive to build on it.

Biological diversity must be preserved in every village ecosystem

It is not enough to preserve biological diversity in just those areas where the flora and fauna are genetically-rich by setting-up biosphere reserves and national parks. The biological diversity must be preserved and/or created in every village ecosystem. The productivity of our basic natural resources, like plant and animal genetic resources and land and water, will have to be increased substantially. But sustainable increase will be possible only under a system of participatory management and control.

One of the most conspicuous characteristics of traditional agricultural technology is the diversity of crops it employs. It is typical for a subsistence household to employ a number of cropping systems and a variety of crops within each of these cropping systems, including the interplanting of different crops in the same field. This crop diversity strongly shapes the way traditional farmers perceive the natural resources available to them for agricultural production.

Natural variability versus created variability

The end product of plant breeding, 'the improved variety', through a regular process of testing, identification, release certification, and wide-scale adoption, definitely displaces the existing natural varietal diversity. However, in the whole process, a large amount of variability is generated by all methods: hybridization, mutation and biotechnology. In several crops, a large number of breeding lines available at testing could be preserved-- which may compensate for the natural variability being lost. However, the basic difference between natural variability and created variability is that farmers are acquainted with the major traits of their traditional/local varieties, based on their past experience, but scientists are not aware of all the virtues of breeding lines generated. The details are known only for released and notified varieties after careful study.

Gene/germplasm bank not a substitute for natural on-farm variability

As we realize the importance of genetic variability within a crop (species and genera), its use for practical plant breeding, its fast erosion and in some cases near extinction, various conservation techniques have been devised and are being practiced. Some are *in situ* and some involve simple seedbanks/genebanks, which store material in special medium and long term cold storage modules. Each method has its own merits and demerits.

Apart from other demerits of *in situ* and seed/gene banks, variability is frozen out and the germplasm becomes static. In contrast, in natural ecosystems or farming situations, there is a free flow of genes through natural out-crossing, followed by recombination and natural selection among individuals within a varietal population and also between various varietal populations. As a result, new variations are continuously generated and varietal populations remain in dynamic and evolving states, thereby remaining capable of coping with changing environmental conditions.

Keeping these aspects in view, we suggest that natural genetic variability under real farming situations or ecosystems has its own dynamism and evolutionary significance. The Faizabad method of participatory plant breeding has an in-built system for genetic enhancement and promotes and preserves genetic variability through matching, parallel processing and offering multiple options of improved breeding lines.

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ENHANCING GENETIC RESOURCES AND BREEDING FOR PROBLEM SOILS

B. Mishra, R.K. Singh and D. Senadhira

ABSTRACT

The Central Soils Salinity Research Institute (CSSRI) is a nodal institute in India with a national mandate for enhancing genetic resources and breeding crop varieties for salt-affected soils. During 25 years of research, it has had significant achievements. Indigenous and exotic germplasm resources involving traditional landraces and other adapted cultivars (along with their wild relatives) in rice, wheat, Indian mustard, barley and many other crops have been explored, collected, evaluated, utilized and conserved, saving them from rapid disappearance and genetic erosion. Some coastal landraces from highly specific habitats were not accepted by farmers of other states but they proved to be good donors. Experience has also revealed that the introduction of high yielding varieties for non-stress soils to problem soils, with the aim of increasing production, has not only resulted in yield failure but has also contributed to the genetic erosion of traditional landraces. Soon after this realization, systematic breeding was initiated for problem soils. There have been excellent results in the Rice Breeding Program, where a highly salt-tolerant dwarf, early maturing rice variety, CSR10, has been bred and released which combines salt-tolerance (from landraces) with high yields. It proved to be very effective on alkali soils when farmers were directly involved in adaptive research and demonstration. Continuous growing of this variety without any soil/chemical amendments reclaims alkali soils in three years to the extent that other crops like wheat, barley and mustard can also be grown. It has now become very popular among resource poor farmers. More than two and half dozen rice varieties have been bred for various types of salt tolerance. Studies revealed that there was no correlation between vegetative stage salinity tolerance and reproductive stage tolerance; and grain yield too. Reproductive stage salinity score is more reliable for grain productivity. K^+ content exhibited a strong positive correlation with grain yield while Na^+ content showed a poor negative correlation. Both additive and non-additive types of gene action, with a preponderance of additive types, was observed. The involvement of one group of genes having dominance for salinity tolerance and Na^+/K^+ ratio; and two groups of genes for K^+ was observed. Isozyme studies demonstrated the presence of Est.2^1 in tolerant and Est. 2^2 in susceptible genotypes.

The Indian Council of Agricultural Research- International Rice Research Institute (ICAR-IRRI) Collaborative Program for the <u>Improvement of rice germplasm for saline soils</u>, involving many countries in Asia and an Indian network consisting of target centers (hotspots) in eight states, has led to the development of more than 20 promising lines involving recombinants, anther culture derivatives, and somaclonal variants which are superior to many traditional local cultivars and landraces. Thus shuttle breeding has proved to be a model approach for developing salt-tolerant rice for sustainable productivity in fragile ecosystems. An Indo-U.K. (CSSRI-Sussex) Project on <u>Soil salinity and breeding for salt-resistant crops</u> has further strengthened our research program by inducing, through pyramiding, the desirable physiological and bio-chemical parameters related to salt-tolerance. CSSRI-UPLDC Adaptive Research has enhanced our activities by involving farmers as our partners in the evaluation and development of salt-tolerant crop varieties. This has now provided a practical and more reliable approach for germplasm collection and

improvement at target sites. Farmers' participatory variety selection has been found to be more effective, especially for identifying abiotic stresses, as the varieties are exposed in the hot spots at target sites owned by farmers. No doubt, scientists' guidance will remain a pre-requisite since breeding for salt tolerance is highly complex involving multiple tolerances and because careful monitoring of stress is the basis for right selection and generation advancement. Farmers participation in later generation selection seems to be the ideal. No doubt, on-farm conservation of genes (in situ) by farmers will save the traditional landraces for problem soils, will maintain the evolutionary processes which shape new germplasm, and will guarantee the continual supply of germplasm to ex situ collections.

INTRODUCTION

Meeting the increasing demand for food, forage, fibre and fuel will be a pressing challenge for the world community during the years ahead. This will require a larger production of biomass over a shrinking land area. Breeding crop varieties for increased salt tolerance is now considered as a more promising, energy-efficient and economical approach than major engineering processes and soil amelioration techniques which have gone beyond the limits of marginal farmers. Stresses under adverse soil conditions are highly complex and often compounded with climatic hazards. The stress varies from location to location and even from season to season. Soil stresses are often associated with nutritional imbalance (deficiency/toxicity). The interaction between soil stresses and other environmental factors influences the plant's response to that stress. Such complexities are responsible for the slow adaptability of high yielding crop varieties in adverse edaphic environments. It is, therefore, necessary that crop genotypes be screened at target sites having adequate stresses in order to identify dependable sources of varietal tolerance. The on-going research at the Institute, including collaborative national and international research projects, has given CSSRI access to different target sites (hot spots) of the country and to various kinds of agroedaphic stresses. The Institute also benefits from a huge collection of donors/germplasm materials for salt tolerance in important crops; such genepools are necessary to provide the variability needed for successful breeding programs. Genetic diversity provides parental material from well-adapted landraces to enhance local adaptation. It helps to overcome susceptibilities to problem soil and also provides the foundation for breeding for novel requirements. Breeding now takes place from a much broader genetic base (greater number of varieties) in many crops. Genetic improvements can be easily adopted by resource-poor farmers for such problem soil environments where there are low-input conditions.

CROPS TOLERANCE TO SODICITY/SALINITY

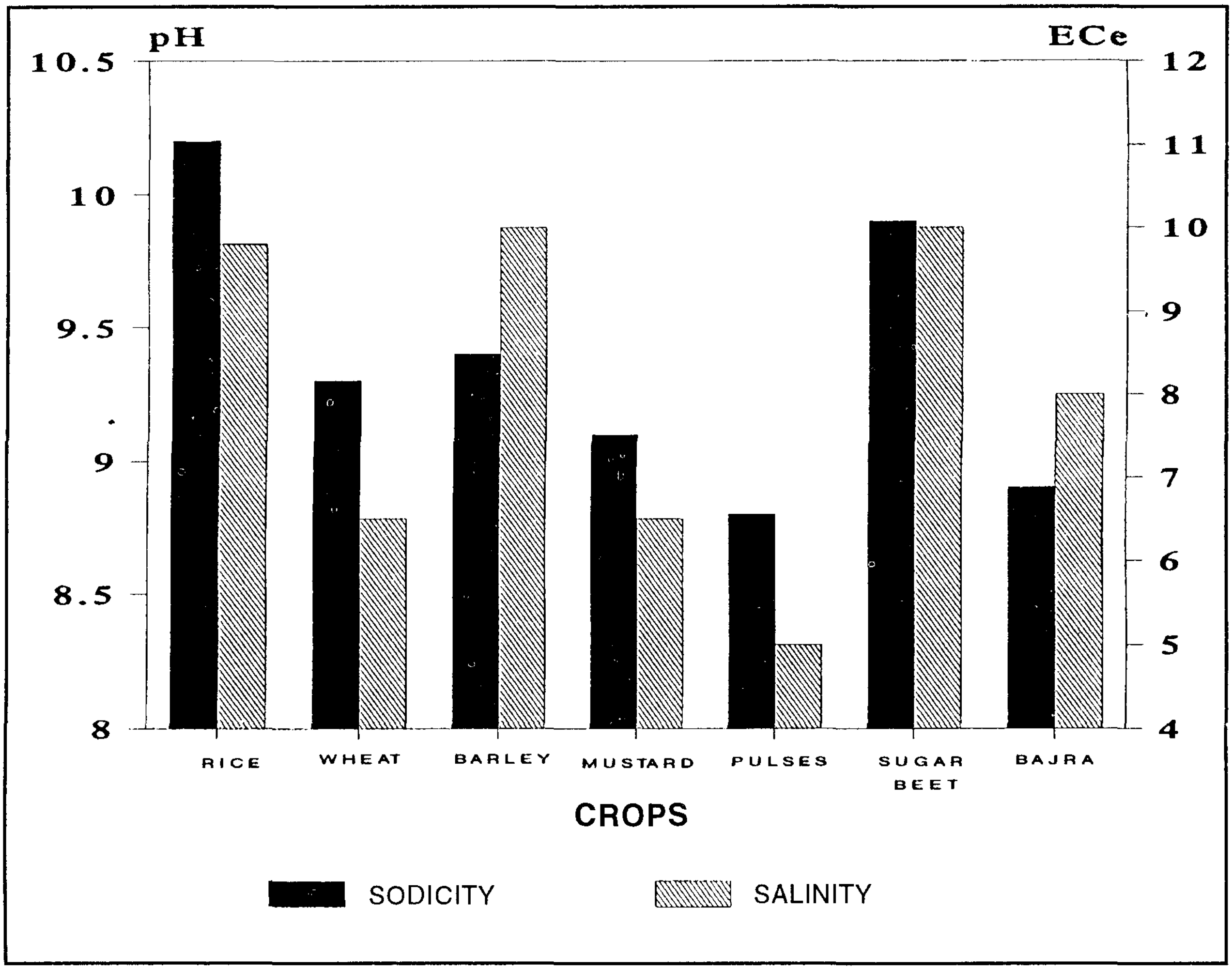
Limit of crops tolerance

The tolerance limits for salinity and sodicity stresses differ in crops, halophytes and glycophytes. Such limits have been studied in the field and in artificially-controlled environments in pots and microplots. The extent of variability within the crop has also been observed. The limits of salt tolerance, with less than 50% reduction in productivity, are given in Table 1 and shown in Figure 1 for a range of crops.

Table 1: Limit of salt tolerance in rice (based on the stress level with less than 50% reduction in grain yield)

Crop	Level of stress	Varieties	Remarks
Rice	1)Highly deteriorated alkali (pH_2 9.8 to 10,2) and saline soils (ECe 10 dSm^{-1})	CSR10, CSR11	Dwarf, early maturing (120 days) and high yielding salt-tolerant varieties. They are also used in biological reclamation of alkali soils without application of amendments.
	ii)pH_2 9,4 to 9.8	CSR10, CSR11, CSR12, CSR13, CSR19 and CSR20	CSR12, CSR19 and CSR20 long slender rices.
	iii)pH_2 <9.4 ECe <8.5	Most of rice varieties of normal soil.	pH_2 9.4 is not detrimental for rice crop in Indo-gangetic plains
Wheat	i)pH_2 9.2 to 9.3 ECe 6.5 dSm^{-1}	KRL1-4, WH157 Raj. 3077	Economic yield can be obtained up to pH 9.3.
	ii)pH_2 8.7-9.0 and ECe 5.5 dSm^{-1}	HD2009, HD2285 HD2329, WH542, C306	
Barley	Up to pH_2 9.3 and ECe 11.0 dSm^{-1}	CSB1, CSB2, CSB3, DL200 Ratna, BH97 DL348	All are hulled barley varieties. Hull-less vars. are sensitive to saline and alkali stress. Economic yield can be obtained up to pH 9.6.
Indian mustard	pH_2 8.8 to 9.2 and ECe 6.5 dSm^{-1}	Pusa Bold, Varuna, Kranti	Economic yield can be obtained up to pH 9.2.
		Promising lines CS52, CS416 CSTR 330-1,CSTR 609-B10 & CSTR 610-10-1-1	They are under evaluation.
Sugar-beet	pH_2 9.5 to 10.0 & ECe 10 dSm^{-1}	Ramonskaya-06 Polyrava-E, Tribal, Maribo-Resistapoly	Sugarbeet is highly tolerant to alkalinity but processing is a limiting factor.
Sugar-cane	< than pH_2 9.0	CO453, CO1341, CO6801,CO62329 and CO1111	Crop should not be encouraged where water table is shallow.

Figure 1: Limit of salt tolerance in crops (based on 50 % reduction in yield)



Intra-crop variability

Intra-crop variability reflects the future success of any breeding program in stress environments. Based on our work in sodicity and salinity stress over the years, the range of intra-crop variability is given in Table 2. Rice is found to have the maximum range of genetic variability for sodicity tolerance while barley has the maximum for salinity tolerance. The ranges of variability within some important crops are shown in Fig. 2.

Varietal evaluation and improvement

All domesticated species have been derived from wild species and many progenitors of important species were those which pre-agricultural man gathered for food. In general, the wild relatives of crop plants have been used for breeding for resistance to diseases and pests but there are other significant prospects for utilizing these genepools. To date, these have been largely untapped by breeders and most existing collections are seriously deficient in such materials. The Institute has improved the scope of its varietal collections and also developed new varieties adapted to varying levels of salinity and sodicity stresses.

Table 2: Intra-crop variability of salt tolerance in some important crops

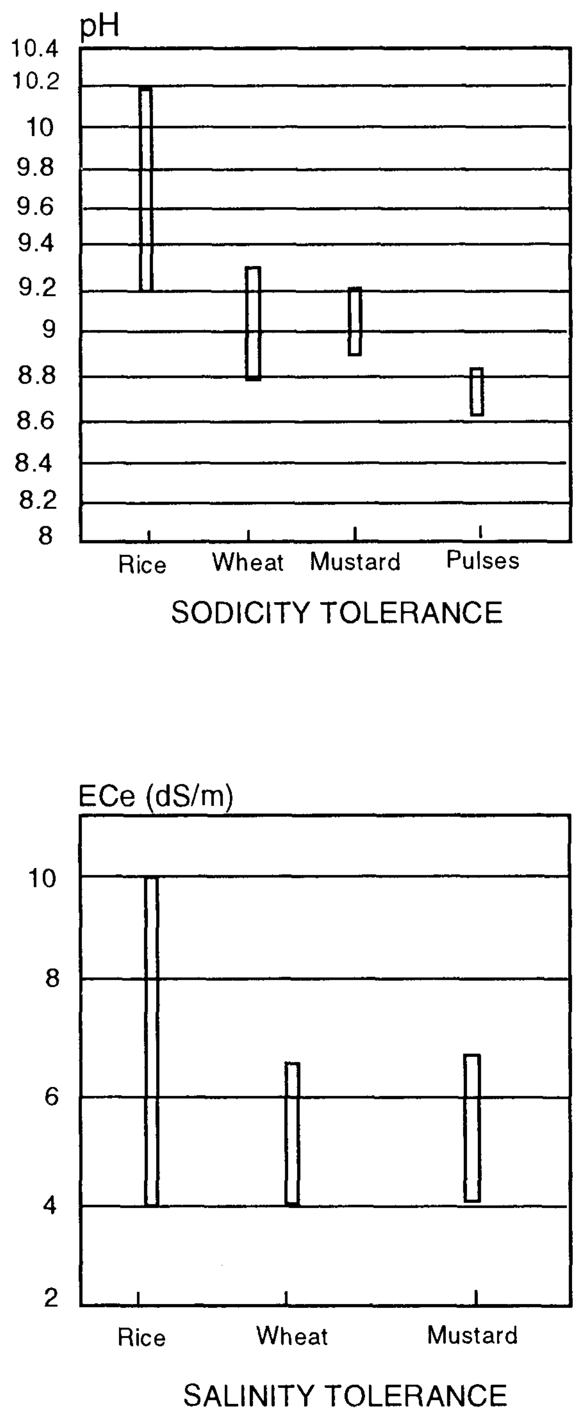
Crops	Sodicity (pH_2)	Salinity (ECe dSm^{-1})
Rice	9.2 - 10.2	4.0 - 10.0
Wheat	8.8 - 9.3	6.5
Barley	9.0 - 9.3	4.0 - 11.0
Indian Mustard	8.9 - 9.2	4.0 - 6.5
Toria	8.8 - 9.0	4.0 - 5.5
Taramira	8.7 - 8.9	4.0 - 6.0
Linseed	8.7 - 8.9	4.0 - 6.0
Safflower	8.7 - 8.8	4.0 - 6.0
Sunflower	8.6 - 8.8	4.0 - 6.0
Sugarcane	8.8 - 9.0	-
Cowpea	8.6 - 8.8	4.0 - 5.0
Pulses		
Greengram	8.6 - 8.8	-
Pigeon pea	8.3 - 8.6	-
Pea	8.6 - 8.8	4.0 - 5.0
Gram	8.6 - 8.8	4.0 - 5.0
Bakla	8.6 - 8.8	4.0 - 7.0
Sugarbeet	9.2 - 9.8	4.2 - 10.0
Bajra	8.7 - 8.9	4.0 - 8.0

Selection criteria

The *in situ* performance of a variety and its reduction in grain yield at defined stress levels was followed in screening and evaluating our rice breeding materials and varieties. A high percentage of spikelet sterility relates to a low level of salt tolerance and was used in rice evaluation. Low Na^+/K^+ ratio of ion uptake is positively correlated with a high level of salt tolerance and was taken into consideration as a desired characteristic while screening the lines.

The genotypes with high means (μ), regression values near to unity (bi) and the lowest deviations from regression (Sdi^2) under multiple stress environments are selected as the most suitable, stable and adaptable genotypes for sustainable productivity in problem soils. Association studies reveal that the number of ear-bearing tillers, grains per panicle and panicle length, etc., are positively correlated with grain yield in rice.

Figure 2: Range of intra-crop variability for alkalinity and salinity tolerance in selected crops



Screening techniques

Screening is an essential part of the commencement of a breeding program. The complexity of salt tolerance, heterogeneity in soils and significant interacting environmental factors restrict a simple and reliable technique, i.e., that gives dependable results. Different methods which are followed for screening important crops and their varieties at this Institute are:

a. Field evaluation

Screening work originally started at the Institute's naturally occurring, barren fields, which had been uncultivated for an unknown period. It was immediately realized that there was great variability, restricting the data processing and conclusions which could be drawn on the tolerant limits of the crops and their varieties. The gradient of soil sodicity was determined by soil tests at shortly-spaced intervals and a long strip running across the entire sodicity gradient has been allotted to each genotype. The plots generally consist of 2 to 3 rows for each variety, with each row 20 to 30 meters long. This allows comparable exposure of all genotypes to varying soil sodicity conditions. The layout for such a test generally consists of an incomplete block design, although a set of check varieties is replicated many times. The procedure increases the potential number of test varieties, allowing the simultaneous screening of a large number of genotypes. It is further possible to cut across the long plots in several parts to obtain varietal performance at varying levels of soil sodicity. There has thus been an overall increase in screening efficiency. This screening method is being used in rice, wheat, barley, pearl millet, oilseed and pulse crops. When the number of advanced materials is greatly narrowed, varieties are evaluated in a randomized block design with a maximum number of replications and with national and local checks to allow for initial yield evaluation. These further screened varieties are tested together with our developed varieties to determine yield ability; all are grown in bigger plot sizes to select for maximum productivity. The involvement of a greater number of checks has been shown more effective for data processing and for finalizing the tolerant lines.

b. Microplots

The soil great heterogeneity and spatial variability restricts the reliable interpretation of the responses of genotypes. This problem spurred the construction and maintenance of mini-field environments having varying levels of salinity and sodicity. The device developed at the Institute consists of a series of dug-out cavity structures made of brick-mortar-concrete materials, measuring 2 m x 2 m, and 6 m x 3 m with a depth of about 0.8 m and 1 m respectively. They are filled with artificially prepared soil, so that the soil is uniform all through the profile. It is possible to create and maintain desired levels of sodicity and salinity in these microplots in a manner very much comparable to field conditions--but minus the soil heterogeneity.

c. Pots

The edaphic environment of the pots is more or less uniform throughout the growth period of the plant in respect to the degree of stress. Sand culture and soil culture both are used in the pots for controlled studies in different crops. Studies of the genetics of salt tolerance and physiological experiments are carried out in these controlled and artificially-created varying stress environments.

d. Others

Wooden trays are used for the studies on germination of different crop varieties.

e. Farmers' participation

Farmers are now involved through the CSSRI-UPLDC adaptive research. Promising lines are evaluated at farmers' fields under the guidance of the Institute plant breeders. This has proven effective for evaluating the varietal adaptation and performance.

BREEDING METHODS

Conventional

Evaluation and plant breeding work started with the collection, evaluation and systematic cataloguing of available Indian and exotic germplasm of rice, wheat, barley, pearl millet, oilseed, sugar, pulses etc. We followed a sequence of: introduction, different methods of selection, hybridization, mutation and shuttle breeding. The salt-tolerant varieties Damodar (CSR1) and Dasal (CSR2), and Getu (CSR3) are pure line selections of local traditional cultivars found in the Sunderban areas of West Bengal. These salt-tolerant varieties were later identified as possessing the genes for sodicity tolerance too. Hence CSR1 became one of the donors for salt tolerance in our hybridization program. A large number of segregants were advanced following the pedigree and modified bulk pedigree method. The varieties CSR10, CSR11, CSR12, CSR13, CSR18, CSR19, and CSR20 have been developed following the pedigree method. The advancement of generations was made following pedigree selection simultaneously in moderate stress and high stress sodicity and salinity environments, a method we call the 'Parallel Pedigree Method' for the development of salt-tolerant varieties in problem soils. Backcross breeding has been used to induce salt tolerance in the prevailing genotypes. Similarly the wheat variety KRL 1-4 has been developed following the pedigree method. Mutation breeding has been used in rice, wheat and barley. Recurrent selection has been used in the case of bajra [pearl millet]. The pedigree and bulk methods have been used in barley. Shuttle breeding is being adopted in the development of salt-tolerant rices under the ICAR-IRRI Collaborative Project. More than two dozen varieties are being developed and tested in the national network program.

Non-conventional

Promising salt-tolerant F_1 Anther culture Derivatives:

IR51500-AC-17, AC6534-1 and AC6534-4 are promising anther culture lines developed by the CSSRI-IRRI Collaborative Project.

Biochemical markers for salt tolerance:

Enzymes of basic metabolic pathways are often good indicators of response to biotic and abiotic stresses. One such enzyme is esterase which plays a role in lipid metabolism. The rice esterase 2 (Est2) locus is involved in the metabolism of cell membrane lipids. As salinity stress is also associated with the response of the cell membrane, it is expected that Est-2 locus would also influence the response of the carrier genotype to salinity stress. Preliminary studies with varieties involved in a diallel showed very encouraging results. Salt-tolerant donors Nona Bokra, Pokkali, CSR10, and CSR13 were having the isozyme pattern of Est 2^1, sensitive types IR28, MI-48, and Basmati 370 showed Est 2^2, while a tolerant cultivation CSR1 showed Est 2^0. When they were grown in varying levels of salinity stress, the patterns were the same except in CSR1 with Est 2^1.

CROPS

Rice

Rice is recommended as the first crop in a reclamation strategy for alkali soils. It can also being grown on inland saline soils when sufficient water is available. It is monocropped in coastal saline areas. The Institute first started its screening of traditional landraces in the early seventies in gypsum-treated sodic soil. The high yielding variety Jaya was used a check. Experimentation over the years has indicated that, under reclaimed conditions, the high yielding varieties perform better than traditional landraces. Further, the traditional landraces are tall and have poor agronomic characteristics. They have also proved to be adapted to specific sites and can not outperform in the sodic soils of the Indo-gangetic plains. After few years, it was realized that screening should take place in the actual stress environments and so we conducted pot culture experiments using varying levels of salinity and sodicity. The traditional salt-tolerant variety CSR1 (Damodar) was identified as a donor based on its less than 50% reduction in grain yield at soil ESP 73 (pH_2 10.1) and ESP 85 (pH_2 10.3). Based on such results, the pot culture experiment was transferred to Gudha Farm where the variety CSR1 yielded 3 t/ha grain yield in the first year without any soil amendment. The other varieties Jaya, IR8, Pusa 2-21, and Basmati 370 failed because of high sterility. The continuous cultivation of CSR3 improved the soil and brought its ESP and pH to a level where other crops can now be grown. The variety CSR1 was very tall, late-maturing and unacceptable to farmers in this area and so it was used intensively in our hybridization and mutation breeding program for the development of dwarf, early and high yielding salt-tolerant rice varieties. High yielding rice varieties on normal soil, although available, fail to perform in salt affected soils. Therefore, a vast spectrum of genetic variability was screened for salinity/sodicity tolerance and many untapped and uneven unexplored genes were identified. A systematic breeding program at this Institute, following intensive hybridization and mutation breeding, has led to the development of many salt-tolerant rices adapted to varying levels of salinity and sodicity stress (Table 3).

Table 3 : Varieties developed at CSSRI, Karnal

Variety	**Stress** pH2	**adaptation** ECe(dS/m)
CSR 1 (Damodar)	9.8 - 10.4	6 - 11
CSR 2 (Dasal)	-do-	-do-
CSR 3 (Getu)	-do-	-do-
CSR 5	9.0 - 9.5	< 6.0
CSR 8 (M2-2-1)	9.0 -9.6	< 7.0
CSR 9	> 9.7	< 9.0
CSR 10 (81-H21-2-4)	9.8 -10.2	6 - 11
CSR 11 (81-H57-7)	-do-	-do-
CSR 12 (80-H3-12)	9.2 - 9.8	< 7.0
CSR 13 (80-H3-13)	9.2 - 10.0	< 9.0
CSR 14 (Suweon 294)	9.2 - 9.8	< 8.0
CSR 15 (Sipi 690233)	-do-	-do-
CSR 16 (M15)	-do-	-do-
CSR 17 (IR29725-21-1-3-2)	-do-	-do-
CSR 18 (80-H5-76-64)	-do-	-do-
CSR 19 (BC 3)	-do-	-do-
CSR 20 (BC 4)	-do-	-do-
CSR 21 (CSR-87IR-1)	9.8 - 10.0	< 9
CSR 22 (CSR-89IR-2)	9.6 - 9.9	< 10
CSR 23 (CSR-89IR-5)	9.8 -10.0	< 10
CSR 24 (CSR-88IR-5)	9.6 - 9.9	< 10
CSR 25 (CSR-88IR-4)	9.8 - 10.0	< 10
CSR 26 (CSR-88IR-7)	9.8 - 10.0	< 9
CSR 27 (CSR-88IR-6)	9.6 - 9.9	< 10

Our first high yielding salt-tolerant early maturing rice variety, CSR 10, was released in 1989 for the sodic and inland saline soils of various zones across the country. This is the first dwarf, high yielding, salt-tolerant variety released by CVRC which can withstand the highly deteriorated alkaline (pH_2 9.8 - 10.2) and inland saline soil (ECe 6-11 dSm^{-1}) conditions found in the transplanted irrigated management systems. CSR 10 (M 40-431-24-114/Jaya) is 80-85 cm tall, with a strong culm which prevents the lodging of plants. It matures in 120 days. The grain is short and bold with white rice and high amylose content. The yield potential of the variety is 5-6 t/ha under normal soil conditions while, under highly deteriorated salt-affected soils, grain yield ranges from 3.0 to 5 t/ha. In moderate stress, it yields from 5.0 to 5.5 t/ha. At breeding stations in multilocational AICRIP trials under salt stress, its yield was much higher than the salt-tolerant varieties Pokkali, Vikas and other high yielding varieties like Jaya. Under adaptive and minikit trials on farmers' fields, it yielded up to 4.9 t/ha in comparison to the local check varieties Saket 4 (1.5 - 2.4 t/ha), Sarju 52 (1.3 - 2.6 t/ha) and Jaya (2.2 - 3.0 t/ha). Marginal and poor farmers, who do not have enough resources to purchase chemical amendments to reclaim their fields, can use this variety as a biological amendment. The cultivation of this variety for three continuous seasons improves the soil sufficiently to enable most of the other crops to grow. Minikit and adaptive trials in Uttar Pradesh (U.P.) have confirmed the outstanding performance of this variety compared to the local varieties. This variety is presently the best salt-tolerant cultivar in the country which can be grown as biological amendment in highly deteriorated sodic soils having stress up to pH_2 10.2 (without any soil amendment). No other rice variety grows economically at this high stress level of sodicity. This variety has also excelled others in many countries and was rated as a very high salt-tolerant rice variety by IRRI in a global testing network.

Sixteen demonstration trials were conducted by CSSRI at Mandanpur, Aligarh, (U.P.) with resource-poor marginal farmers. The trial included the salt-tolerant high yielding dwarf rice variety CSR 10 along with the local variety, in gypsum-treated and without gypsum-treated plots. The variety CSR 10 yielded more than 3.6 t/ha in salt-affected soils while the local variety miserably failed. This variety also performed best in many other parts of U.P. State. It has given more than 5 t/ha in the saline soils of Goa. The variety has also performed excellently in Gujarat, Maharashtra and Rajasthan.

All-India evaluation of other salt-tolerant rice varieties in the national evaluation network demonstrated the excellent performance of some of our promising lines, including: CSR 11, CSR 12, CSR 13, CSR 18, CSR 19, CSR 20 and CSR 21. Other promising rice varieties include: CSR 22, CSR 23, CSR 24, CSR 25, CSR 26 and CSR 27. Most of them are recommended for sodic and saline soils of U.P., Haryana, Gujarat, Maharashtra, Andra Pradesh and Karnataka.

Biological management of salt-affected soils

The biological management of salt-affected soils by growing the salt-tolerant rice variety CSR 10 has become successful without any chemical amendment. The variety yields 3.5 to 4.5 t/ha in the first year. It brings down the original soil pH_2 from 10.2 to 9.9 after the crop harvest. In the second year, the yield goes beyond 4.5 t/ha and the pH_2 level comes down to 9.7 and, in the third year, the pH_2 remains around 9.5. Similarly the ESP comes down to 40, from 85. The soil physical characteristics are also improved. By the third year, the field becomes ideal for growing wheat or Indian mustard (*raya*) in the winter season. The variety has become very popular and is being grown in salt-affected soils in many states.

Recommendations

- The most salt-tolerant early maturing dwarf rice variety CSR 10 should be grown immediately on a large scale, without further delay, in highly deteriorated sodic or saline sodic soils. This variety can be grown even without soil amendments and achieve 3-4 t/ha. A little addition of gypsum/pyrite (10-20% of the total amendment requirement) can enhance the productivity in sodic soil having pH_2 more than 10.2 and ESP more than 73.

- The demonstration plots of fine grain salt-tolerant rices CSR 12, CSR 13, CSR 18, CSR 19, CSR 20 and CSR 21 can be taken to the hot-spots in the country to find out their adaptability as compared to local varieties. This will lead to the identification of better quality rice varieties with salt-tolerance.

- Seed of the variety CSR 10 should be multiplied through the state machinery in order to meet the requirements. Seeds are already being multiplied by The National Seeds Corporation Ltd., and The State Farms Corporation of India Ltd. Breeder seed has also been supplied to U.P. Land Reclamation Corporation Ltd., other seed multiplication agencies, State Institutes, Universities and also to the some farmers. The present seed requirements for CSR 10 have gone beyond 2000 tons (including breeder seed, foundation seed and certified seed).

Wheat

Variability for salt tolerance has been observed in wheat varieties. Most of high yielding varieties can be grown in sodic soils only up to pH_2 9.1. Beyond this pH, only salt-tolerant varieties have the ability to survive and produce some economic yield. For saline stress, wheat varieties can be grown up to ECe 5-6 mmhos/cm. The KRL 1-4 wheat variety developed by this Institute was released in 1990. This variety is dwarf (85cm) with 145 days for maturity. The grain texture is hard, its color is amber with medium bold grain size. It yields 3.2 - 4.8 t/ha under non-stress and 3.4 t/ha under sodic stress up to pH_2 9.3. It also tolerates salinity stress up to ECe 7.

The other promising lines developed by this Institute are KRL9, KRL10, KRL11, KRL12 and KRL13. The varieties PBW65, WH157, LOK1 and KRL4, KRL2-2-2 can tolerate up to pH_2 9.3, while Sonalika, HD22O4, HD2236, HD2177, RAJ 1972, HD1982 and IWP72 up to pH_2 9.1. The varieties HD2009, HD2329, WL711, C306 are medium-sensitive and HD4502, HD4530, Raj911, LSW34, N18622, N18622, Malwaraj, Jairaj and Moti are sensitive types which fail badly beyond the pH_2 8.8.

Oilseed Crops

Indian mustard (*raya*) has been recommended as best among the oilseed crops for both saline and sodic soils. It has relatively less irrigation and other inputs than wheat. Its salt tolerance limit is nearly same. Therefore, work has been intensified towards the development of salt-tolerant *raya* varieties. CS52, CS416, CSTR 330-1, CSTR 600-B-10, CSTR 610-10-1-1 and CS12 are the promising Institute breeding lines. The varieties Kranti, Varuna and Pusa bold have been identified as better tolerant cultivars. Among the other suitable oilseed crops, *Brassica campestris* var. *toria* has been observed as the second oilseed crop but its tolerance limit is less (up to pH_2 9.0) than that of *Brassica juncea* (up to pH_2 9.2). Taramira (*Eruce sativa*), a preferable crop of the dryland areas, has shown its limit of tolerance up to $pH_2$8.9. The other oilseed crops like safflower (*Carthamus tinctorius*) and sunflower (*Halianthus annus*) have miserably failed in sodic soils having pH_2 9.1. However, they seem to be promising in saline soils. Work for salinity stress is in progress. Linseed (*Linum usitatissimum*) has been observed to grow in sodic soil up to (pH_2 8.9) and in saline soil up to ECe 6. Soybean has also been observed as a promising crop for saline soils up to ECe 6 dSm^{-1}.

Pulses

Pulses are found to be sensitive for salt-affected hazards. Work conducted at this Institute has already demonstrated that pulses, although sensitive, also have a good range of viability i.e., between and within the species. Among pulses, studies so far conducted at this Institute have revealed that cowpea (*Vigna unguiculata*) is moderately suitable up to pH_2 8.8, followed by Green gram (*Vigna radiata*). Pigeonpea (*Cajanus cajan*) has shown more susceptibility to sodic stress. Broad bean (*Vicia faba*), locally known as *bakla*, is showing relatively better tolerance to salinity up to ECe 7. Recent work has revealed that pea is better adapted to moderate sodicity (pH_2 8.9) followed by gram (pH_2 8.8).

Millets

Pearl millet is an important crop for saline soils of semi-arid areas. Pearl millet has been found to have proper growth and maturity up to ECe 10.0 dSm^{-1}. However, the crop yields well to ECe 8 dSm^{-1}. As the crop is sensitive to waterlogging, it is not suitable for sodic soils, where physical properties of such soils render low infiltration of water. The germination and flowering stages have been found to be relatively more sensitive stages in its plant growth. The bristled hybrid/ populations have been observed to perform better than nonbristled ones in saline soils. In a nutshell, to have better growth of pearl millet in saline soils, the bold-seeded bristled varieties, preferably hybrids, should be sown after one or two rains so that excess salts are leached down before the sowing. The population/hybrids viz. GH3100 (Gujarat), ICH451 (ICRISAT), MBH10 (Mahyco), MBH137 (Mahyco), MBHV-82 (Hissar), ICMS8010 (ICRISAT) have been found promising in saline soils.

Barley

Among the winter crops, barley has been observed as one of the best for saline areas and it can be cultivated successfully up to ECe 10-12 dSm^{-1}. It grows well in sodic soil up to pH_2 9.3 and the salt-resistant varieties can tolerate up to pH_2 9.4. The promising salt-tolerant varieties developed by this Institute are CSB1, CSB2, CSB3, CS-54 and CS 80-2. Among the other varieties DL200, Ratna, BH97, DL348, BL88, P469, DL352 are some promising cultivars for salinity and sodic stresses. Experiments under controlled stress environments of salinity and sodicity and field trials under saline and sodic soils exhibited very clearly that hulled barley varieties are more tolerant than hull-less varieties. Hull-less varieties were observed as highly sensitive to saline and sodic soils. Barley varieties are better suited to saline than sodic soils.

Sugar crops

Among the sugar crops, sugarbeet is very tolerant to both salinity and sodicity stresses. The varieties Ramonskaya-06, Polyrava-E and Tribal can be successfully cultivated in highly sodic soil (pH_2 10.0) while for partially reclaimed sodic soil (pH_2 9.3), the variety Maribo Resistapoly is suitable. Under the saline soils (ECe 10 dSm^{-1}), the variety Tribal has recorded the yield of 71 t/ha. Sugarcane varieties can be grown only up to pH_2 9.1 and the promising varieties are CO453, CO1341, CO6801, CO62329 and CO1111.

CONCLUSIONS

Breeding rice varieties depends upon access to genetic resources including traditional landraces and wild relatives which are more adapted and have performed at a sustainable level in poor stress environments. Introduction of high yielding rices of irrigated ecosystems into fragile environments has not been productive and has resulted in the loss of local cultivars through the destruction of their habitats. Further, as the concept of *ex situ* conservation has gained currency in recent years, the notion of *in situ* or preserving biodiversity in its natural habitats has been given less attention. Our explorations and collections of these landraces have revealed that a system of *in situ* or on-farm conservation has to be developed immediately, otherwise we will lose a wealth of biodiversity in fragile ecosystems. On-farm conservation keeps alive the evolutionary processes which lead to the generation of new genepools, and also maintains a continual supply of germplasm for *ex situ* needs. Our experience advocates that farmers' participation in varietal selection and their involvement in the final cycle of selecting breeding populations for stress environments in poor fragile ecosystems will be an ideal approach.

CONSERVING GENETIC RESOURCES AND USING DIVERSITY IN FLOOD-PRONE ECOSYSTEMS IN EASTERN INDIA

J.L. Dwivedi

ABSTRACT

Eco-edaphic conditions under which rice grows range from deepwater swamp to rainfed upland, with this wide range of zones being a contributing factor to its great varietal diversity. The genetic wealth of cultivated and wild rice germplasm in eastern India is rich and diverse. There is little genetic erosion owing to the release of only a few varieties for flood-prone areas and the rate of replacement of landraces is slow. Breeders and genetic resource personnel have made efforts to collect landraces and their wild relatives, but flood-prone areas located in remote places (10-15% of flood-prone regions) are yet to be explored. Efforts have been made by breeders to maintain farm diversity through the launching of a farmer participatory program whereby synthetic landraces and a 'genetic soup' (a method of testing bulk hybrids from F4 stage) have been employed. Testing of hybrid bulks on farmers' fields enables the breeder to create new landraces within a few seasons through continuous natural selection. It also provides feedback on the relative the merits of elongation ability and submergence tolerance as well as base breeding materials on which breeders can perform line selections in experimental sites. This testing approach provides a considerable opportunity for broadening farmers' farm diversity through including landraces of sub-ecological groups, including wild type races. Farmers adopt only those varieties which are well-adapted to their existing set of environmental conditions. Criteria to be considered for using this diversity-enhancing approach should include: rate of replacement of landraces by improved types, range of environments, richness of genetic diversity, and assessment of past collection efforts.

INTRODUCTION

Distinct climatic and ecological variations have led to the differentiation of irrigated lowland, rainfed lowland, upland, cold tolerant, deepwater and saline-tolerant rice varieties. Accordingly, genetic wealth of cultivated and wild rices in India is rich and diverse. While genetic erosion has taken place to a critical point in India's favorable rice ecosystems, there is a little genetic erosion in the flood-prone ecosystem due to the release of only a couple of varieties suited to this adverse condition. Reselections from landraces still dominate and cover about 60% of the flood-prone areas. Efforts have been made by breeders to collect landraces and their wild relatives from these areas but remote regions, with large acreages, are yet to be covered; these are the areas where unimproved races possessing high level of tolerance to eco-edaphic stresses can be traced. Out of the thousands of accession maintained in International Rice Research Institute (IRRI) germplasm bank, only 733 accessions belong to the flood-prone ecosystem (Table 1).

In eastern India, about 2.3 million ha of land annually suffer from excess water, ranging from 50 to 400 cm where rices of different cultural types are grown. Accordingly, unlike other ecosystems, in flood-prone areas, we find a full range of varieties under cultivation, from very primitive to improved types. Uncontrolled flooding is the dominant feature of this ecosystem, with depth and duration of floodwater in the field varying from place to place and from year to year. Therefore, each variety group is adapted only to a specific set of environmental conditions. Flood-prone rice, which is mainly close to wild types, varies considerably in traits such as morphological character, grain pigmentation and quality, tolerance to many abiotic stresses (e.g., excess water tolerance, drought and soil toxicities), and tolerance to biotic stresses (including resistance to blast, bacterial blight and sheath blight). Studies have revealed that O. nivara, a wild rice, is the only source of grassy stunt virus and grows in seasonal ditches of plateau regions. O. rufipogon is a perennial, photoperiod-sensitive, floating type, with thick and long culm, well-exerted and spreading panicles, and an ability to elongate under abrupt flooding. This indicates that genetic wealth is hidden in the flood-prone ecosystem and that such a resource requires the special attention of policymakers and scientists in order to be conserved.

Table 1: Status of deep water varieties in IRRI germplasm bank

Country	No. of landraces
Bangladesh	443
Cambodia	25
China	21
India	42
Indonesia	13
Myanmar	8
Sri Lanka	82
Thailand	34
Vietnam	22
Others	43
Total	733

Alternative approaches for identifying cultivars that are acceptable to the farmers have been suggested. Earlier, Maurya *et al.* (1988) tested advanced rice lines with villagers in Uttar Pradesh and successfully identified superior material that was preferred by farmers. 'Synthetic landraces', a bulk hybrid population and genetic soup approach, will be discussed as a method which may be particularly suited to adverse conditions. The relationship between the release of a variety, its adoption rate and their joint effect on genetic erosion in flood-prone races will also be emphasized.

A NEW APPROACH FOR TESTING MATERIAL ON FARMERS' FIELDS AT AN EARLY STAGE

There are many areas new to deepwater rice (DWR) where farmers intend to grow rice but show reluctance when told that it takes 10 years to breed new location-specific DWR varieties. In order to obtain high yields under local conditions, researchers should first study existing farmer varieties, with suitable replacements being developed by testing materials on farmers' fields and under the existing set of conditions (that is, from the beginning, planning to cope with local concerns of soil problems, deepwater survivals, plant stature and maturity).

In a 'synthetic landraces' and 'genetic soup' approach, early hybrid populations (F3-F4) should be subjected to naturally-flooded rice areas which are representative of most of farmers' fields. Planting should take place in adjacent plots marked 'submergence-tolerant bulk' and 'elongating bulk'. As these early segregating materials have potential variability, populations will segregate into early, late, tall, short, good-, poor-survivals, etc. Two bulk populations may survive differently across water depths. Only limited panicles which mature at the appropriate time (as per requirement of the area) should be harvested and then replanted 2-3 generations in the field. Breeders can later select lines at the breeding station with reasonable confidence that the line selected will at least survive the deepwater conditions prevailing at the site.

OBSERVATIONS ON ON-GOING WORK IN THE FLOOD-PRONE ECOSYSTEM

In order to conserve farm diversity, scientific approaches are in progress which test both synthetic landraces and a genetic soup where traditional varieties are still being used as donors. However, work has become difficult due to the poorly understood and fragile ecosystem. Flood-prone rice breeding also poses a great challenge as the agro-ecological system is extremely diversified. It is difficult to select a genotype for all or even most of the traits needed for the different environments. Therefore, I particularly stress the need for more detailed study of the diversity in the present ecosystem.

DIVERSITY RELATED TO FLOOD-PRONE RICE ADAPTATION

Factors that contribute to great varietal diversity among sub eco-cultural types such as flash-flooded rice, semi-deep and deepwater rice, floating rice and tidal wetland rice include specific hydrological conditions and the requirement of farmers in the local area. Important traits like submergence tolerance and elongation ability represent opposite mechanisms or strategies for flood adaptation. DWR lines with improved plant type, elongation ability and submergence tolerance to fit the complex environmental matrix (of soil, water depth, maturity requirement and plant stature) are difficult to develop. Mutually exclusive choices in the articulation of breeding objectives include deepwater survival strategy, maturity timing starting from October to January, plant stature and soil types. The variants on these choices add up to 126 mutually exclusive ideotype options-- in order to cover the full range of prevailing diversity in the ecosystem (Table 2). Fortunately, all the types are not required in any one region. Hence, the breeder can make his choice depending upon the specific demands of local ecology and specific local farmer needs. Although photoperiod sensitivity is a most desirable trait in flood-prone rice improvement, it imposes restrictions on varietal adaptation. Because of the specific photoperiod response needed in different DWR areas, breeding for improving varieties has to be very site-specific.

Table 2: Diversity with respect to deep water adaptation

Factors	Choices
Deepwater survival strategy (3 choices)	• Submergence tolerance • Elongation ability • Fast emergence
Maturity time (7 choices)	150 d. to 220 d. Oct. to Jan/15 d. interval
Plant stature (3 choices)	• Short (130 cm) • Medium (130-160 cm) • Tall (>160 cm)
Soil types (2 choices)	• Neutral • Acidic
Photoperiod sensitivity (2 choices)	• 12 to 12.5 day length hour (Latitude up to 14.00° N) • 13 to 14 day length hour (Latitude 22.5 to 27° N)

THE ROLE OF SYNTHETIC LANDRACES AND GENETIC SOUP IN THE EARLY ADAPTATION OF MATERIAL

Since the testing of breeding materials on farmers' fields starts from the F3-F4 generation itself, Farmers are provided a bulk population with which to shape their own 'landraces' within a few seasons (through continuous farmer and natural selection). These landraces (the survivors) then can be used as base populations for the breeder, before he spends resources on line selection. Testing early in farmers' fields also provides feedback on the relative merits of elongation ability and submergence tolerance for the area in question. Finally, selection in farmers' fields enables the farming community to choose the materials suited to their existing adverse conditions and to maintain diversity of almost equal range. It also gives them early access to varied material.

THE RELATIONSHIP AMONG THE DEVELOPMENT OF VARIETIES, THEIR ADOPTION AND FARM DIVERSITY CONSERVATION

Progress in developing improved DWR cultivars in eastern India has been slow because DWR must be adapted to a diverse, complex and poorly understood ecosystem. Besides the financial, technical, and personnel constraints, certain features such as the survival problem, diversity in farm land, specific day-length requirements and problems in testing in target environments contribute to the slow improvement process. Hence, there is a need to collect, conserve and utilize the landraces from unexplored areas and to involve farmers as partners in the gathering of such material. From such a wealth of genetic diversity, breeders can then further improve the yield level. Lists of released varieties for the flood-prone ecosystems of southeast Asia and India are furnished in Table 3 and 4.

Table 3: Deepwater rice varieties developed by different countries

Country	Varieties
Bangladesh	Indra sail, Tilakkachari, Biasbish, Gabura, Malibhanga, Habiganj Aman 1, Habiganj Aman 2, Habiganj Aman 3, Habiganj Aman 4, Habiganj 5, Habiganj 8 Habiganj Aman 6*, Habiganj Aman 7*, BR 118-3B-117**
Thailand	Leb Mue Nahng 111, Khao Nahng Nuey 11, Pin Gaew 56, Tapow Gaew 161 RD 19*, HTA 60* BKNFR 76 106-16-0-1-0**
Vietnam	Nang Tay, Tao Binhc

* Cross bred varieties
** Submergence tolerant advanced breeding lines

As regards the adoption of newly developed DWR varieties, experience shows that farmers grow only the varieties with highest adaptability and stability. A new variety that requires different or improved management practices will not be easily accepted by the farmers, unless the replacement variety shows yield superiority under similar environmental and management conditions. Therefore, the objectives for developing varieties should be based on an analysis of the weaknesses of the varieties already grown. This requires a good knowledge of these varieties, especially of their local tolerance of abiotic stresses. At present, above 80% of the released varieties for flood-prone ecosystems in eastern India are reselections of landraces (Table 4). Keeping in mind the widely varying hydrological and flooding trends from year to year on the same location, scientists have developed a plant type concept where need-based elongation is the main feature. It prevents unnecessary excess growth and directs the additional food resources to enhanced grain yield. However, landraces/floating rices lack this ability. Improved plant types include RD19, IR 11141-6-1-4 and Jalpriya for deepwater environments.

Table 4: Rice varieties released in different Indian states for flood-prone and deepwater ecologies

State	Flood affected areas	Deepwater and floating rice
Assam	T 2205, T 2208	A R C 146
Bihar	BR 13, BR 49	BR 14*, BR 46*, Jai Suria*, BR 7, BR 8, Janki, Sudha, Varidhi
Kerala	ITB 15, PTB 16	AR 614 - 25 B
Orissa	FR 13 A, FR 43 B	Marsh 1, Marsh 2, Utkal Prabha
Tamil Nadu	CO 14, PTB 7, ADT 7	TNR 1, TNR 2
Uttar Pradesh	Madhukar, Barh-Avarodhi NDGR 24	Jalmagna*, Jalnidhi* Chakia-59, Jalpriya
West Bengal	Jal Plavan 1, Chin 31 Tilakachari	Jaladhi 1*, Jaladhi* 2, Chinsura 21, Suresh, Biraj, Savita, Mendira, Gogen, Nalini Natangini, Dinesh, Amulya

* Floating rice (suitable for 1 m water depth)

Farmers are better judges than scientists in choosing cultivars for any particular area. There are cases where varieties have been widely used in areas but formally released later, e.g., Mahsuri, a rainfed lowland variety is very popular and has been cultivated for the last 10-12 years in different areas but was only notified recently. Pant Dhan 4 and Indrasan serve as similar examples in irrigated ecosystems. However, simultaneous testing of materials on farmers' fields under an International Fund for Agricultural Development (IFAD) supported Indian Council of Agricultural Research (ICAR) project for strengthening rainfed/deep water ecosystems led to the release of Jalpriya for deepwater up to 100 cm water depth and Jalnidhi floating rice for 2-3 m depth (Table 5).

Experiments conducted at the Crop Research Station, Ghagharaghat, Uttar Pradesh, India with IRRI and Thai materials revealed that the transfer of fixed breeding materials and varieties is not very useful in the Indian context due to the problem of phenotypic acceptability (including correct flowering date and adaptation to new flooding patterns). Therefore, in order to get fruitful results, early segregating populations from F2-F3 onwards need to be tested under natural fields conditions over long periods. Such materials need to be exposed to natural selection for the desired flowering date, level of stability and sustainable yield. If progress is to be made, extensive work has to be done directly in the target environments, in close contact with farmers, and on farmers' farms.

Flowering date is affected by slight variations in latitude within the country. Sabifa, a most popular and adapted variety of deepwater released for the West Bengal area, flowers 10-12 days in Uttar Pradesh due to a change in latitude. Similarly Jalpriya, Jalmagna, Jalmagna and Jalnidhi flower early in West Bengal. This suggests that a variety should be bred with the local context in mind as its adaptation is limited only to a set of specific environmental conditions.

Specificity in adaptation helps to maintain farm diversity and enables farmers: to fit their cropping system to their heterogenous conditions; to enhance the food security of their household; and to exploit a range of varieties.

Table 5: Relationship between varietal adoption and release of varieties in Uttar Pradesh: a few examples

Variety	Status	Ecosystem
Mahsuri	Fully adopted, then notified and released	Rainfed lowland
Pant Dhan 4	Identified by State Govt officials and farmers first, then released	Irrigated
Indrasan	Well saturated but yet to be formally released/notify	Favorable
Jalnidhi	Simultaneous testing on farmers' fields and released/ notified	Very deepwater (floating group)
Jalpriya	Simultaneous testing on farmers' fields and released by SVRC*	Deepwater
Barh Avarodhi	Simultaneous testing on farmers' fields and released by SVRC	Flash flood

* SVRC - State Variety Release Committee

CONCLUDING COMMENTS

- A number of local varieties and wild types have been collected from different states of India where flood-prone rice is grown. However, it is believed that 10-15% of landraces have not yet been collected from the DW and rainfed lowland areas which are located in remote places and accessible only by boat.

- Due to the poor germination ability of certain landraces, it becomes necessary to recollect cultivars from their original areas.

- Most of the rices from flood-prone races are late maturing, tall, and with varying flowering dates. Therefore, a germplasm collection program should be mapped to ensure that the varying types are collected during limited trips to the areas.

- Since farmers have a better understanding of adaptation of these flood-prone rice types, their involvement in the breeding program should be encouraged.

- As regards the conduct of on-farm trials on farmers' fields within a participatory approach, some incentive should be given to the farmers as production is very risky.

- It was most surprising that only 733 accessions related to flood-prone rice are documented in the rice germplasm bank of IRRI. Timely evaluation of genebank accessions is also problematic as only a few accessions are evaluated annually.

- As regards the extent of genetic erosion in flood-prone rice, it can be mentioned that the rate of genetic erosion is slow as most of the varieties released in flood-prone ecosystems are reselections from landraces. Even the improved varieties developed for the deepwater rice context include existing varieties as one of their parents in order to retain the local adaptation for a specific situation. Therefore, the genetic situation is not very alarming in the flood-prone ecosystem.

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EVALUATING PEARL MILLET VARIETIES WITH FARMERS IN BARMER DISTRICT

M.K. Choudhary, E. Weltzien R., and M.M. Sharma

ABSTRACT

A newly formed NGO, operating in Barmer district in western Rajasthan, applied and modified methods of farmer participatory variety evaluation develop by ICRISAT scientists in other regions of Rajasthan. Barmer district has the largest area under pearl millet of all the Indian districts; it is characterized by low and erratic annual rainfall.

The first year results of varietal evaluations with farmers indicated that farmers from Barmer district assigned the two highest ranks to varieties with medium to late maturity, large panicles and high yield potential. The farmers from the more sandy, drier areas of Barmer district did prefer higher tillering, earlier maturing varieties, commonly with larger grain size as a secondary group of desirable materials. The traits used to compare varieties most often were also the characteristics of the most preferred varieties. Farmers insisted on at least one more year of such evaluations before a decision on initial adoption of any of these varieties could be taken.

INTRODUCTION

The Society to Uplift Rural Economy (SURE) has recently begun to manage and direct a Krishi Vigyan Kendra (KVK), a farmer training center, with the approval of the Indian Council of Agricultural Research (ICAR). In collaboration with ICRISAT, the KVK has started a program to identify cultivars of pearl millet [*Pennisetum glaucum* (L.) R. Br.] suitable for cultivation in Barmer district. Barmer district has no previous research results on the adaptation of newly released varieties of pearl millet. The current program was designed to evaluate a broad range of genetic diversity on the KVK-farm and on farmers' fields. The new varieties were exposed to a wide range of growing conditions, and farmers were able to observe the material throughout the growing season before their preferences were obtained.

GENERAL CHARACTERISTICS OF THE AGRICULTURE IN BARMER DISTRICT

Barmer district is located in western Rajasthan and is part of the Great Indian Desert (Thar). The whole district is part of the Western Arid Plain Zone (1A) in the state's classification of agro-ecological regions. The only river is the Luni river which rises in the Aravalli hills near Ajmer and, after passing through Barmer district, drains into the Runn of Kutch.

Among the five desert districts, Barmer has the highest percentage of population (83%) engaged in agriculture. This may be due to the lack of other job opportunities. This percentage is higher for women than men. The district is lacking modern transportation and communication facilities. The district has a geographical area of 2.82 million ha. In 1993-94, about 0.9% of the area had forest cover, 7.3% constituted pasture land, 19.4% was fallow land and 55.9% was cultivated crop land. The remainder was either not available for cultivation or culturable wasteland (Table 1).

Table 1: Changes in land use pattern in Barmer district from 1956 to 1994: area (in '000 ha) and percentage of total geographical area in Barmer district used for different purposes

Type of land use	Area 1956-60 (1000 ha)	% of total area	Area 1985-89 (1000 ha)	% of total area	Area 1993 (1000 ha)	% of total area
Total geographical area	2809.6	100.00	2817.0	100.00	2817.0	100.00
Forest area	7.2	0.26	23.4	0.83	24.7	0.88
Area not available for cultivation	222.2	7.91	198.2	7.03	200.3	7.11
Pastures and tree crops	150.6	5.36	210.4	7.47	206.5	7.33
Cultivable waste land	242.4	8.62	285.8	10.14	266.1	9.45
Total fallow land	994.6	35.40	769.2	27.30	545.8	19.37
Net area sown	1192.6	42.45	1330.5	47.23	1573.7	55.86

Source: State Agricultural Department and Revenue Department of Barmer (Rajasthan)

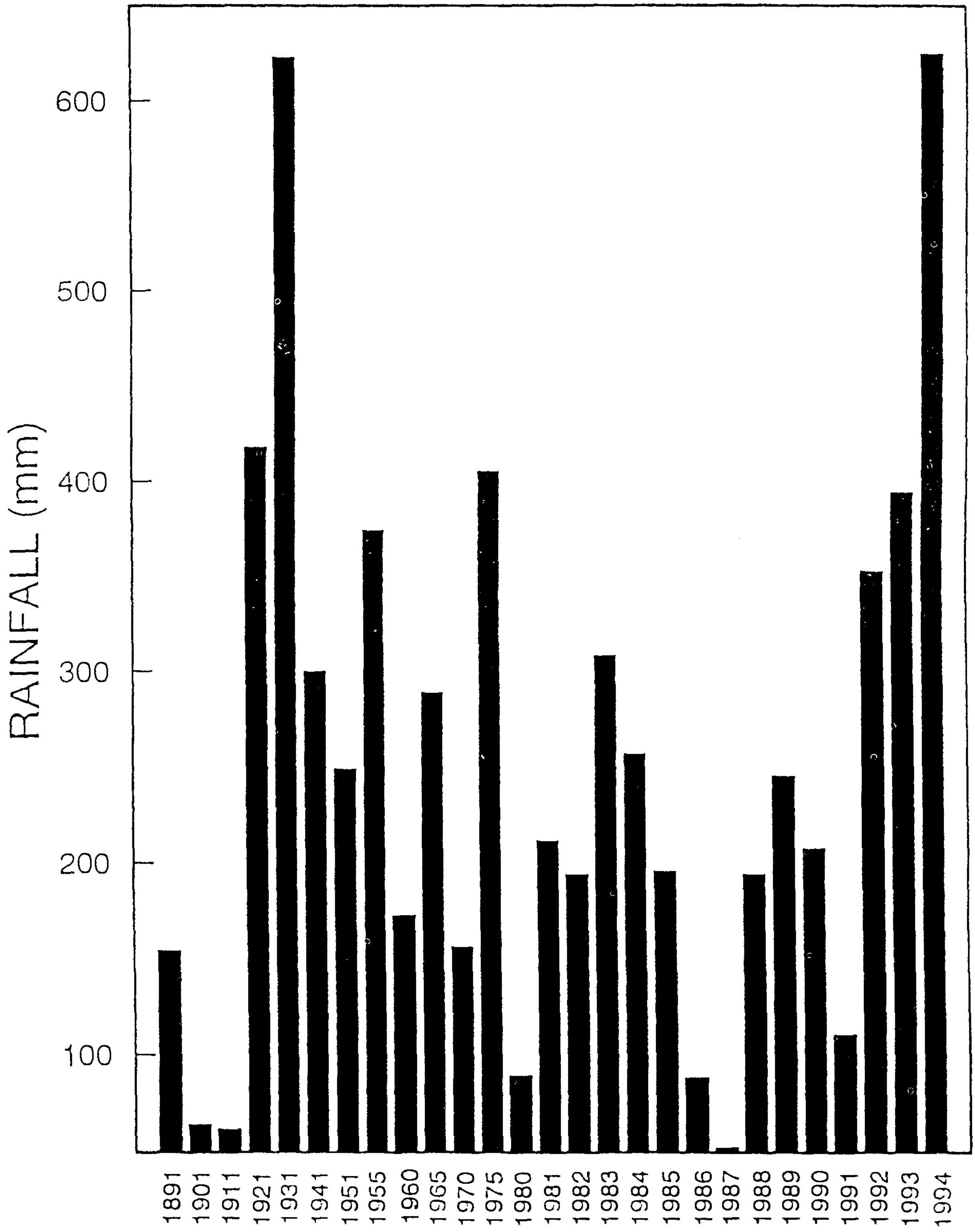
The district is characterized by low rainfall with an erratic distribution (Figure 1), resulting in frequent drought and crop failures. The mean annual rainfall varies from 209.7 mm at Sheo to 34.5 at Siwana, with the mean number of rainy days varying from 9.4 to 15.2. May and June are the hottest months recording mean maximum temperatures of 41.9 and 40.3°C. The lowest mean minimum temperatures (10-12°C) occur during December and January. The mean monthly wind speeds vary between 5.3 and 14.2 km/h. The potential evapotranspiration across the district varies between 1500-2000 mm per year and is highest from April to June.

Table 2 shows that 49.7% of the land holdings are larger than 10 ha, and these account for 82.35% of the agricultural land. Large land holdings are a reflection of the harsh environmental conditions, and hence low population density (51 people km^{-2}).

Table 2: Number and size of operational holdings in Barmer (1985)

Holding size class (ha)	No. of holdings	% distribution	Area (ha)	% distribution
<1	4583	2.96	2243	0.10
1-2	7151	4.63	10719	0.48
2-4	17368	11.23	51968	2.32
4-10	48696	31.51	530511	14.75
>10	76763	49.67	1844859	82.35
Total	154561	100.00	2240300	100.00

Figure 1: Rainfall at Barmer, Rajasthan State, India



Productivity of major crops in Barmer district is low (Table 3). Productivity and thus production of rainfed crops (pearl millet, mung bean (*Vigna radiata*), moth bean (*Vigna aconitifolia*), guar (*Cyamopsis tetragonoloba*) and sesame (*Sesamum indicum*) fluctuates with annual rainfall. Although 20% of Rajasthan's pearl millet area and 22% of its area under guar are grown in Barmer district, the contribution to the total production is low. Pearl millet is the most important crop in Barmer district, grown on 55.7% of the cropped area, followed by Guar (25.2%) and moth bean (5.3%). Irrigation is available on only 4.3% of the area, which allows double cropping with a variety of specialty crops like cumin, mustard or isabgol.

Table 3: Area, production, and grain productivity of major dry land crops during five years (1990-94) in Barmer district

		Crop				
		Pearl millet	Guar	Moth bean	Mung bean	Sesame
Area (1000 ha)	1990	896	469	149	14	5
	1991	950	316	69	16	9
	1992	1032	410	126	20	8
	1993	806	407	203	25	12
	1994	863	416	280	34	10
Production (1000 t)	1990	750	158	57	2	1
	1991	32	6	2	1	0
	1992	222	77	22	4	1
	1993	13	14	5	2	1
	1994	180	85	61	3	1
Grain productivity kg/ha	1990	837	336	382	165	190
	1991	34	19	34	86	38
	1992	215	186	177	191	118
	1993	16	34	25	88	51
	1994	208	204	217	97	91

Source: State Agricultural Department and Revenue Department of Barmer (Rajasthan)

Common rotations found in different rainfed areas in the district are:

1. Pearl millet - fallow (rabi = postrainy season);
2. Pearl millet - fallow (rabi)- mung/moth bean - fallow (rabi);
3. Guar - fallow (rabi) - pearl millet - fallow (rabi).

FARMERS' PREFERENCES FOR PEARL MILLET VARIETIES

At present, farmers in Barmer district grow predominantly local varieties of pearl millet. Initial discussions with farmers revealed that during the mid-seventies a single cross hybrid, BJ 104, was popular in the district. Seed of BJ 104 is no longer produced because this hybrid became susceptible to downy mildew (AICPMIP 1975-91). Farmers are keen to test newly released and advanced experimental varieties under their growing conditions. We selected six villages for on-farm trials in 1994. Four varieties, HHB 67, ICMH 90852, CZ-IC 922 and ERajPop were grown in these villages. Twenty farmers, who were interested in experimentation were selected in each village. Each farmer compared one of the new varieties to his/her own. Thus five farmers in each village tested the same new variety. The on-farm trials were evaluated through group discussions (Weltzien *et al.*, 1995b). Farmers were asked to compare the varieties for traits of importance to them.

At the KVK-farm in Bhadka, 35 km north of Barmer, these same four varieties were grown under two soil fertility treatments. In addition, a demonstration of 16 pearl millet varieties was grown with two replications. At the time of maturity farmers were invited to visit the KVK-farm, and discussions were held to evaluate these varieties. The villages are all villages in which the KVK is active; two are located three to five km west of Barmer (Marudi and Balera), Aati is located 15 km west of Barmer and Bijard is located in the sand dune area on the western border of Barmer district, near Chotan. A total of 42 male farmers from these four villages participated in discussions, on two consecutive days. All these farmers are participating in the KVK activities on a regular basis. Groups of three to five farmers visited the demonstration plot to evaluate the varieties individually. Each farmer's comments on individual varieties was recorded separately. Each farmer was then asked to name the five highest ranked entries. These results were used to arrive at an overall ranking of varieties for each village (Table 4), and ranking of the traits, based on the frequency with which farmers used them for the assessment of individual varieties (Table 5).

Table 4: Highest ranked varieties, based on pooled ranking of individual farmers' choices from a demonstration plot of 16 diverse pearl millet varieties

Rank	Balera/Marudi (8)[1]	Aati (14)	Bijard (20)
1	RCB-IC 911	RCB-IC 911	RCB-IC 911
2	MH 179	MH 179	MH 179
3	CZP-IC 923	CZP-IC 923	RCB-IC 926
4	ICMH 90852	ICMH 90852	CZH-IC 313
5	WRajPop/RCB-IC 926	WRajPop	Local
6	CZP-IC 315	HHB 67	HHB 67
7	CZP-IC 311	ICMP 94881	RCB-IC 924/ CZP-IC 315

[1] Figures in parentheses are number of farmers.

Table 5. Desirable plant traits as mentioned by farmers during variety selection from a demonstration of 16 pearl millet varieties (x times mentioned by one farmer on average)

Desirable traits	Marudi/Balera	Aati	Bijard
No. of farmers	8	14	20
No. of responses	48	40	224
Large panicle size	3.60	1.07	3.00
Large grain size	0.00	0.79	1.85
High tillering	0.00	0.07	1.70
Good seedset	0.38	0.07	0.95
Tall plant height	1.50	0.21	0.60
Low water requirement	0.00	0.00	0.65
Sweet taste	0.00	0.00	0.55

Traits mentioned, but rarely:

Marudi/Balera: Bristles, high grain yield, and suitable for fodder.
Aati: Bristles, high grain yield, strong growth, high stover yields, and tillering.
Bkjard: High grain yield, strong growth, earliness, adaptation to low fertility, thick stems, thin stems, food from tillering, low bird damage, and no diseases.

The farmers who grew experiments on their own farms in Bhadka village were asked to compare the four test varieties and the local varieties grown in their village. To structure the discussions and allow for interaction among farmers, a matrix ranking table (Table 6) was made with the farmers, following the method described by Weltzien R. *et al.*, (1995b). The scientific description of the plant type of the test cultivars is summarized in Table 7.

Table 6. Matrix ranking of four experimental varieties grown by KVK Bhadka in six villages, Barmer district. Summary of farmers' group discussions

	HHB 67	ERajPop	ICMH 90852	CZ-IC 912
Grain yield	1	3	2	4
Grain size	1	3	2	4
Grain color	1	2	3	4
Height	4	3	1	2
Soft stem	2	1	4	3
Fodder qual.	1	2	4	3
Lodging	1	2	3	4
Bird damage	4	1	3	2
Earliness	1	3	2	4
Uniformity	2	4	1	3
Cut hay	2	3	1	4

Other traits mentioned: disease intensity, panicle size, leaf softness, growth

Table 7: Main characteristics of the varieties evaluated by farmers in Barmer district during the rainy season 1994

Variety	Characteristics
HHB 67	extra early single-cross hybrid, bold grain, short panicles, the ability to produce basal tillers regularly, short plant height
ICMH 90852	medium to late maturity, high tillering potential, thin intermediate panicles and medium grain size, topcross hybrid
CZ-IC 922	medium maturing, open-pollinated variety, low tillering potential, medium to large panicles, medium thick stems, medium-tall plant height, medium grain size
ERajPop	early maturing, open-pollinated variety, good tillering potential, including nodal tillers, medium long, thin panicles, small seed size, intermediate plant height
RCB-IC 911	medium maturity, open-pollinated variety, very large grain size, thick compact panicles, low tillering potential
MH 179	late maturing single-cross hybrid, long panicles, low tillering potential, thick stems, medium grain size, bristles, medium-tall plant height
CZP-IC 923	late maturing, open-pollinated variety, long, thick panicles, low tillering potential, tall plant height, large grain size, thick stems
WRajPop	very similar plant type to ERajPop, except that it is later maturing
RCB-IC 926	early-medium maturing, open-pollinated variety, medium tillering potential, short compact panicles, large grain size, medium plant height
RCB-IC 924	very similar to RCB-IC 926, except that it's panicles are longer, but thinner, seed set is less uniform
CZH-IC 313	early maturing, topcross-hybrid, medium-high tillering potential, large grain size, and medium long panicles
CZP-IC 315	medium-late maturing, open-pollinated variety, with high tillering potential, medium-long, thin, compact panicles, with small-medium grain size, and medium plant height
CZP-IC 311	similar plant type as CZP-IC 315, but higher nodal tillering potential, and less compact panicles
ICMP 94881	late maturing, open-pollinated variety, with intermediate tillering potential, tall plant height, intermediate panicle size, grain size
Local variety	very high tillering potential, short and very thin panicles, very small grain size and intermediate plant height

The farmers from the three villages close to Barmer (Marudi, Balera and Aati) chose exactly the same five varieties as the highest ranked (Table 4). For the sixth and seventh ranked varieties, they both chose crosses between varieties with large panicles and local varieties, achieving a balance between panicle size and tillering. This indicates that the farmers from these three villages have similar preferences for specific varietal traits, as supported by the results in Table 5.

The farmers from Bijard village also ranked the RCB-IC 911 and MH 179 first and second but chose higher tillering, earlier maturing varieties for ranks three to seven. They included the local variety as one of the most desirable genotypes, despite the fact that the conditions for crop growth in 1994 were very favorable for later maturing genotypes with large panicles. The remaining four high ranked entries all represent breeding efforts to combine better panicle characteristics and downy mildew resistance with earliness and high tillering capacity. It is interesting to note that the majority of the preferred entries were open-pollinated varieties. There appeared to be no specific preference for uniformity expressed by farmers as no comments were made about this varietal attribute, either positive or negative.

The varietal trait that farmers from all four villages most often mentioned as desirable when comparing varieties was large panicle size (Table 5), which is consistent with the choice of the highest ranked varieties in all cases (Tables 4 and 7). Farmers from the three villages near Barmer further mentioned tall plant height, good seedset and large grain size regularly. The varieties that they ranked highly (Tables 4 and 7) all have these characteristics. Other traits were mentioned only rarely. Generally, these farmers appeared less responsive during this discussion.

Farmers from Bijard responded with more detailed observations. The second most important traits for them were large grain size and tillering, which is well reflected in the choice of high ranked varieties (Tables 4 and 7). Good seed set, tall plant height, low water requirement and sweet taste of the grain were mentioned regularly as desirable. Many other traits were also mentioned, but rarely.

The results from these discussions show that farmers from the drier, more sandy part of Barmer district place more emphasis on high tillering, and two other traits associated with adaptation to low rainfall: good seedset and 'low water requirement' (Table 5). Studies using similar methods in other districts of Rajasthan showed a similar differentiation between preferences from farmers from drier, sandier areas and farmers from other pearl millet growing regions in Rajasthan (Weltzien R. *et al.*, 1995a). There was a very close correspondence between the traits that farmers used to compare varieties and the actual preferred choice of varieties. Thus the ranking of varieties and the analysis of frequencies of traits both give very similar results.

The comparison of the four experimental varieties grown in on-farm trials in Bhadka village showed that these farmers were observing a wide variety of traits (Table 6). Several traits are directly related to stover (fodder) quality, emphasizing its importance in this production system. The farmers' ranking of the individual varieties for traits commonly evaluated are mostly consistent with expectations based on on-station trial results.

It is interesting to note that farmers only rarely mentioned differences in grain or stover yield *per se*, but rather spoke more often of their components, size of grain and panicles, tiller number and plant height. While the two grain yield components are commonly used in pearl millet breeding programs, the two stover yield components, tillering and plant height, are not. If they are used, selection is usually practiced in the opposite direction, for lower tillering capacity and medium to short plant height.

Stover yield itself is used only by some breeders in testing experimental varieties, very rarely in selection, and it is not regularly considered in the legal procedures for varietal release. These results support evidence that fodder yield is a major criterion for the adoption of new cultivars (Kelley *et al.* 1996). The potential for using this trait as a selection criterion should be explored. Fodder quality and grain quality characteristics are also regularly evaluated by farmers and considered important (Tables 5 and 6). Systematic attempts to consider these quality parameters in selection and variety testing by breeders are rare. Farmers in Barmer appear to use a variety of traits that are components of these quality traits, i.e., stem or leaf softness. These can apparently be rated visually and could thus be evaluated easily in a breeding program. It may be worthwhile to try this in on-station experiments in cooperation with specially interested farmers.

Farmers regularly mentioned that their selections were affected. by the favorable climatic conditions of 1994 (rainfall 625 mm). Testing of these cultivars in contrasting years is required before farmers can make a balanced judgment on the usefulness of these varieties for their own farming conditions.

These results are preliminary. More detailed analyses of the diverse factors influencing farmers' choices and preferences are required. The results of these varietal comparisons will be useful in identifying new varieties suitable for farmers in Barmer district, and will also help to focus on-going pearl millet breeding programs in Rajasthan on traits relevant to farmers in the region.

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DISCUSSION

KOTHARI: A question to Dr. Maurya. I am wondering exactly where this participatory exercise is taking place; what have been the results and responses of farmers towards this kind of participatory breeding exercise?

MAURYA: The impact has been excellent around our Narendra Dev University headquarters. Within a 40 km radius, a rainfed area comprising upland, lowland, saline and alkaline situations, more than 50 genotypes are being grown by farmers. For different micro-niches, with different soils and water concerns, farmers have picked out their own varieties. We have given them options; we have not said that this variety is the best or that variety is the best.

However, the problem I want to highlight is that of seed production. Farmers have identified varieties and these may be of local importance. But how can these varieties be notified within the formal release system and how can we get a small seed company to multiply the variety? There is a need to modify the varietal release notification system so that varieties adapted even for small, maybe risk-prone areas, can be taken up by seed companies. But the impact has been very encouraging.

SPERLING: Dr. Dwivedi, might you further explain the term 'genetic soup'? I probably missed something. Does it concern segregating materials that are being subjected to natural selection? You mention some work with farmers. Are they involved in the selection of this diverse material?

DWIVEDI: Regarding the 'genetic soup': when we talk about individual crosses, we are dealing with synthetic landraces, including the bulk populations raised for elongation ability and submergence tolerance. In this case, we used more than one cross in the F3 and F4 generations and we used to mix them together and put them under an abrupt flooding situation where deepwater rice is fast emerging. A similar technique is used with the submergence-tolerant varieties: they are tested under flash flood conditions and only the best survive. The best elongated bulk and submergence tolerant types will automatically be retained in the field.

LOEVINSOHN: Dr. Mishra, you said that, in breeding for problem soils, the breeder has a distinct advantage in being able to define clearly the environment and to identify the optimal responses in the plant. According to M. Choudhary, who is working in collaboration with ICRISAT, in respect to another stress, the drought stress, there was a preference to go for early involvement of farmers in the selection of useful material. Does the difference in these two perspectives reflect something about the nature of the salinity and alkalinity stress? Is this stress something relatively simple and which can benefit from a breeder's relatively precise tools or might there be more space than you grant for farmer participation? Is there a role for farmers' differentiated, area-based understanding?

MISHRA: I said two things in reference to participatory varietal selection and participatory breeding. I have concerns in providing advanced materials, segregating F2 or F3 material to the farmers and giving them more responsibility. Unless you define the environment, suppose the salinity stress is more than 10, it is likely that all your material will vanish, nothing will remain available. So, it means you are losing a lot of your diversity there.

There is another issue. If you look at the [testing] network in India, farmers are supposed to be involved. The problem is that the network system is not working. Government officials are going to the village and they just go to the head of the family or the resourceful farmer. They get a good cup of tea and sitting place. Then they give the variety and bring out the results on paper. There may be some problems here.

If some network could exist, with regular monitoring, maybe with the NGOs, and maybe with the breeders actually involved, there would be interest. That is why ICAR has now asked that, in the coming years, each breeder has to give 20% of his time in the demonstration of on-farm trials. This is because we want farmers' participation. But how much responsibility we should give to farmers so breeders still have accountability has to be discussed. The genetic world is about germplasm and there are examples, like in barley, where a number of fixed lines have been lost because people put them under high stress. Our recommendation is to put them under high stress, moderate and normal stress, so that at one time you will not lose the material. Also, the expression of a variety is different under different levels of stress and you can select the real worth of the material for specific adaptation.

OOSTERHOUT: Dr. Mishra, I am interested to know where the germplasm has came for the salt-tolerant barleys. Is it from the area or is it exotic, and from where?

MISHRA: In India, we collected the indigenous resources for five years; we do not have exotic resources. We evaluated them, started a crossing program, and then advanced some of the material. All of a sudden, because of a serious stress, I was lost. That is why I was explaining this problem in reference to farmers. We have to be very careful. Apart from the hot spots and you also have to grow in modest areas so that you can save the material.

RILEY: In reference to this discussion on stresses, I wanted to share some experiences from Vietnam. Inland, where there is less salinity, there is almost complete less of landraces to the HYVs, while at the coast, where the salinity is higher, landraces are common. And I was wondering to what extent this is similar in India. If you are successful, is there going to be an erosion from the areas of stress. Or do you feel that you will be able to find solutions with the same degree of diversity that presently exists?

MISHRA: For inland salinity, I would say the stress is always more. For coastal salinity, because the inundation by either seawater or a good rain, there is a dilution effect and you can get a crop of rice. In the winter season, when there is no rainfall, salinity goes up to more than EC 20 and you cannot get a crop. For inland salinity in India, we do have tubewell or canal water. So, you can control the salinity stress, but the problem is sodicity... In the inland, saline areas, we have already replaced the traditional lines, so there has been genetic erosion. You can hardly see a local variety anywhere. We have been successful in breeding a variety whose demand this year was up to 21 thousand tons. We cannot cope with the demand for seed. Why the high demand? Because there was a change in government policy and we monitored farmers' reactions.

I would like to discuss further the role of farmers as far as salinity tolerance is concerned. We have a program of adaptive research and we are doing varietal selection, at F5 onwards, in farmers' fields in Uttar Pradesh. This year we have six districts and have already planted the nursery in hot spot areas. We will be planting and transplanting for selection to be done by farmers. But I believe that farmers should only be involved at the advanced stage. If we give them F2 or F3 generations, without good linkages, without some technical support or government literate laborers or supervisors, we will not be able to select the real material....

As for farmers' choices, they have selected some of the best varieties: the Thailand or the Basmati of India. The same is true of the quality of rice in the Philippines and in Pakistan. Nobody can replace these varieties. We have had a lot of good labs and people working on them, the cream of scientists over the years. Till today, nothing better has come up.

MAURYA: Dr. Mishra is again talking about a unilateral approach. It is not as if farmers alone will be making the decisions: breeders are also there, working together. Participatory approaches should go on at the F4, F5, F6 stages. F2 is the individual plant and the F3 population is too small. Our bulk breeding material can be exposed over large areas. I see no problem sharing this with the farmers.

STHAPIT: I want to make a point about our experience with stress work. It is much easier to get participation from farmers in stress situations. Farmers living in stress situations feel their problem is more acute. The breeder has the key role up to the F3 or F4 stage. After that, farmers' participation needs to be greater.

LOEVINSOHN: Dr. Sthapit, you said that there was good agreement between farmers' and breeders' criteria yet there was a distinction between the varieties selected. Could you explain?

STHAPIT: At the first stage there was good agreement between farmers and breeders for this particular location. But there are different stages at which farmers do selection and the women, particularly, told us they wanted to see the milling, eating and cooking qualities. After this latter evaluation, we found that their choices had changed: M-7 was dropped because of a poor milling percentage and M-6 was dropped because of a peculiar smell.

SEEDBANKING AND SEED SUPPLY SYSTEMS: ENSURING ACCESS TO NEEDED SEEDS

THE ACADEMY OF DEVELOPMENT SCIENCES RICE PROJECT: NEED FOR DECENTRALIZED COMMUNITY GENEBANKS TO STRENGTHEN ON-FARM CONSERVATION

R. Khedkar

ABSTRACT

India is a center of diversity for rice. This finds an expression in the thousands of indigenous cultivars grown in different parts of the country. This invaluable genetic resource has been safeguarded by farmers over centuries. The past few decades have seen serious genetic erosion in the rice crop as hundreds of indigenous cultivars have been discarded in favor of a few 'improved' varieties. The present concern to promote on-farm conservation stems from the threat to the survival of indigenous varieties. Establishment of regional, national and international genebanks has not served to strengthen on-farm conservation initiatives because the accent has been on mere collection and storage of varieties. Efforts are not being made to realistically assess the performance of indigenous varieties or to distribute seed to farmers.

The Academy of Development Sciences (ADS) Rice Project is trying to promote on-farm conservation through the establishment of decentralized 'rural' genebanks at the community level. These genebanks serve to improve the availability of seeds of indigenous varieties to farmers, besides playing an important role in the mapping and realistic evaluation of different varieties. Work on the conservation of rice varieties at ADS was initiated seven years ago under the guidance of Dr. R.H. Richharia. A genebank of rice cultivars from the Konkan region of Maharashtra has been established and efforts are being made to safeguard the long-term conservation of these varieties whilst taking the present production needs into consideration.

The ADS Rice Project serves to demonstrate some possibilities for setting up decentralized genebanks for various crops at the village level and dispels the myth that management of genebanks can be undertaken only by 'formally' trained manpower. ADS organizes periodic training camps for farmers and organizations to create awareness about the need to conserve genetic resources on-farm and to demonstrate the methodology of setting up a farmer's genebank.

PREAMBLE

India is a center of diversity for rice. This finds an expression in the thousands of indigenous cultivars grown in different parts of the country. Indian farmers have acted as custodians of this priceless heritage over centuries.

Survival of the indigenous cultivars was jeopardized with the advent of the Green Revolution in the 1960s. A wide range of indigenous cultivars being cultivated in each rice-growing region were replaced by a handful of genetically-uniform, semi-dwarf hybrid varieties. In the process, several indigenous cultivars have been irretrievably lost. The loss of indigenous cultivars has resulted in serious genetic erosion in the rice crop.

So far, the response to the crisis has been to collect and conserve small samples of indigenous cultivars in cold storage genebanks. Genebanks have been established at the regional, national and international level to cater to different crops or ecosystems. The accent of these genebanks has mainly been on collection and storage of the genetic variability of their mandate crops, with some accessions being used for breeding work by scientists from the public or private breeding sector. Efforts are not being made to access realistically the performance of indigenous varieties or to distribute seeds to farmers.

A common farmer generally does not have easy access to the varieties stored in the genebank. Most farmers may not even be aware about the existence of such genebanks. In a sense, a valuable public resource is going beyond the reach of the common man. In view of the impending General Agreement on Tariffs and Trade (GATT) regime, which has provisions for monopoly control by individuals or private companies over seeds and other biological materials, it is not at all desirable that an important public resource be allowed to be controlled solely by government or private agencies. The need to conserve indigenous rice varieties at the community level should be viewed in this context.

NEED TO PROMOTE ON-FARM CONSERVATION

On-farm conservation should secure location-specific conservation, besides ensuring people's control over natural resources. There is a need to make available a wider choice of varieties to farmers, without any bias about high-yielding varieties (HYVs) or traditional varieties. Similarly, farmers should be involved in decisions relating to the selection and breeding of varieties.

THE ADS RICE PROJECT

The ADS project on rice is trying to address these issues and, in so doing, it has demonstrated some possibilities for setting up decentralized genebanks at the community level. The ADS project on conservation of indigenous rice varieties draws inspiration from the pioneering efforts of Dr.R.H.Richharia.

To begin with, a survey of the Karjat Tribal Block (KTB) was undertaken to study the status of rice cultivation in this 'micro' region and to understand the preferences, priorities and problems of farmers in terms of cultivars. The survey revealed that cultivation of most of the indigenous varieties was given up following the introduction of HYVs. A set of 10-15 indigenous cultivars was replaced by two major HYVs: *Ratna* and *Jaya*. The KTB could thus be considered a case study indicative of the trend and extent of genetic erosion in the rice crop in India.

This prompted us to undertake a survey of the whole Konkan region in order to gain a better perspective on the status of rice cultivation in this agro-climatic zone. The situation was more or less similar in all parts: a wide range of indigenous cultivars were replaced by handful of HYVs. On the other hand, yields of HYVs were stagnating, despite increases in expensive external inputs like chemical fertilizers, pesticides, herbicides, etc., and soil fertility was also declining. Cultivation of monocultures with a narrow genetic base over wide areas and intensive cropping patterns had provided ideal conditions for the proliferation of pests and diseases. Risk of epidemics has, in turn, lead to ever increasing consumption of chemical pesticides. All these factors have been leading to increases in cultivation costs without parallel increases in incomes. Rice cultivation has thus become no longer economically viable.

Faced with such realities, many farmers expressed a desire to revert back to the cultivation of indigenous varieties. But by this time, seeds of most of the indigenous cultivars were simply not available. A need was thus felt to improve the availability of seeds of indigenous varieties. The first step was to conduct a systematic survey of the status of rice genetic diversity existing in the region and to begin collection of indigenous varieties from different parts.

SEED COLLECTION TOURS

We began our efforts by visiting farmers in the four districts of Konkan: Thane, Raigad, Ratnagiri and Sindhudurg. There were informal meetings with groups of farmers in villages to understand their views and priorities about different varieties. Request for seed samples of indigenous varieties for the purpose of conservation and multiplication were always considered favorably. The concerned farmer would take us to his/her field to show the variety being cultivated. The farmer would narrate his/her experiences with that particular variety.

The seed collection tours helped us to understand a great deal about individual cultivars and rice cultivation practices in different areas. The tours were organized during rice harvesting seasons. We would stop in villages and ask farmers about the 'old' varieties which were being cultivated in earlier days. We would invariably get a list of 10-15 varieties. We would then ask the farmers if these varieties were still available. That would lead us to names of farmers in nearby villages who 'would' know more about these varieties. Of the ten farmers we would meet, eight would tell us that they had abandoned the varieties a few years ago. One or two farmers, however, would present us with the gift of strange looking varieties. We often had to walk several kilometers to collect a single variety and quite often the search would be futile because the farmer had abandoned the variety. This was slow and patient work.

THE FIELD GENEBANK AND SEEDBANK

Seeds thus collected were brought back to ADS, property catalogued and stored in paper envelopes in the seedbank. The varieties were then shown in the field in small plots. Seeds of 20 varieties were collected in the first year and thus began our work on the conservation of indigenous rice varieties. A people's genebank was taking shape in the Karjat Tribal Block.

Over the years, we have collected more than 250 indigenous cultivars from the Konkan region. The seeds are maintained in the ADS field genebank and seedbank. Each variety is characterized based on morphological and agronomic parameters.

UNDERSTANDING NEEDS OF FARMERS

From the third year onwards, we began interactions with farmers and organizations. Farmers are invited to the ADS field genebank during the rice season and we note down their request for seed of different varieties. Based on the demands from farmers, we multiply seeds of different varieties in larger quantities and distribute these to farmers in one to two kilo cloth bags.

SEED DISTRIBUTION CAMPS

Seed distribution camps for farmers are organized during April and May. Seeds of different indigenous varieties are distributed to farmers in one to two kilo cloth bags. Farmers are asked to return one and a half to two times the quantity of seed to ADS or give it to some other farmer in a nearby village.

The seed distribution camps began attracting more and more farmers as the years went by. By the summer of 1995, we had distributed seeds of nearly 60 indigenous varieties to more than 1000 farmers. We noticed that there was spontaneous 'informal' exchange among the farmers. Genetic diversity of rice in this region was being restored as more and more indigenous varieties came back into cultivation. The ADS genebank thus served a long 'felt' need of farmers for seeds of indigenous varieties and helped promote on-farm conservation.

TRAINING AND EDUCATION CAMPS

ADS then began organizing training and education camps for non-governmental organizations (NGOs) from other rice-growing regions of India. The objective has been to create awareness about the need to conserve indigenous varieties of crops at the community level and to demonstrate the methodology for setting up a community genebank. About 30 groups have so far participated in these camps. Some groups have also started work along these lines. These groups are, in turn, encouraging smaller groups and farmers within their regions to initiate similar efforts. In a sense, the ADS project has set off a chain reaction which has country-wide ramifications.

EVALUATING INDIGENOUS VARIETIES

ADS is systematically evaluating the performance of some indigenous varieties which are commonly cultivated in the Konkan region. This exercise demonstrates the fact that 'yield' is not the only criterion used by farmers while selecting varieties for cultivation in their fields. Apart from yield, factors like duration, medicinal properties, nutritional characteristics, eating preferences, religious and cultural factors, pest/disease resistance, market demand, ability to withstand drought, processing and milling characteristics, other features like aroma, etc. are generally considered while selecting any variety. Realistic evaluation of any indigenous variety along several parameters is necessary to understand its true worth.

THE STAFF

An important aspect of the ADS rice project is the fact that all activities-- from seed collection, documentation and maintenance of genebank, to characterization of cultivars--- are being carried out by farmers, with some orientation and help from experts. The ADS project demonstrates the possibility for setting up a genebank at the community level. The work serves to dispel the popular notion that a 'genebank' is a 'high tech' and 'sophisticated' place managed by highly qualified and formally trained manpower.

The ADS project will continue to encourage and facilitate the establishment of decentralized genebanks of local crops at the community level to strengthen on-farm conservation initiatives.

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NAYAKRISHI ANDOLON: AN INITIATIVE OF THE BANGLADESH PEASANTS FOR A BETTER LIVING

F. Mazhar

ABSTRACT

The Nayakrishi practice of ecological agriculture has its own unique philosophy and design. Nayakrishi Andolon is not a "project" that is being executed by UBINIG[1]. 'Andolon' means movement. It is a movement of farmers growing from the grassroots: to ensure that the living environment is free from toxic and unwanted chemicals; to promote the conservation and regeneration of seeds so as to protect and enhance biodiversity and genetic resources; to resist dispossession and centralization of natural resources through centralized structures such as 'seedbanks' and/or 'genebanks' (which exclude farmers from having access to the common property of the community); to search for alternative methods and institutions for the conservation of biodiversity and genetic resources on-farm through structures controlled by the community/ village; to ensure food security and nutrition; to search for agricultural practices that can conserve other life forms, mainly endangered species; and to become culturally aware of the intricate role played by all those species of nature that are not the object of immediate human needs.

There are more than 2000 farmers all over Bangladesh engaged in Nayakrishi agriculture. The number has been rapidly increasing since the recent fertilizer crisis, where farmers dependent on chemical fertilizers could not cultivate crops. There are already eight villages in Tangail that are known to farmers as 'Nayakrishi villages'. These are villages where at least 70% of the farmers have stopped using pesticides, chemicals fertilizers, and ground water for irrigation.

This paper will draw lessons from the experience of the Nayakrishi Andolon, where UBINIG is playing an inspirational role and serving as a source of alternative information for farmers. The agricultural policy environment of the Bangladesh Government will form the context in which to better understand the policy implications of some of the ideas of farmers who are working to counter genetic erosion and the loss of biodiversity.

In particular, the paper will focus on the following themes:

- *Highlighting the seed conservation and regeneration practices within the broad movement of Nayakrishi Andolon. How farmers are perceiving Intellectual Property Rights in a Post-Uruguay political and economic environment.*

- *Some of the specific issues related to biodiversity and genetic resource conservation in a floodplain agro-ecological system and the disastrous consequences of embankments.*

- *Why farmers think maintenance of genetic resources on-farm is the only way to ensure their control and access to the natural wealth. Why they revoke and defend the traditional concept, right and cultural norms of 'common property'.*

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[1] UBINIG (Policy Research for Development Alternative) is a research and policy advocacy organization. The major areas of activities include environment and agriculture, handloom and rural industrialization, health and population, toxic trade, trade union issues, etc.

- *What debates farmers are having among themselves with regard to an institutionalized seedbank or genebank. Can it be accepted as a back-up in case farm-level preservation fails?*

- *Whether nature should be allowed to destroy, change, transform biodiversity and genetic resources. Are biodiversity and genetic resources 'static' phenomena? Is it true that the 'conservation' mentality is either a romanticized view of the non-agricultural class who are not directly related to nature or a corporate view to collect genetic resources for economic profit?*

- *Why farmers claim that 'conservation' is a new term for centralized control by the corporations and the state when it is not a 'living' conservation immediately related to the living agricultural practices of the farmers.*

A FEW WORDS ON "ANANDA"

The *Nayakrishi*, or the new way to relate productively with nature, is essentially an *andolon* or movement of the farmers of Bangladesh to produce healthy food, a healthy environment and a happy life. In its simplest expression, it is an act of *ananda*, a happy way to relate with nature and enjoy life. It is production, distribution and consumption of happiness among and within the members of the world of human and non-human beings, both organic and inorganic. Why do you practice *Nayakrishi*? The response from the farmers is: "I want to be happy, that's all!" It must be granted that the search for *ananda* or happiness is the most sensuous yearning that couples both material and cultural desire. Apart from such objectives, where material and cultural desire are not separate, there is no other transcendental or teleological intention of *Nayakrishi*. Consequently, *Nayakrishi* is conscious of the value of the subjective and qualitative appreciation of farmers' life activities, in addition to the quantitative and objective evaluation.

Nayakrishi did not start with any pretension of practicing fancy 'ecological agriculture' as a show case, or any variety of the so-called 'sustainable agriculture' approaches, a new apology to continue business as usual in the agricultural sector. The *Nayakrishi Andolon* developed as a response against the overwhelming promotion and practice of chemical agriculture in Bangladesh and the erosion of community power in the face of encroaching and centralizing forces beyond the control of the peasantry. It is a practical response of farmers against the destruction of environment and the consequent loss of their means of livelihood. The economic, social and political processes of dispossession and disempowerment, privatization of natural resources and the consequent erosion of common property rights and privileges, loss of seeds and genetic resources and, above all, the increasing perception of insecurity of food and productive resources are the major factors precipitating a deep sense of displacement among the rural communities in Bangladesh. Discontentment is manifested through various social forms of protest and resistance. The *Nayakrishi Andolon* is an exercise in productive and positive engagement with the dynamic realities of life to regenerate visions and practical means for a new and happy community.

UBINIG is mainly playing a role as an information source, an interpreter into popular language of the available knowledge from science or other discourses. Together with UBINIG, farmers test new ideas in practical ways , to see if they are capable of responding to the crisis of their daily struggle. It is a collective, reflective and critical role, because immense care is taken not to suppress the popular wisdom of the peasants in the name of the so-called 'science', while at the same time not to romanticize peasant life and peasant 'knowledge'. In essence, our actions aim for critical appropriation of both 'science' and 'traditional knowledge'. In addition, UBINIG carries out the secretarial tasks of documenting and preserving the valuable information constantly being generated by such interactions at the grassroots level.

In the context of the profit-based organization of society and knowledge systems connected to the global market, the experiential knowledge of the peasantry is given privilege and priority against the 'laboratory' knowledge of empirical modern discourse. UBINIG defends the values of the subsistence life activities of peasantry, not because that they are ideal or free from contradictions, but mainly to rebuild the power of living experience over the formalized, dry, and highly institutionalized systems of thought that are inherently suppressive and intolerant to opposing modes of thought.

NAYAKRISHI FARMERS: PERCEPTIONS, IDEAS AND ACTIONS

There are more than 2000 farmers who are practicing *Nayakrishi*. Most of them are in the district of Tangail. In recent months, farmers from other districts have been contacting UBINIG, as well as the *Nayakrishi* farmers, for information and training. UBINIG has been working in Tangail since 1986 among the weavers. After the flood of 1988, we got involved with these farmers. Our involvement included disaster relief and support to farmers in the form of seed and credits. During this period, we became acutely aware of the crisis for seed, in particular, and of the perception of farmers that there was a general crisis in agriculture. To get a more comprehensive understanding of how farmers perceive chemical agriculture, we undertook a study. A wealth of information was collected.

The salient points raised by the farmers in the course of their evaluation of the existing agricultural practices are the following. We tried to understand them in the order of significance farmers give to each of them:

a. The fertility of the soil is clearly declining.

b. The health situation is terrible, with the strongest opposition against chemical agriculture coming from women. Without fail, each and every peasant woman complained about her health and the health of her children. This is also the reason why women are the natural leaders in the *Nayakrishi Andolon*. It is not for any fancy 'ecological' issue, but precisely because of the painful suffering she and her family members are going through, caused mainly by pesticides. She can experience the change in the chemistry of the environment by her own body. The desperate necessity to overcome the disease and sufferings caused by pesticides and chemicals was the single most important reason of the initial success of the *Nayakrishi Andolan*.

c. The fish populations are declining in the water bodies and ponds, in quantity as well as in diversity. Most of the familiar local varieties of fishes have disappeared. The frog population has also declined alarmingly. Farmers don't even notice leeches in the water anymore.

d. The pest attacks in the field are more widespread and intense. Most of the pests are new. Old farmers claimed they had never before seen many of the pests now encountered in their fields. The government agricultural extension workers are not capable of solving the problems of these farmers.

e. There is a general decline in livestock and poultry. The reason is not economic poverty, but the poverty of biomass production caused by high yielding varieties (HYVs) rice. The local varieties were the main source of fodder. In the absence of local varieties, straws from the International Rice Research Institute (IRRI) varieties of rice have failed to meet livestock needs.

f. The total income of the family has declined, both in economic value and in terms of returns from agricultural activities. Whenever we made calculations of the benefits gained from HYV varieties, farmers were able to distinguish between the calculation of the productivity and income on the basis of a single crop and the total income of a farming family. Farmers felt that they have been cheated by scientists, agricultural extension workers and the government. Simply, a 'high yielding' variety does not mean a 'higher' income for the farming household.

g. There are fewer birds, and very few bees, butterflies and insects. While the fruit trees come into flowering during the season, the quantity of fruit harvested is very low, and, in some seasons, almost nil.

h. There is a general decline in nutrition, mainly because farmers are not producing pulses and oilseeds in the face of an overwhelming HYV cultivation.

The above farmer perceptions drove them to search for new ways of food production. Initially, the peasant women took the lead in stopping the use of pesticide. This experience was extremely important for UBINIG. Soon a group of farmers organized and started to experiment with green manure and compost. The compost, made mainly of a water-hyacinth biomass, became quite popular. Water hyacinth is plentiful in the wet seasons. This was the first breakthrough in the sense that the initial group of farmers became convinced that they did not need to depend on pesticide and chemical fertilizers. As their experience and confidence grew, these farmers developed a set of general principles for the production of food.

a. Absolutely no use of pesticides, chemical fertilizers or ground water.

b. Farmers who are new in the *andolon* must learn from other farmers to use green manure or the art of making compost. Many different methods of compost-making and biomass sources were tested by farmers. Continuous research is ongoing and a wealth of knowledge has already been accumulated. Farmers have also been able to make compost for fish feed.

c. Farmers with long experience in the movement now know that bringing fertilizer (organic, or inorganic) from outside the farm field is not the only, or the best way to remedy the soil fertility crisis. They are aware that 'external' application of inputs is a hangover from the old habits of chemical agriculture. Farmers are constantly trying new ways to increase the fertility of their soil, without 'external' inputs. Their ingenuity rests on their recognition that soil becomes alive if given proper care.

d. Nitrogen-fixing species of plants and trees are becoming familiar, and farmers are eager to experiment with new species.

e. Multicropping, intercropping, mixed cropping, agroforestry and other familiar methods are used to retain and enhance soil fertility. Nevertheless, more and more farmers are convinced that the best method for pest management is conservation and constant regeneration of biodiversity. The practice of *misra fashal* or 'multicropping' has become popular mainly for pest management and maintenance of the health of the soil.

f. Livestock, poultry, and semi-domesticated birds are seen as a part of the farm land. Farmers are relearning to calculate the total yield of the farm, not the quantitative productivity of a single crop.

g. Emphasis is placed on the production of fuel wood, fruit trees along with rice and vegetable fields. The combination of rice-duck, fish-duck or triple combination of rice, fish and duck are seen as potential ideas. Some of the new breakthroughs have come from the more innovative farmers. For example, the cultivation of catfish and water aram, which has proved to be very profitable. Farmers have developed a keen interest in observing and studying the ecology of fresh water bodies and ponds to integrate into the farm's environment.

h. Among the fish varieties, local species are given priority. The economic advantage of a specific habitat is emphasized.

i. Local poultry is preferred, because it is more profitable in a *Nayakrishi* farm: less intensive care, no need for external supply of feed, and virtually no disease. There is always plenty of feed for chicken in *Nayakrishi* households. A 50 decimal land with homestead and an adjacent rice/vegetable field can raise 300 to 500 chickens. The best time is the rainy season, when there is not much to do in the agricultural field. The idea that imported varieties of chickens should remain confined has been questioned as, on some farms, they are being raised in the open, along with local species.

j. Raising local species of livestock in a *Nayakrishi* farm has been easy and profitable. In a one and half acre of farm, at least 20 cows are being raised, without bringing or buying any 'external' fodder. *Nayakrishi* farmers are critical of artificial insemination for moral and cultural reasons, but they are not against cross-breeding. The concept of 'pure' breed is criticized for the assumption that life is not evolutionary and does not undergo change. Similarly there is no hangover or romanticization over 'pure' local varieties of seed or plant. Farmers are aware that at least four out of ten useful plant species came to Bangladesh from other geographical regions and are doing quite well.

THE ACTIVITIES OF *NAYAKRISHI* CENTERS

UBINIG runs two centers at Bishnupur and Gadtala Rupshi villages in the District of Tangail under Pathrail Union. Another center is located in the coastal district of Cox's Bazar, in the Badarkhali. Two other centers have been planned this year, for Noakhali, a southern district, and for Kushtia, in the north.

The centers organize training and conduct research. UBINIG coordinates the task whereby experienced *Nayakrishi* farmers train new members. UBINIG produces the training material. From our experience, we have learned that certain general assumptions with regard to training materials did not hold for the training of farmers. For example, oral and anecdotal sharing of experience and dissemination of information proved to be more intense and had longer-term impact than audiovisuals. This is despite the fact that farmers like audiovisuals.

The Bishnupur center provides space for training, with accommodation for farmers and non-governmental organization (NGO) workers assisting the farmers, who come from different places of the country. All centers have two to three acres of farm land, which are used for research and experiments and kept as a source of seed, healthy livestock, and poultry for the villagers-- <u>not</u> to demonstrate 'model' activity .

The backbone of the *Nayakrishi* farmers' network are the *'gram karmi'* or the village workers. *Nayakrishi* activities are led by experienced *Nayakrishi* farmers in 2 thanas, 6 unions and 31 villages. For close monitoring, information collection and documentation, 1387 farming families in Tangail are in direct contact with UBINIG. New additions since last June 1994 total 617 families. In the last few months, more farmers from the northern and southern districts have also been linked directly.

Every year, an agricultural exhibition is organized in Tangail in which thousands of farmers participate. The *adhunik* farmers also take part. It becomes an excellent event for debates and sharing information between the two major approaches to agriculture and agricultural life.

WHO ARE THE FARMERS OF *NAYAKRISHI*?

It is important to note the categories of farmers who are joining the *Nayakrishi* farming. During the period July to December 1994, the number of farmers joining the *Nayakrishi* project increased significantly. The socioeconomic classification of the farmers for the period of January to June 1994 revealed the following:

Poor farmers having land of	less than 1 acre	:	617	(80%)
Middle farmers having land of	1-3 acres	:	130	(17%)
Surplus farmers having land of	3-5 acres	:	23	(3%)

Poorer farmers are more numerous in the *Nayakrish Andolon* mainly for economic reasons. The prices of chemical fertilizer and pesticides have increased significantly, and more fertilizers are required to get the same return as that of the previous season. There are cases where poor farmers have been forced to sell land because they have not been able to cultivate anymore due to shortage of cash. It is particularly this group of poor farmers who are attracted to *Nayakrishi*.

However, during the months of July to December 1994, in the span of a six- month period, there have been clear trends of change. More of the middle-range farmers with marketable surplus have joined the *Andolon*. If we compare with the figures in June, of the total farmers joining *Nayakrishi* was 17% for middle farmers and 3% surplus farmers. This has increased to 18% and 5% respectively. The increase in the number is (from 130 to 250, i.e. 92%) for middle farmers and (from 23 to 69 farmers i.e. 200%). While the poor farmers are primarily joining to meet mere subsistence needs, the middle and surplus farmers have acknowledged the economic viability of the farming system as a whole. They have also realized the environmental hazards and the loss of biodiversity due to the use of chemicals and the overwhelming practice of monoculture. One of the reasons for the late response of the middle and surplus farmers is that they are more conscious to avoid direct contact with mud and dirt while cultivating. The modern agricultural practice has created an impression of 'white-collar' farming which enables them to wear watches, and sandals and to avoid mud on their bodies. Compost-making therefore did not initially attract them. Up to now, surplus farmers have been buying compost from the poor farmers to use in their own fields.

The most memorable events for the farmers were those in Goaria and Hinganagar villages when two deep tube wells stopped operating because the farmers no longer needed the ground water for irrigation. Their technique of maintaining enough moisture in the soil had been developed by trial and error over the years--as had the choice of an appropriate cropping pattern to ensure higher productivity and income on slightly raised land. Farmers use both plain and live mulching, and land is never left without cover.

LAND USE PATTERN OF *NAYAKRISHI* FARMERS

The statistics below are only from those farmers whom we can monitor more directly. The total land owned by the 1387 farmers is 1919.27 acres. Out of this, 748.50 acres are being used for *Nayakrishi* practices, amounting to 39% of the total land owned by *Nayakrishi* farmers. In these tracts, there is absolutely no use of pesticides, chemical fertilizers or ground water irrigation.

In the rest of the land, there is no use of pesticides, and the use of chemical fertilizer is relatively lower than with the '*adhunik*' or 'modern' farmers[2]. The *Nayakrishi* farmers are strictly against pesticides. Chemical fertilizers are discouraged in principle, but there has been a slow and gradual decrease in its use in practice. In the case of some degraded land, it will require a long period to activate the soil. In such cases, productivity would fall drastically without specific fertilizer use.

The location of the farm land is a critical. Land located far from the homestead and in the middle of the farms of *adhunik* farmers is difficult to bring under *Nayakrishi* practice. In a flood-plain lowland area, the management of the soil fertility requires collective efforts and hard work. The recent fertilizer crisis has created interest among the *adhunik* farmers in the *Nayakrishi* method.

Out of 38 villages in Tangail where *Nayakrishi* farming is being practiced, 12 villages are already known to the farmers as *Nayakrishi Gram* or *Nayakrishi* village. In these villages, at least 65% of the cultivable land has been brought under *Nayakrishi*: no pesticides, no chemical fertilizers, no ground water irrigation.

Among the 1387 farming families, the practice of the kitchen gardening has widened and intensified. Apart from the need for family consumption, there is a growing market for *Nayakrishi* products. In small village bazaars, a portion of consumers prefers vegetables from *Nayakrishi* farmers, due to superior taste, quality, as well as health reasons. These products are sold at a slightly higher price in the village. Farmers can get a good value if the products are brought to Tangail town. The kitchen gardening is done strictly by *Nayakrishi* methods. No chemical fertilizer or pesticide is used for growing vegetables. Some families have had success in economic terms from home-gardening work.

SEED AND GENETIC RESOURCE CONSERVATION

Peasant women are the natural leaders of *Nayakrishi*. They started the movement by taking a strong position against all forms of pesticides. After their initial success, these women were the first to organize themselves around the seed issue. The reasons are interesting and educative.

In central discussions with peasant women, it has come out strongly that the loss of seeds from the household also meant the loss of power for women. In the agrarian culture, it is the woman who conserves, preserves, and germinates seeds. This involves highly intricate knowledge, which is transmitted from mothers to daughters, from sisters to sisters, from mothers-in-law to the daughters-in-law, or from one village sister to another. Unless one is familiar with the delicate

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2 While '*Adhunik*' literally means modern, *Nayakrishi* farmers do not consider '*adhunik*' farmers as 'progressive', although terms like 'modern', 'modernity', 'modernization' etc. are normally associated with 'progress'. To the *Nayakrishi* farmers '*adhunik*' farming means conventional farming in contradistinction to 'traditional' farming. *Nayakrishi*, on the other hand, is neither 'conventional', nor 'traditional'. Literally *Nayakrishi* means "new agriculture".

wisdom of seed conservation and propagation, it is hard even to guess why some seeds should be dried under bright sun, and others under shade. Among the germination techniques, some seeds are left overnight in the atmospheric moisture. Once such knowledge sharing started among peasant women, they decided to recollect their science in a more systematic manner. They asked us to document their seed practices, many now gone due to the availability of HYV seeds on the market. A separate study is being conducted under the guidance of the peasant women.

Dependence of the farmers on the market for seeds also means the displacement of women from the control of a crucial technology, the heart of agriculture. Once women have lost that control, they have become disempowered and felt dispossessed. It should be remembered that women do not generally possess land, and that possession of seed is therefore crucial to women's ability to assert their positive and powerful role in agrarian culture. Loss of seed has made women redundant and powerless.

Peasant women started to build their '*veez-sampad*' or 'seed-wealth'. The concept is strongly opposite to concepts like 'seedbanks' or 'genebanks'. Peasant women are against any centralization of seed wealth in the form of a 'bank'. The principles of seed collection, conservation, preservation and regeneration are the following.

a. Women must regain control over seeds and the associated art. Seeds should be preserved at the household level. This should be maintained strictly for seeds that are common and that are generally used in the village.

b. For specialized seeds, or seeds that are not considered economically-valuable to the villagers in immediate terms, a specialized women's network should be organized. Village women should know who is expert on what, and who is preserving which special seeds. This network will work as breeders generally work and will conduct investigations to learn more about a particular variety. Interaction will take place within and between villages, among the seed network members. Men can also be members of such a network, but a separate men's network may be preferable due to past, bitter experience. It is a constant struggle for peasant women to assert their voices in the *Nayakrishi* network. Information on seeds and their collections cannot be shared with any "unknown" persons or agencies, without the consent of the group.

c. UBINIG will operate a community seed wealth center in an initial experiment where *Nayakrishi* farmers can exchange seeds at no cost. UBINIG will mainly collect indigenous seeds from all over Bangladesh, and will help farmers to test them. UBINIG will have to fill the gap in areas where the community fails to maintain their biodiversity.

d. The community seeds wealth center will be based on the experience of women in seed preservation and germination. UBINIG may learn new techniques, but the priority of the first years will be on gathering the popular knowledge of peasant women and putting their insights into practice.

e. All *gram karmi* or village workers must maintain a nursery. In every village nursery, activities are to be done on a regular basis. *Nayakrishi gram karmis* will be helped to sell their seeds and saplings, from which a part of their income should come. Similarly, seed women should be supported from the income derived from selling seeds by all *Nayarkishi* farmers in the village so that they can have economic support to continue their work.

The community seed wealth center uses earthen pots for preserving seeds. Study is continuing on the preservation problems of a normal peasant household. The seeds are kept in a place not different from a farmer's house. The impact of the weather is being observed closely, and as are appropriate, standardized drying methods for long-term preservation. Research priorities are determined by the needs of the seed network.

As an example, we describe one of the procedures for collecting and preserving some of the common seeds of rice, pulses, sesame, kaon, wheat. etc: After collecting good seeds from a well-maintained source, the seeds are cleaned by hand, removing dirt and degradable organic matter. The seeds are dried under bright sun for at least five to six days. To test if they are properly dried, the experienced peasant woman may bite the seeds between her teeth. This is in addition to her physical observations. Dried seeds are kept in a cool place and the seeds are then poured into a *kalash*, an earthen pot. Dry sands are placed on top of the pot and the mouth is sealed with clay. The prepared pots are kept in a shaded and cool place. Vegetable seeds sometimes are kept in colored glass bottles.

The community seeds center has already collected and reintroduced 27 varieties of local paddy. Our experience has been varied, but farmers particularly like the species that are cultivated in the *aman* season. More research is necessary to evaluate the different indigenous varieties. Side by side our experiments in conservation, we are comparing the performance of local and HYV seed.

The *Nayakrishi* farmers are not against the 'high yielding' varieties offered by the formal sector, as long as they can collect and preserve the seed. They are willing to try new seeds from the laboratory, as long as they do not require pesticides, chemicals and irrigated water. They are strongly against hybrids. There have been quite positive results in using 'high yielding' varieties without chemicals. However, to get profitable results in the *boro* season, irrigation is required. The local varieties are preferred by those farmers who also own livestock. The 'HYV' seeds that can be cultivated in a *Nayakrishi* way are playing a key role in the transition from the *adhunik* to the *Nayakrishi* system of cultivation. The trend is towards a pattern that is best suited to a 'farm' in its totality-- with livestock, birds and fish-- and incorporating its own seed preservation. A farmer in need of more biomass as fodder and fuel prefers the local variety and shows keen interest in reintroducing the old variety--which previously may have disappeared from the area. The main objection of experienced *Nayakrishi* farmers to HYV seeds is the difficulty in their preservation. The women's seed network is against HYV mainly because they feel that these seeds cannot be kept for long under normal household conditions.

COMPARISON OF PRODUCTIVITY AND ECONOMIC RETURNS

The major economic challenge of the *Nayakrishi* farmers is to turn their single crop rice field into a mixed cropping system, where feasible. This is an ecological challenge as well. The single crop *Nayakrishi* rice fields are competitive with HYV fields mainly because chemical inputs are not used-- a substantial saving. In terms of quantitative productivity, the initial return is less in *Nayakrishi*, although farmers perceive an improvement in soil condition and a decline in environmental damage. Nevertheless, less immediate output is a factor for poor farmers.

Abdur Rahim, an *adhunik* farmer cultivating HYV varieties in Tangail, calculated that his 'profit' for the whole year from a 150 decimal flood plain lowland was Taka 25,322/- over and above his 'total costs' of Taka 19,970/=[3]. He calculations were based on returns from BR-11 in *aman* season (August-December, 1993) and BR-2 in *boro* season (January-April 1994). The output was 20 kg during *aman* per decimal and close to 19 kg during *boro*. The calculation's do not include his time and cost of management, but do note the time he employed in plowing and weeding. The profit includes the value of straw (Taka 7,800/=). Rahim is a representative case from the *Nayakrishi* area, a good farmer who still considers *adhunik* farming to be more profitable than *Nayakrishi*. He spent Taka 5670/= on pesticides and fertilizers.

Let us compare his performance with that of Khasru Mian, a *Nayakrishi* farmer who tried both HYV seed and local varieties in the consecutive years of 1993 and 1994. In 1993, he cultivated Biplab (BR-3), a HYV *aman* variety, and Mala or BR-2 in the *boro* season. He did not use chemical fertilizers or pesticides, but did use a large quantity of compost, more or less 15 kg per decimal. Khasru Mian produced 17.5 kg of Biplab per decimal and slightly over 16 kg of Mala per decimal. His total cost was Taka 15,400/= and the profit was Taka 26,650/= over and above the cost. The costs of the compost, weeding and harvesting included his own labor efforts. The includes the value of the straw which was Taka 11,700/=.

In the next year, when Khasru Mian cultivated the indigenous variety of Lal Chamara in the *aman* season, the output was 13.50 kg per decimal. In the *boro* season, he cultivated Guni-haita, another local variety. The output was approximately 9 kg per decimal. The 'profit' over and above the production 'cost' was 21,070/=. This includes the value of the straw which was Taka 13,070/=.

We calculated the value of the straw because that changes the comparative scenario. The straw of the local variety is easy to sell as fodder, but the HYV straws are not. The price is higher in the case of the indigenous variety. If the straw is excluded from the calculations, the profit for the HYV with all inputs is Taka 17,522/= , HYV without inputs Taka 14,950/=, and indigenous variety is Taka 7940/=. So with straw included in the calculation, the local variety gives 79 to 83% of the profits of the HYV. Without straw, comparable profits vary from 45 to 53%.

In terms of economic calculations, the returns are greater in case of the HYV without external inputs compared to the HYV seed with chemicals and water. The productivity of the land where external inputs have been reduced is improving significantly and UBINIG is trying this year to have figures from wider samples to understand the degree of improvement. Farmers prefer using HYVs without external inputs and consider the practice as a transitional phase from conventional to organic agriculture. The use of his local variety also made Khasru Mian happy. He needed the local straw as construction material due to its fiber quality. The roof constructed from such straws survives easily for at least three years, a substantial savings for Khasru Mian. In his cost and profit calculations he included the straw which can easily be sold at a much higher price than the HYV variety. The greatest advantage with the straw of the local variety is that it does not quickly degrade, like the HYV straws. Farmers can store it as fodder for a long period of time. According to farmers, old straws are a treat for the cows. These are the additional advantages, apart from their use in mulching.

Khasru Mian is not an exceptional *Nayakrishi* farmer. There are others like him who are ready to accept low yield and less income, as long as they do not have to starve. They are motivated for environmental reasons, and want to experiment with their land to beat the *adhunik* farms both in productivity and income. Once they can make that breakthrough, they believe their village will become alive with livestock, poultry, fish, and plenty of fruit and timber trees.

[3] 1 US dollar is equivalent to Taka 40/=.

However, these calculations are from the low-flood plain lands. In the slightly raised lands, where flood and rain water does not stay for long, the picture is different. The calculation from the land of Abdul Barek will demonstrate the case. He is a mixed cropper with innovative ideas. From October 1993 to September 1994 his amount of profit over and above the cost was Taka 37,448/=. Barek planted potato, sugarcane, onion, garlic, amaranth, coriander and maize. The market value of the output was Taka 61,390/= while the cost was Taka 23,942/=.

While a generalized calculation is not possible and where comparisons are questionable, these representative farmers can tell us a lot to guide the direction of *Nayakrishi*. *Nayakrishi* is appealing to farmers who can practice mixed cropping; therefore the type of land owned by the farmer is a factor. As the movement can show positive for some lands, interest is growing to creatively redesign the cropping pattern of low flood plains. The recent fertilizer crisis has contributed to generating wide interest in *Nayakrishi*. Experienced *Nayakrishi* farmers are very eager to make a breakthrough in the flood plain land.

It is important to mention that floodwater is seen as a resource and is considered positive for agriculture. The top soil and its management are perceived by most farmers in the flood plain area as factors of flood and a natural process external to the soil system. Perhaps this is the reason why the conservation and management of the top soil is less appreciated by the farmers in the flood plain agro-ecological zone. The fertility of the soil is linked to the question of floodwater management. This is critical for understanding flood plain agriculture. Flood plain farmers take time to appreciate the value of top soil because their land is replenished with fertile soil more or less every year.

MULTIPURPOSE TREES AND MEDICINAL PLANTS

In the beginning, UBINIG was very keen to introduce legumes and nitrogen-fixing trees. This is because we were very concerned about the fertility of the soil. From the peasants' point of view, the problem was to find an appropriate design by which to introduce and integrate a plant into the farming system. Farmers were more attracted to tree species which could produce large quantities of biomass. There was a need for trees that could be used for fuel wood, apart from supplying organic materials in the form of green manure or raw materials for composting. As a result, farmers became acutely interested in local species such as Jiban tree (*Trema orientalis*), a common and widely available tree previously ignored by the farmers. It is an excellent source of fuel wood and a favorite tree of many birds. Among the timber species, the *Nayakrishi* farmers shifted towards favoring the old jackfruit tree (*Artocarpus integra*), blackberry (*Eugenia jambolana*), and gab (*Diospyros peregrina*) more than the mahogany and acacia species promoted by the forestry department.

A shift in perception is taking place among the senior *Nayakrishi* farmers, who are increasingly reinforcing the notion of agriculture as the production of food, energy, timber and moisture. Retaining the moisture in the land has recently become a major issue, in the face of the severe drought in certain parts of Bangladesh.

The peasant women are also interested in medicinal plants. UBINIG field workers, working with the women's groups and extension workers, played a very important role in identifying the different species of plants in the villages which are used as medicine. There were few surprises for the villagers as many of these plants are still in use.

from June 1992 to September 1992. We went to the villages, collected information as well as the plants, and were sure to identify the locality. An album was made in which the parts of the plant used for medicinal purposes were pasted, with the description of the entire plant and the pattern of use for different diseases. The information was collected from 21 villages. Sixty-four women and 11 men served as sources of information in the villages. Awareness building for plants with medicinal qualities is important to preserve and enhance biodiversity . Among the 140 plants collected, there is one plant which is used for at least six different diseases: garlic. Garlic was found to be the most effective medicine for: cough/cold, whooping cough, arthritis, skin disease, ear troubles and heart disease. There are three plants which are used for at least five diseases. These are Bishkathali, mango and betel leaves. For example, *Bishkathali* is used for headaches, as painkiller from fish bone injury and thorn injury, foot-skin reaction due to cold, etc. Betel leaf is used for different kinds of stomach troubles, indigestion, and for fever. Mango is used for diabetes, throat pain, leucorrhoea, diarrhoea etc. Similarly, there are five plants which are used for at least four diseases; there are 15 plants which are used for at least three diseases; there are 47 plants which are used for at least two diseases; and there are 69 plants which are used for at least one disease. The village families are being encouraged to increase the local plant resources by bringing useful medicinal plants from other areas. Planting medicinal plants is being undertaken as a component of homestead gardening and horticultural activities. Women are obviously playing a predominant role in this respect.

CONSOLIDATING THE GAIN AND DISSEMINATING THE MESSAGE

The major issue, at present, revolves around seed and the question of biodiversity. Seed issues will get maximum priority, not only to assert control over such a politically-sensitive resource, but also because the success of *Nayakrishi* depends on the introduction of appropriate seeds to meet the demand of quality as well as quantity. Farmers are constantly experimenting in the areas of agroforestry, nitrogen-fixing trees, compost-making, aquaculture, and livestock and poultry, but the strengthening of the seed network and building of strong community institutions for seed conservation will receive the maximum attention of the farmers of *Nayakrishi Andolon.*

UBINIG is concentrating on the issue of the community seed wealth, and working towards developing a farmers' network all over Bangladesh around *Nayakrishi*, in general, and seed, in particular.

Secondly, the demand for training has been increasing rapidly. Recently the Government Rural Development program has selected *Nayakrishi* as one of the major training partners for their rural co-operative members. Individual farmers from all over the country are continuously contacting UBINIG expressing their desire to participate in the training program.

Thirdly, systematic and intensive studies should be undertaken immediately in two directions: a) a thorough study on the flood-plain ecology in the context of *Nayakrishi*. The study should help farmers to promote innovative ideas with lowlands; farmers have already identified lowland plants that can be used as agroforestry species; b) an exercise with the farmers and the community to conduct a natural resource auditing. This is extremely important to chart the future direction of the *Nayakrishi Andolon.*

Fourthly, the role of UBINIG as an information center should be strengthened. We have been publishing a 48-page fortnightly called CHINTA for the last four years. More than 60 % of its content covers agriculture and environment. Nevertheless, there is a tremendous demand for a *Nayakrishi* Journal where readers can get latest ideas of science and knowledge in simple and popular language and, at the same time, documentation of the experience of farmers, *Nayakrishi* practitioners or not, who are evolving agricultural systems free of toxic chemicals and alive with green.

In the face of modern agriculture and all the supports from the government and the international agencies, the message and the practice of *Nayakrishi Andolon* is attracting the peasantry without having to expend substantial effort. This fact is already a surprise for UBINIG. To the practicing peasants, the benefits are already visible. The possibility is immense for expanding the movement to address wider issues of biodiversity, genetic resources and related questions of ecology and environment.

GENES, GENDER AND BIODIVERSITY: DECCAN DEVELOPMENT SOCIETY'S COMMUNITY GENEBANKS

P.V. Satheesh

ABSTRACT

In low-input farming systems, women have traditionally been the managers of germplasm. As subsistence farmers, they value traditional crop varieties since these crops have harmonized over a long period of time with the environment and hence are easier to grow. Such landraces demand less resources and thus fall within the management capabilities of women. The gradual disappearance of these landraces makes a harsh impact on women.

The Deccan Development Society (DDS) works with sanghams (voluntary associations) of poor village women, mostly dalit [low caste] agricultural laborers in 60 villages in the Medak District of Andhra Pradesh. The community genebank project initiated by the Society and targeted at these dalit women farmers envisages the following:

> *To secure crop biodiversity in the area and ensure a safety net for women who are dependent on subsistence farming;*
>
> *To establish in situ rural genebanks;*
>
> *To empower the women to reclaim their unproductive lands;*
>
> *To enable the women's groups to develop the skills and management capacity to grow local landraces as seed crops and start village-level seedbanks;*
>
> *To develop a seed distribution network for the local crop varieties and ensure large-scale re-emergence of these varieties;*
>
> *To empower the women to develop into seed entrepreneurs and enter agribusiness.*

The era of commercial seed business will give the women a chance to enter the market once they become good seed producers. DDS visualizes a new context in which organic (non-hybrid) agricultural products will be bought at a premium. This will certainly be to the advantage of the women who grow traditional crops using non-chemical farming practices.

INTRODUCTION

The biodiversity which had been nurtured carefully for centuries by the indigenous people, particularly women, through traditional systems at community level, has diminished in recent years with the promotion of hybrid seeds, monocropping and changes in traditional agricultural practices.

> <u>In low input farming systems, women have traditionally been the managers of germplasm. But the modern agricultural practices, which have pushed seeds into a market economy outside the village community, has displaced the women from their original roles.</u>

Women belonging to the poorer sections of rural society and the dalits [low caste groups] are basically subsistence farmers. For them, traditional crop varieties are very important since these crops have harmonized over a long period of time with the environment and hence are easier to grow. Such landraces have been gradually disappearing making it harsh on women.

> <u>Traditional varieties demand less resources and therefore fall within the management capabilities of women.</u>

Decrease in farm biodiversity has made the livelihood systems extremely vulnerable. In case of one single pest attack, the entire crop may disappear, creating in its wake hunger and famine. The hardest hit by this phenomenon are women, who have to constantly worry about food availability for their families.

Monocropping and the promotion of hybrid varieties on a large scale has accelerated this process. Being susceptible to market conditions, these seeds are available only to the rich farmers. Even if made accessible, the poor will not be able to use them because they demand a package of farming practices which can only be followed by the resource-rich farmers.

Acute shortage of local varieties of seeds which are hardy and need the least of resources adversely affects the prospects of sustainability for poorer farmers.

Within this context of general hopelessness, one tiny ray of hope exists. In the new dispensation, where large seed manufacturers will be main players in the arena, a new niche will be created in the market for the organically grown non-hybrid varieties. The health-food chains will create this demand. This will be an unfilled gap.

CAUSES FOR PROBLEMS

The myopic state policy, wherein financial institutions do not support rainfed food crops, forces farmers to grow cash crops using state subsidy. This means the lavish use of scarce resources (read: water, chemical fertilizers and pesticides), thereby creating massive environmental hazards.

The government-operated Public Distribution System (PDS) provides food security (supply of rice on ration cards) through its outlets. This has meant that the farmers need no longer produce local food crops to meet their food requirements. <u>Consequently every year the acreage under dry crops shrinks and the production falls. This may soon result in the disappearance of hundreds of species.</u>

Commercial agriculture has brought in its wake seed and input corporations and multinationals. They enter an arena which used to traditionally belong to women and have displaced them from their occupation.

DDS AND THE COMMUNITY GENEBANK

Deccan Development Society (DDS) is a decade-old organization which works in the Medak District of Andhra Pradesh. Zaheerabad region, where the Society operates, has been listed as a Drought Prone Area Programme (DPAP) district. The semi-arid tract runs through this region. People here have traditionally followed dryland farming.

The Society has catalyzed the formation of *sanghams* (voluntary associations) of poor village women, mostly agricultural laborers, in 60 villages. These women manage on their own most of their credit needs, and manage programs of community health, environment conservation and regeneration and education.

This group of women in 60 villages, who comprise the target group/beneficiaries of the Community Genebank project, are mostly dalit. By profession, they are mainly agriculturists and work as wage laborers for a major portion of their earnings. During the rest of the time, they cultivate the small patches of land owned by them, work as well-diggers and as labor in other construction works. As members of DDS sanghams, they are actively involved in the collective cultivation of lands and have a high awareness of environment-friendly farming practices.

The Society pioneered and has extended the concept of Permaculture among these groups over the last six years. Apart from the theoretical and technical issues that it advocates, the issue of ethical farming and regional self-sufficiency lies at the core of Permaculture. Years of experience of practicing it (and debating it) with women farmers have created a need for several initiatives that promote regional self-sufficiency.

Three main initiatives have been taken up by the Society to fulfill these objectives. They are: an Alternative Public Distribution System known as the Community Grain Fund; massive wasteland development; and the raising of traditional seeds and establishment of decentralized village-level seedbanks called the Community Gene Fund.

The Community Grain Fund operates on 3000 acres spread over 30 villages. The project involves reclaiming fallows through making them productive through the raising of sorghum. The investment made by the Society in rendering the land productive is repaid by the project-partner farmers in kind (a fixed quantity of sorghum every year for six years). This grain is stored in the village and for six months a year is sold to the poorest 100 families in the village, at subsidized prices. The money accrued from the sales becomes a village fund for further investments in the reclamation of fallows and also becomes a revolving Community Grain Fund. This ensures that the environmental hazards that fallows bring in their wake can be countered. In each village, at least 2000 person/days of employment are created every year[1]; the grain availability is increased by 25%; and fodder production goes up by 20%. The poor do not need to migrate out of the village to fight their hunger. The Community Grain Fund also ensures the principles of local production, local distribution and local consumption-- as opposed to the dominant PDS system which promotes centralized production and centralized distribution systems.

If the Community Grain Fund is meant to tackle the problem of foodgrains, the Community Gene Fund is designed to answer the problem of seeds. The project proposes to identify 30 acres of land per village and start raising traditional crops for seed purposes. The lands are selected by the village sanghams along the following criteria:

- The poverty of the woman who owns the land and her commitment to grow the traditional crop;
- The suitability of the land to grow the traditional crop as seed.

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1 In each village, 100 acres of fallow or extremely marginal lands are brought into active production. On each of these acres, an average of 20 women are employed just for weeding. People are additionally employed for harvesting, plowing, etc. Even sticking to the minimum employment figure of 20 persons per acre, multiplied by 100 acres, we arrive at the 2000 person days of employment.

Once the lands have been selected, an amount of Rs. 2500[2] will be made available to the farmer as input support to cover the expenses towards timely plowing, purchase and application of farmyard manure, timely weeding and harvesting. This is a one-time investment and will be recovered in the form of seeds. The recovered seeds will be stored in the village to serve as an *in situ* genebank to help other farmers grow traditional crops. As with all programs of DDS, the Community Gene Fund program was a result of continuous dialogue between the DDS workers and the members of the women's sanghams.

DDS runs a health program which is completely based on local healing systems and local herbal and plant medicines. The regular interaction with our health workers and local healers has given us a clear insight into the richness of folk nutritional systems and the problems of the mainstream medical establishment. Such discussions have also revealed the strengths of traditional food and nutrition. With the disappearance of these foods, a host of problems has arisen.

As a consequence of the shortage of traditional food, the issues of nutrition and seeds started to be elaborated in our discussions. After additional participatory research assessments (PRAs) with health workers, healers and women farmers, it became clear that some steps needed to be taken. The result was the Community Gene Fund project.

Our present project partner is GTZ.

Target Group

The Community Genebank project focusses on dalit women as the direct beneficiaries of the project. This primary target group will consist of the women in the 60 DDS sanghams (with those in 30 villages engaged in a first phase). The total number who will directly participate in the program will range between 300 to 600 women, whose farm sizes are between half an acre and one acre. They will be using the inputs provided through the project to raise seeds of local crop varieties on their own or leased lands and will store harvests in their villages for profitable selling and multiplication.

The second group which will benefit from the project are the other sangham women who, while not direct participants, will receive the seeds produced by the project beneficiaries and start a seedbank in their own sangham. Their number will approximately be 1500.

The secondary target will be the small and marginal farmers outside the sanghams, in and outside the 60 villages, who have no resources to grow irrigated crops and find it hard to get the seed varieties to grow on their small farms. This group will number about 20,000.

Why this group of marginalized dalit women?

These are the most vulnerable sections of the population and hence they need a mechanism to:

- transcend their present status of being dependent on market forces;
- widen their security net by being producers of seeds and hence gain control on the most crucial element in the food chain;

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[2] 1 US dollar is equivalent to Rs. 33.

- create their own fall-back system outside the mainstream market-- which has always acted hostile to them;

- create and operate their own markets, thereby entering into the agribusiness as entrepreneurs and increasing their agricultural incomes.

The process

We expect the process to be as follows:

- The dalit women in the DDS project area own small pieces of land, either gifted to their families by the erstwhile feudal system for services rendered or the later democratic government as a part of the land ceiling and reassignment. Most of these lands have been left fallow by the women because they cannot afford the inputs to make the lands productive. To make the lands productive, the women have to initially plow the land an extra couple of times or employ a tractor. This needs an investment up to Rs. 500. Most of them can't afford this.

- Secondly they have to sow in time. For this, they have either to own or hire a pair of plow bullocks. Most of them don't own a pair of bullocks. To hire one, they have to give ready cash-- which they don't have. Hence they try to request a plowshare to work on their land for a quarter share of the harvest (and all the fodder a pair of bullocks can eat), which most are unwilling to do on small pieces of land. They would rather take on larger tracts which makes the operation profitable. The second option open to poor women is to employ the plowmen on a deferred payment. This is agreeable to plowmen but they come to plow at the end of the season. Since that will be too late, the yields will be very low. This way the cycle of 'uneconomicness' rolls on.

- The third operation is weeding. Though the persons who weed the fields are the dalit women themselves, the temptation of going to other fields to earn cash income is too great to miss. In the entire agricultural cycle, weeding is the only operation which earns them cash. Hence the women first finish weeding in other people's fields and at the end come to weed their own fields.

As a result of this vicious cycle of poverty and apathy, their own lands continue to lie fallow or remain extremely underproductive, yielding half a bag of sorghum per acre whereas, with a proper treatment, they could have yielded three to four bags. We call these fields 'two visitation fields' which means that the women visit the lands only twice during a season: once to sow the seeds and the second time to harvest.

The Community Genebank project proposes to tackle this problem in two steps:

- Step one: Provide sufficient inputs, like plowing support, farmyard manure and weeding support for one agricultural season. This would improve the fertility of the land and increase the yield considerably.

- Step two: Convert these lands into seed farms thereby increasing the profitability.

By converting the lands into seed-farms, we would like to ensure that the production brings one and a half times the normal income (the present practice in the region is that if someone borrows a kg of seed s/he returns one and half to two kgs during the next season).

Present income from their lands (per acre)	Income by making lands productive	Expected Income converting them into seed farms
Rs. 150-200	Rs. 900-2000	Rs. 1500-3000

Finally, by bringing the women sanghams to control the entire seed operation, we will be giving a great fillip to the self-help nature of the groups. Eventually the seed exchange will involve about 3000 women members of the sanghams as the beneficiaries and will encompass the entire community in the 60 villages. The size of that 'community' will be nearly one lakh [100,000] persons.

Expected Results

The Community Genebank project envisages the following results, to:

- Secure crop biodiversity in the area and ensure a safety net for women who are dependent on subsistence farming;
- Empower the women to reclaim their unproductive lands;
- Create an *in situ* genebank;
- Enable the women's groups to develop the skills and management capacity necessary to grow local landraces as a seed crop and to establish village level seedbanks;
- To develop a seed distribution network for the local crop varieties and ensure large-scale re-emergence of these varieties;
- Empower the women to develop into seed entrepreneurs and enter agribusiness.

Community Genebank and the women

- Since much of the low-input farming is managed by women, the seed situation hits the women in a particularly harsh manner. Earlier, all the seeds needed for their farming were produced by them at their own farms. But with the growth of commercial agriculture, and with the entry of the transnational seed companies round the corner, poor women will have to go to the market every time they need to buy seeds. Hence their age-old self-reliance faces possible extinction.
- By being actual controllers of seeds, women do not have to be at the mercy of the outside seed market, which supplies what the manufacturer has made available and not necessarily

what the people want. This situation is very apparent in dryland agriculture. As a consequence of such market forces, the women are currently forced to buy, against their will, hybrids and other high-input-demanding seeds-- in contrast to their own native seeds, which demand low-inputs.

- By becoming seed producers, women can get more income out of their lands than before. For example, if a woman earns Rs. 1000 per acre producing a normal crop like sorghum on her land, and if she engages in seed production, which is a specialized activity, she will earn Rs. 1500 to Rs. 2000, an increase of between 50 to 100% over her normal income.

- The era of commercial seed business will also give women a chance to enter the market. once they become good seed producers. We also visualize a new context in which organic (non-hybrid) agricultural products will be bought at a premium. This will certainly be to the advantage of the women who can become seed entrepreneurs.

The project has just begun. The lands have been identified, the project partners have consented to start seed farms. Manure has been bought and applied onto these lands. One complete cycle of agricultural operations in 30 villages is almost over. We are sitting with our fingers crossed. We don't know how we will go. But any distance traversed is worth it--for the cause of biodiversity.

REBUILDING THE GENETIC RESOURCE BASE THROUGH FARMER-SCIENTIST-ACTIVIST ALLIANCE

G.N. Reddi

MAJOR CHALLENGES

During the past decade, Third World governments have come under considerable pressure to promote policies and practices which further western-oriented agriculture. The support from the World Bank, IMF and other bilateral aid agencies to the third world governments, agriculture research, education and extension agencies has completely wiped out the indigenous initiatives for biodiversity which existed before 1960. The top scientists from all over the world were encouraged to promote high-input agriculture. The scientists and extension agencies had no discretion power and were obliged to implement top-down programs and prescriptions. In fact, in the initial stages, during the 1960s and 70s, farmers virtually revolted in different parts of India in order to counter the advice of the extension agency. Even with liberal subsidies and loan programs from the cooperative and commercial banks, the extension agency was able to demonstrate the efficiency and effectiveness of chemical agriculture. At present, scientists in agriculture research centers and agriculture universities are deeply wedded to the idea of the invincibility of high-input agriculture for continuing sustained growth in food production. Hence, we have reached a critical stage where scientists and policy makers do not appreciate the idea of rebuilding agriculture based on indigenous wisdom and knowledge.

MAJOR INITIATIVES IN RESTORING BIODIVERSITY

The author's close interaction with Dr. Richharia, a well-known rice scientist from Bhopal, has revealed the following insights:

- Even before the introduction of the International Rice Research Institute (IRRI) varieties by the Government of India, Dr. Richharia was able to undertake experimentation on the local high yielding varieties of rice. He had facts and figures demonstrating the superiority of selected local varieties over the high yielding exotic varieties. During 1965, the eminent authorities in Indian agriculture ridiculed his ideas and he was not given the support to continue his experiments.

- The Madhya Pradesh government offered him facilities to continue his experiments related to biodiversity in rice. In his enthusiasm to demonstrate the effectiveness and efficiency of indigenous varieties, Dr. Richharia collected more than 20,000 local varieties. But Dr. Richharia could not withstand the onslaughts of the monoculture Green Revolution mentality.

- Dr. Richharia advocated (and still advocates) the idea of Walking Genebanks. He himself travelled on foot to remote tribal areas to collect interesting and high performance rice varieties. Since he had no support either from the scientific community nor from the non-governmental organizations (NGOs), he could not continue his experiments.

- During the past four years, Dr. Richharia has assisted an NGO based in Kurzat near Bombay. Within their program, he has trained farmers representatives to identify and collect rice varieties from Maharastra. He has helped them select certain varieties which were of interest to farmers themselves. The scientific guidance and support from Dr. Richharia has enabled the farmer representatives to develop indigenous varieties of rice through the clonal propagation method. Kurzat has been an important learning center where the farmers themselves have become strong advocates for promoting and sustaining biodiversity.

- According to Dr. Richharia, although monoculture has done major damage to the biodiversity in India, he feels that the illiteracy, ignorance and backwardness of farmers have remained as a boon. The country has not lost all its biodiversity. If concerted efforts are made by the scientists, activists and farmers, it might be possible to retrieve the indigenous genetic wealth.

PHILIPPINES' EXPERIENCES IN PROMOTING BIODIVERSITY

When IRRI was celebrating its silver jubilee functions, a big procession was held by farmers to protest against the irreparable damage that IRRI operations have effected in the Philippines. According to them, due to the presence of IRRI, the Government of the Philippines completely abandoned its independent research on rice cultivation. Further, it started replicating the ideas of IRRI for promoting monoculture. Initially for the first seven or eight years, the country obtained bumper crops and they could export rice to other countries. However, they started to witness a steep decline in rice production and the country had to import rice. Hence, the farmers organizations sought support from highly committed scientists from the agriculture research stations. The farmers organizations conducted independent research in 20 centers and a number of scientists, deeply wedded to the interests of the farmers, joined the movement. The network in the Philippines is in a position to provide necessary inputs for participatory research on sustainable agriculture.

INITIATIVES OF THE INDIAN RURAL RECONSTRUCTION MOVEMENT (IRRM)

Since 1988, IRRM has developed active linkages with Dr. Richharia, Pat Mooney, and outstanding farmers interested in sustainable agriculture in South India. Initially IRRM planned to work with farmers directly. The support of outstanding farmers in sustainable agriculture was obtained for training the farmers. Very soon IRRM realized that it is very difficult to withstand the onslaughts of the extension agency because of the power that they process. Hence IRRM started interacting with the agricultural scientists from the regional research station, Tirupati, and the teaching staff of the agriculture college, Tirupati.

Since the college of agriculture, Tirupati, has introduced a separate paper on sustainable agriculture, the author took the initiative to introduce case studies on the work of sustainable agricultural practitioners. The farmers were invited to give special guest lectures on their experiments to promote sustainable agriculture and biodiversity. For the first time in the history of the college, the scientists listened to the views of the farmers, and the scientists networked in Chittoor district for designing and developing agriculture based on farmers' wisdom, with a scientific outlook.

CONCLUSION

In order to preserve and promote biodiversity it is necessary to tap the potentials of NGOs who have the commitment to work with farmers' organizations in identifying, preserving and enriching genetic wealth. It is necessary to obtain the support of well-intentioned and committed scientists for strengthening the work. A strong alliance of scientists, farmers, and activists is the only solution for reconstructing the genetic resource potential. The results could be achieved by organizing the work in different agro-climatic regions of India. Simultaneous work has to be initiated in order to counter the dominance of mainstream agriculture.

DISCUSSION

SAHAI: One important point that emerged from Rajeev Khedkar's paper is how local efforts like the kind described, and how a network of local efforts can really amount to a very significant exercise. This would address to some extent the doubts that Dr. Reddi raised that local efforts may not be so effective and that conservation has to be done at the national or international level. I agree that it has to be done at the national and international level, but it is much easier, and the control remains with local people, if you can ensure that effective and local initiatives are established and then linked in a network of such initiatives.

Another thing that emerges from almost every contribution is the role of women. It is well-established that everywhere there are farming communities, the control of material has traditionally been with women because the skills are with women. Not only the skills and knowledge of biodiversity but also its storage, its use, its refinement. It is important for us to focus on this in an upfront way. All kinds of new national authorities are being established to talk about and regulate the question of biodiversity. We must very consciously promote the role of women in these national authorities because women are the repositories of skills, knowledge. For example, in national authorities that are established in our countries which involve controlling access to genetic resources, women must have more than a 50% presence. They must be included formally in a decision-making capacity.

OOSTERHOUT: On the topic of women farmers maintaining diversity, I think this ties up with the compensation issue which poses a very, very difficult question. Research and marketing have generally been targeted at men. What happens if we start promoting the marketing of these local crops, if they take a place along side the formal cash crops? Will women still be interested and involved?

HALIM: I would like to say something about Dr. Reddi's paper where he talked about farmers coming to the classrooms and teaching the students. At 'Sristi' we have also planned to invite farmers to the classroom as a token of respect to them and to teach students about biodiversity and how to conserve it.

REDDI: I would like to emphasize here that we are involving seasoned and respected farmers who have done outstanding work in their lifetime. It is out of deep respect for these farmers and also because we feel that scientists have to un-learn and re-learn. I work in the College of Agriculture and in the Extension Faculty and have arranged for farmers to give orientation lectures to the faculty members on alternative systems of agriculture. The senior scientists have started feeling, for the first time in the history of the college (27 years) that they can listen to farmers and that this sustainable system will work. As a second step, we have made arrangements for faculty members to visit farmers in different parts of Andhra Pradesh, Karnataka and Tamil Nadu. After their visits, they have approached deans and vice-chancellors about the possibility of changing the curricula--away from the heavy input, HYV emphasis.

STHAPIT: A query for Satheesh: in your plan at the Deccan Development Society to create an *in situ* conservation program at the village level, how have you planned for farmers to get direct benefits?

SATHEESH: Like Saskia's [Oosterhout] presentation, yesterday [Zimbabwean Sorghum Landrace Study], we are also trying to piggyback on development. We are offering a small bait to farmers that, if they start growing traditional crops, the lands they had left fallow will come back to life. The word 'incentive' is also a bit of a misnomer because there is also a tremendous amount of nostalgia.

There is a yearning from farmers to have the landraces they have lost, especially among women from the lower castes. They have seen what is happening to their lives with the Public Distribution System (PDS) and with the mainstream agricultural markets. Today the PDS is selling something to them at maybe Rs 2/kg. But the situation could suddenly change and it may go up to Rs 5. And they want the kind of grains they used to eat, which sustained them in their work.

So while in the initial stages we are trying to give a nudge, there is also an atmosphere within the community which is extremely conducive to getting back the traditional crops. Over the last two to three years, people have seen what is happening to their lives and their lands, with sugarcane, with potato, with tumeric. If you have gone over the brink, then to come back may take a bit of time. That little bit of time--we are trying to offer.

KOTHARI: I have a question to Satheesh: it is a dilemma we have been facing in our own work.

One definition of self-sufficiency could be where all the farmer's inputs come from his or her own fields or surroundings: they are just growing for their own personal consumption. So, it is a relatively closed system. Another is to say that the farmer is growing surplus or is producing for the market and is gaining enough through money to buy other products that he or she needs. In your paper, you proposed that farmers increase their level of self-sufficiency but, at the same time, you are proposing that the women get involved in the national and international seed business, though not with HYV seeds but with traditional seeds. You want them to get involved in these systems as you think there will be increasing demand, both nationally and internationally, for traditional seeds, which may well be the case.

What I am wondering is what happens, for instance, when they become increasingly dependent on supplying these markets eco-friendly seeds and the national or international markets suddenly decide they don't want them or the prices crash, or whatever?

Secondly, isn't there an in-built logic in far away markets of a certain kind of homogenization being required to make things simpler to transport, to sell, and so on, which may go against biodiversity being grown at local levels?

SATHEESH: What I said may have been misleading as I do not think we are ever looking at markets beyond our districts and certainly we share the same concerns as you regarding national and international marketing. It would be very suicidal for people like ours to attempt to get into those kind of markets. Our immediate market would be among the 60 *sanghams* of the Deccan Development Society. We are addressing around 5,000 families who spend about Rs 2 million every year for their food and probably another Rs 5-10 lakhs [.5- 1 million] for other needs like oil.

With the tiny surpluses they presently have, they are going to the town markets, and you know what the market process subjects them to. So when I speak of markets, I am speaking of alternative markets , not national or international, for alternative food systems. It is a dropping out of the mainstream market and creating their own markets within their own communities. If the farmers are able, at some point, to produce an important surplus, then they will have to make a decision about what they want to do--but we are not going to stipulate anything for them.

LOEVINSOHN: This is mostly directed to Farhad Mazhar, but touches on a number of presentations. He mentioned the suspicion people may have of genebanks because access to them and what they contain may be limited. These concerns are certainly there with genebanks which are located outside the community. But I think we should also recognize that genebanks or seedbanks that are situated locally, within the community, may not function that efficiently either, in terms of assuring access to all. There are differences and divisions within what we call communities, which are fissured by caste, class, sometimes language. One has to ask whether one institution would serve everybody.

MAZHAR: What I want to raise are concerns over certain categories we are using, which may be loaded. I am speaking about the conception of a 'bank'. Farmers look critically at concepts which involve centralizing seeds. For example, you cannot just come to farmers and take seed as such. Generally, active farmers are even suspicious of NGOs as they collect and keep seedbanks under NGO control. What farmers really want is to have the seed wealth under the village machinery where farmers control it, can come and go and informally exchange seeds. They consider seed wealth as a living resource which they should exchange and collect without any procedural difficulties.

The formal system says that it serves as a kind of back-up system---but I really haven't had any experience to support this. It has not worked in the cases where villages have lost certain genes or access to varieties.

But I would like to raise a more fundamental issue about the relationship between biodiversity and markets--the two don't go together. You cannot have a corporate economy and biodiversity at the same time as you are bringing in a lot of foreign categories, like 'compensation': you get something and you give something. Agrarian communities do not work all the time on the basis of the market concept. The concept of 'the gift' is extremely important, as is 'responsibility'. You have a responsibility of doing certain things for the community or for some other ethical reason---this obligation can be repressive in its own way. So I think will have to look critically at this concept of 'compensation'---on ethical grounds.

And a third issue is that farmers in Bangladesh will tell you that agriculture is an art of exclusion, because you exclude certain species. It is not necessarily a system which can contain biodiversity because you have to produce for human need. So you cannot just romanticize and say that agrarian economies are the best form of preserving society's genetic resources. Our *Nayakrishi* farmers would say that it is not their responsibility to look after the biodiversity of Bangladesh.

DAS: My first comment is that often conservation is considered a very esoteric anti-utilitarian activity, but the four papers we have heard clearly suggest that conserved biodiversity can be rooted in reality and that it can also improve the quality of life, especially for poorer people.

The role of the Public Distribution System (PDS) that Satheesh describes in Andhra Pradesh is very similar to the role it has been playing in our area [Almora region, Uttar Pradesh]: it is wiping out local crops and replacing them with wheat and rice. The question I have is that farmers in our area feel that there is no way they can achieve food self-sufficiency with their local millet, so they have to use the PDS crops. Sateesh has an interesting example of how they are getting local food sufficiency with their community grain fund. Do you think this could be universally applied to all kinds of zones, like our area in the Himalayas where forests need to be kept and agricultural land is proportionally less?

SATEESH: In our area [Medak District of Andhra Pradesh], it is very possible to get large tracts of land, because they are increasing in fallow--getting out of agriculture. For instance, when we look at area under sorghum, land use is shrinking year after year, which means that land is available, you can grow a crop, but state policy is discouraging it.

Also I would like to ask why the PDS has to be geared only towards irrigated crops. Why not bring in other grains, such as millet, if that happens to be the choice of people in your area. No they have no choice: they buy either rice or wheat.

TOWARDS SETTING UP A COMMUNITY SEEDBANK - EXPERIENCE FROM CHENGAM, TAMIL NADU

K. Vijayalakshmi and A. Nambi[1]

ABSTRACT

Over the last three decades, there has been a progressive decline in the number of rice varieties, cereals and millets cultivated in India, with rapid changes in agricultural technology being responsible for this trend. As the biodiversity and sustainability debates have led us to rethink our traditional practices, a study has been started to understand the processes by which communities have maintained their biodiversity of seeds, their current seed status, and the means by which farmers can be encouraged to revive systems of varietal maintenance. The work described below has been taken up in the Chengam Taluk of the Tiruvannamalai Sambuvarayar District in Tamil Nadu. Several traditional varieties are still being preserved by farmers, with an initial survey showing that most of the cultivators of traditional rice are marginal and small farmers, owning 0.5-1 ha of land. Being poor, both groups have had little access to institutional credit for sinking wells and their investment could not have repaid their loans. The quality of their land is also invariably poor, although the traditional rainfed paddy has fared well on these margins, assuring the farmer food security. Breakdown of traditional water management systems and the falling of the water table have contributed to the spread of traditional varieties in this area. Surveys results show that there is a great demand for the revival of traditional varieties, and through a community effort, a community seedbank is being established.

INTRODUCTION

Over the last three decades, there has been a progressive decline in the number of rice varieties, cereals and millets cultivated in India. Rapid changes brought about in the technological sphere have been largely responsible for this decline. The biodiversity and sustainability debates have led to a rethinking of what we have in our traditions. According to Dr.Richharia, the well-known rice scientist, 400,000 varieties of rice existed in India during the Vedic period. He estimates that, even today, 200,000 varieties of rice exist in India-- a truly phenomenal number. This means that even if a person were to eat a new rice variety every day of the year, he would live for over five hundred years without reusing a variety! Every variety has a specific purpose and utility. Dr. Richharia has collected and identified 20,000 types of rice in the Chattisgarh area of Madhya Pradesh alone. Farmers in every part of the country have a deep knowledge of their own rice varieties, of their environmental and nutritional requirements, and their properties and peculiarities. This has enabled them to harvest a crop even under the most severe stress situations. Farmers also possess high yielding varieties of their own which are not recognized in agricultural extension programs.

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[1] We wish to acknowledge the Third World Network India for providing financial support for this study. We would personally like to thank Dr. Vandana Shiva, Research Foundation for Science, Technology and Natural Resource Policy who has been the guiding force behind this effort. We also wish to express our thanks to all the members of our project team.

Thirty thousand indigenous varieties of rice grew in India prior to the Green Revolution. Today, not more than fifty are widely known and cultivated. This alarming rate of ecological and biodiversity destruction has now been recognized, and the need for conservation is acknowledged at the level of farmers and the State. According to the Agenda 21 (Article 15.2), "Major adjustments are needed in agricultural, environmental and macro-economic policy, at both national and international levels, in both developed as well as developing countries" (in Keating, 1993). The Agenda also calls for both *in situ* and *ex situ* conservation and suggests that national governments take prime responsibility for conserving their biodiversity and for using their biological resources sustainably.

EX SITU CONSERVATION

There are several problems with *ex situ* conservation. While most genebanks and public sector plant breeders collect biodiversity from farmers' fields, this has not been made available to farmers. The diversity flows from farmers' fields to genebanks and from there on to breeders--but not back to farmers: thus, stocks are systematically eroded from the source. This leads to the non-sustainability of agriculture. Farmers are excluded from playing the roles of conserver, innovator and consumer of genetic diversity.

IN SITU CONSERVATION

In situ conservation, or conservation in the farmer's field, has received inadequate attention. Conserving biodiversity in farmers' fields is essential for a variety of reasons.

1. Ecological
   a. Insurance against pest and diseases
   b. Insurance against drought and climate change

2. Economic: strengthening internal inputs supply

3. Nutritional

4. Political
   a. Strengthening farmers rights
   b. Strengthening third world rights.

THE CASE OF CHENGAM TALUK: THE BACKGROUND SETTING FOR A COMMUNITY SEEDBANK

It is becoming increasingly clear that to maintain biodiversity in farmers' fields, an alternative system of seed supply has to be created. Although farmers greatly feel the need to regrow some of the traditional varieties they have lost, one has to be able to provide them with sufficient quantities of local seed varieties in order to fulfill this need,. The community has to be convinced or has to feel the need to bring back lost biodiversity, and any effort should be aimed at the community level. Community seedbanking efforts are now taking place in many parts of the country and, in this paper I would like to share our experiences in the Chengam Taluk of the Tiruvannamalai Sambuvarayar District of Tamil Nadu. I start by giving some background to the general area and its rice crop.

Chengam Taluk

The Chengam Taluk covers an area of 1689.51 km^2 and encompasses 170 villages. It receives rain during the northeast and southwest monsoon periods, with an average annual rainfall of about 900 mm. The taluk has different types of soil, such as black, red loam and sandy loam. Cheyyar River and Pambannar River pass through several villages of this taluk, and the major source of irrigation is tanks (that is, *erys*). Major crops raised in the taluk are paddy and groundnut.

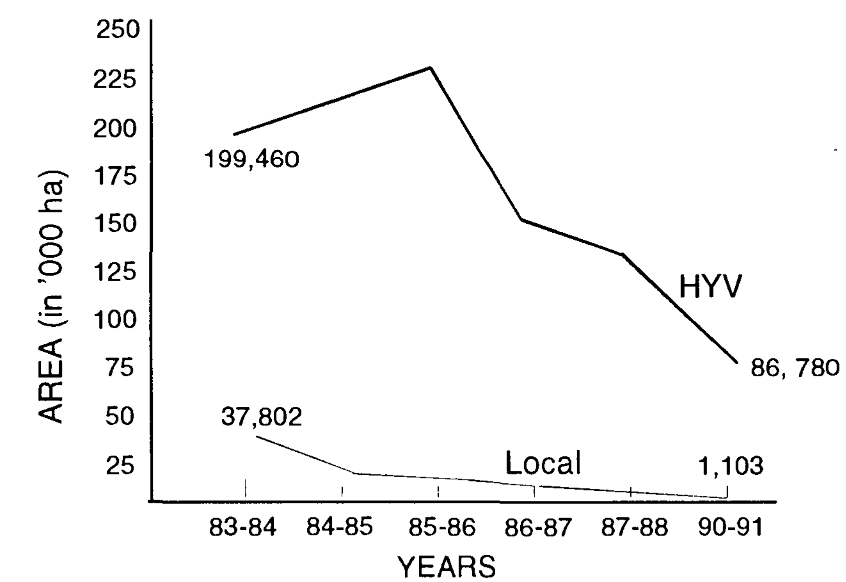
Area under cultivation of high yielding and local varieties of paddy in Tamil Nadu

Paddy is the principal crop of Tamil Nadu. The area in which local varieties of paddy are cultivated has been declining in the last ten years (Table 1). It might be noted that in Kanyakumari District, the local varieties are significantly higher in proportion. Figure 1 also shows the situation in North Arcot district where the area under cultivation of local varieties has reduced from 37,801 ha in 1983-84 to 1,103 ha in 1990-91.

Paddy cultivation in Chengam

Paddy, the principal crop of the district, is cultivated in all three seasons, namely *Swarnavari* (May to September), *Samba* (August to February), and *Navarai* (December to May). The following 14 traditional varieties of paddy have been located in Chengam Taluk: Sirumani, Manavari, Seeraga samba, Kitchidi samba, Ondarai kitchidi, Payagunda, Kappa karu, Kullan karu, Kalar palai, Malai kitchidi, Bangalore kar, Thuya malli, Vadan samba, and Malai Nellu.

Figure 1: Area under high yielding/local variety of paddy in North Arcot



Source: Season and Crop Report of Tamil Nadu, Directorate of Statistics, Madras.

Table 1: Area (ha) under high yielding/local varieties of paddy in each district of Tamil Nadu. In each set, top figure = HYV, bottom figure = local.

District	1983-84	1984-85	1985-86	1986-87	1987-88	1990-91
Chengalpattu MGR	193,874	214,479	234,874	135,506	206,868	222,466
	77,629	59,212	41,593	39,426	12,329	9,494
South Arcot	200,261	277,820	292,052	281,002	235,291	179,942
	20,175	7,430	9,731	8,021	1,769	
North Arcot	199,460	219,736	225,917	142,993	137,051	86,780
	37,801	23,705	20,838	7362	6,036	1,103
Salem	49,308	45,110	30,106	31,479	40,838	28,199
	11,457	8,347	6,769	9,485	10,384	2,176
Dharmapuri	20,972	20,645	22,466	28,215	29,123	22,714
	22,808	15,188	13,804	14,107	11,989	7,213
Coimbatore	30,273	39,786	21,684	26,997	15,741	18,156
Periyar	79,634	73,611	28,810	63,748	33,974	64,255
					88	
Tiruchirapalli	122,196	109,355	80,421	89,545	89,897	78,002
	15, 065	11,771	4,462	4,000	7,763	14,680
Pudukkotai	102,318	84,436	90,213	91,962	99,262	68,443
	4,325	3,610	6,349	180	620	
Thanjavur	491,232	628,289	512,909	465,535	445,120	453,528
	2,504	1,969	4,395	335	2,445	5,894
Madurai	140,092	141,537	96,586	84,374	103,393	118,726
	2,694	1,482	870	243	635	423
Dindigul Anna			22,638	18,711	28,602	21,439
				629	635	515
Ramanathapuram	187,746	53,294	42,447	41,580	55,958	55,164
	15,194	889	8,849	8,487	88,173	96,101
Kamarajar		31,245	24,534	25,381	39,615	35,962
		4,418	3,358	3,216	3,305	820
Pasumpon Muthuramalinga Thevar		70,483	54,964	53,338	91,194	84,434
			5,003	3,630	11,585	4,909
Thirunelveli Kattabomman	109,221	127,546	121,413	57,396	85,942	99,974
	19,977	9,078	8,446	1,755	1,247	1,428
V.O. Chidambaram				18,223	22,366	28,756
				295	42	33
The Nilgiris	159	160	160		61	274
				165	2,182	2,509
Kanniyakumari	14,720	16,812	18,015	15,609	18,350	26,635
	24,899	29,450	26,608	15,336	14,950	14,593

Source: Season and Crop Report of Tamil Nadu, Directorate of Statistics, Madras.

<u>Reasons for the cultivation of traditional rice varieties</u>

Most of the cultivators of these traditional varieties are marginal and small farmers, owning 0.5 to 1 ha of land, with much of the population falling in this category (see Table 2).

Table 2: Statistics on land distribution in Tiruvannamalai Sambuvarayar District of Tamil Nadu, 1980.

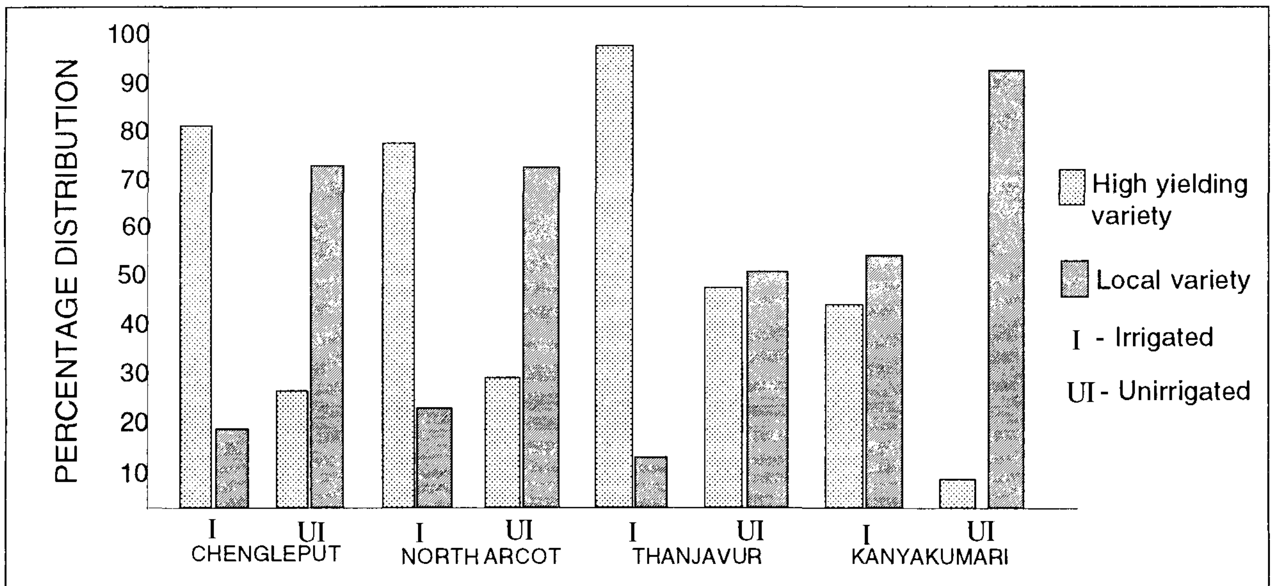
Size of holding	Total holdings	Percentage of total holdings
Below 1 hectare	465,095	69.80
Between 1 and 2 hectares	78,748	11.82
Between 2 and 4 hectares	70,635	10.60
Over 4 hectares	51,824	7.78
	666,302	100.00

There are many reasons why these poorer farmers continue to grow traditional varieties; I briefly list them below:

- Being small and marginal farmers, they have little access to institutional credit for sinking wells and their investment would not bring much return to repay the loans. The quality of lands is also invariably poor.

- The breakdown of traditional water management systems has contributed to the spread of traditional rice varieties since a number of traditional varieties can be grown under unirrigated conditions (see Figure 2). Most irrigation tanks are currently working below their

Figure 2: Area under high yielding/local variety of paddy in North Arcot



Source: Tamil Nadu agricultural census reports (1981-82). Department of Statistics, Madras.

Table 3: Percentage of never-adopters (1972-73), de-adopters (1973-74) and non-adopters (1973-74) of HYV paddy among paddy cultivators by reasons given, North Arcot District

Reasons	1972-73 Farm Survey n = 200		1973-74 Cultivator Survey n = 200			
	Never adopters	De-adopters	Non-adopters			
			Sornavari	Samba	Navarai	All seasons
Fertilizer problems: availability, cost, timeliness, distance of source, etc.			39	80	79	69
Pesticide problems: availability, cost, timeliness, distance of source, etc.			17	56	50	45
HYVs not profitable	4	15	42	50	29	44
Water problems: control, needs pump-set, insufficency, etc.	27	23	19	34	29	29
Soil problems: needs testing, not suitable, etc.	12	15	14	38	15	27
Inadequate knowledge, lack of advice	4	2	12	35	13	24
Grain quality not satisfactory, unpalatable, etc.	1	6	14	18	23	17
Credit problems: lack of funds for inputs	36	32	15	17	23	16
Family members opposed	na	na	3	22	17	15
Not convinced about high yields of HYVs	4	2	10	18	4	12
Season not suitable because of pests	na	na	25	9		12
Tractors too expensive	na	na		12	4	7
Seed not available, price too high, etc.	1			10	4	6
Labour problems	na	na	2	8	6	6

Note: 'Never-adopters' were those who had never tried HYV paddy
'De-adopters' were those who had tried HYV paddy before 1972-73
'Non-adopters' were those not growing HYV paddy in 1973-74
na = not available

Source: *Green Revolution?* by B.H. Farmer, 1977.

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COMMUNITY-BASED RESOURCE MANAGEMENT: CONSERVE (*PHILIPPINES*) EXPERIENCE

F.A. Magnifico[1]

ABSTRACT

Farming communities have much to say when it comes to plant genetic resource conservation. Ensuring the availability of quality seeds and storing diverse materials for future use are forms of conservation. With the continued utilization of these resources, farmers are actually conserving valuable resources for future generations. Knowingly or unknowing, farmers have been practicing conservation for millennia. Formalization and centralization of agricultural research and development, however, has resulted in a shift in the management of these resources. The accelerated erosion of plant genetic resources as a result of the Green Revolution foiled farmers' efforts to conserve and utilize their own varieties. The self-reliant and innovative farmers became heavily dependent on external inputs and lost control over the whole agricultural system.

There is a great opportunity, however, to salvage and effectively utilize and conserve these resources with farming communities. This paper presents the efforts of the Community-Based Native Seeds Research Center (CONSERVE) in promoting community-based conservation and in affecting change and development in marginalized farming communities, and vice-versa.

Recognizing that seed conservation is not the end in itself, this effort is linked and integrated with other project components. These components and their integration with the whole concept of conservation, in response to the need for a more sustainable agriculture, will be discussed in detail. The strengths, limitations, as well as how CONSERVE's program has evolved in response to the many challenges will be presented.

INTRODUCTION

Modernization in agriculture has contributed to the great loss in the diversity of plant genetic resources. With the establishment of a monoculture based farming system and the adoption of modern varieties, traditional landraces of rice are gradually disappearing in farmers' fields. In the Philippines, only five or six modern varieties occupy 87% of the rice land, most of them being derived from the same original cross. The degree of encroachment is still minimal in the uplands compared to the lowlands. However, as breeding efforts for these environments intensify and as new suitable varieties are developed and released to farmers, the traditional varieties as well as the cultural practices associated with them are placed at a great risk.

The situation is further aggravated by the rapid and massive provision of seed and credit in the government's agricultural programs, which are biased against traditional varieties. This is compounded by rapid changes in the environment-- may they be man-inflicted or natural. These

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[1] The Community-based Native Seeds Research Center (CONSERVE) has been working in partnership with farmers in the promotion, conservation and improvement of traditional crops in Arakan Complex, Cotabato, Mindanao Island, Philippines.

Table 1: CONSERVE collection

Type	Number of Villages	Number of entries		TOTAL
		Lowland	Upland	
A. RICE				
1. CONSERVE collections				
Agusan Sur	1	11		11
Bukidnon	1		15	15
Cotabato	12	54*	143	197
Davao Sur	1	1		1
Maguindanao	3	7	38	45
North Davao	1	2		2
Sarangani	1		20	20
Sultan Kudarat	1	1	8	9
Rice subtotal		**76**	**224**	**300**
2. Donated accessions		37	11	48
RICE TOTAL	**21**	**113**	**235**	**348**
B. CORN		14		14
C. OTHER COLLECTIONS		40	13	53
TOTAL ACCESSIONS	**21**	**167**	**248**	**415**

* includes 2 wild rice collections

Having been able to collect an enormous amount of rice diversity in the region, an *in situ* approach to plant genetic resources conservation was started in 1993, initially with 45 farmer curators. Identification of farmer curators was one of the crucial activities when the project was initiated. This was facilitated by various church-based organizations, non-governmental organizations (NGOs) and cooperatives existing in the area, which up to now remain supportive of the project. A series of meetings and focused group discussions with various farming communities and organized farmer groups were conducted to create an awareness of the importance and urgency of plant genetic resource conservation. To-date, there are 106 farmer curators involved, distributed in 23 baranggays in Arakan Complex (see maps, figures 1a + 1b).

Figure 1a: Map of Mindanao, Philippines showing the location of on-farm conservation and germplasm source

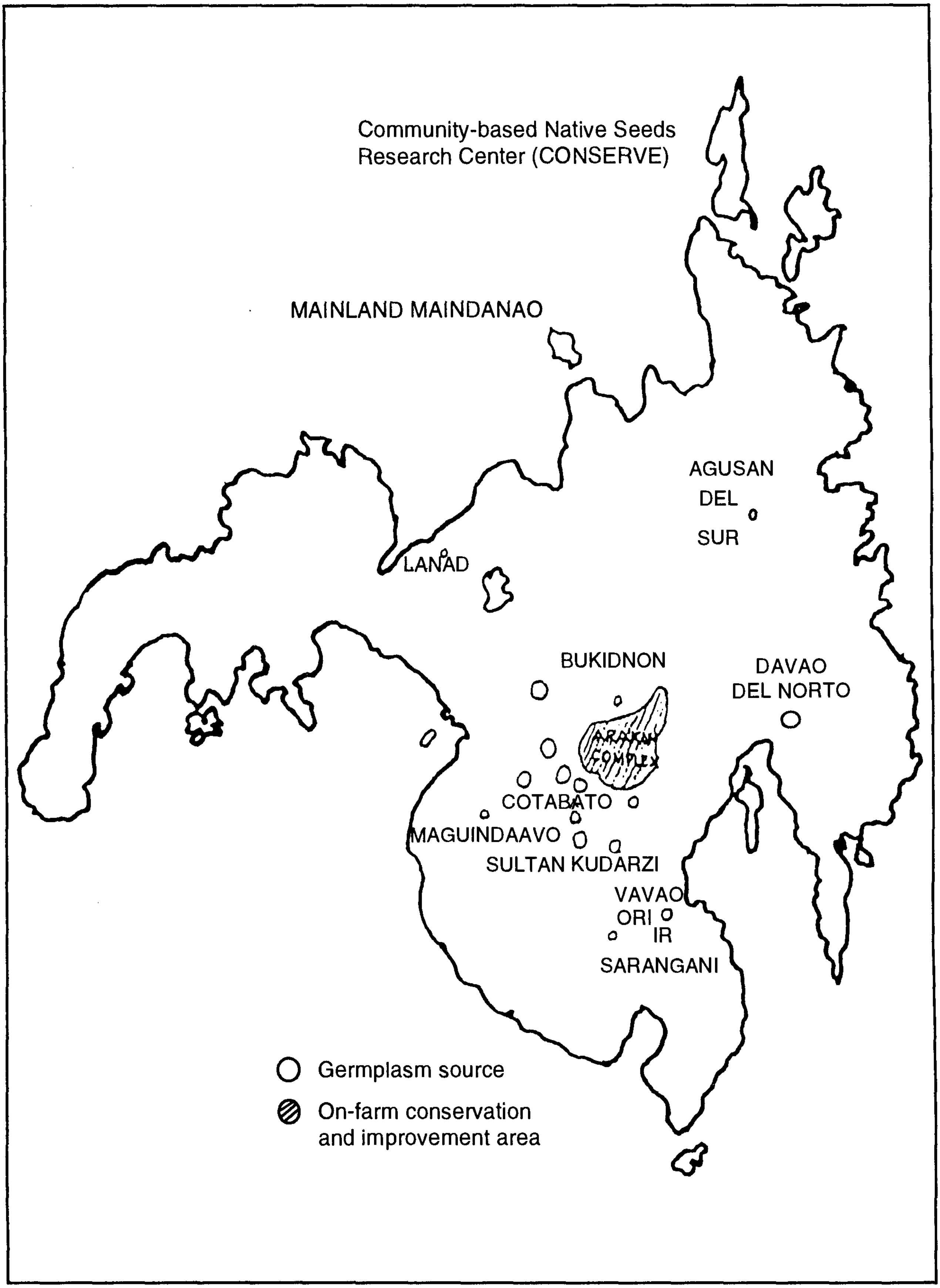


Figure 1b: Seed distribution sites in Arakan Valley-Complex for on-farm conservation

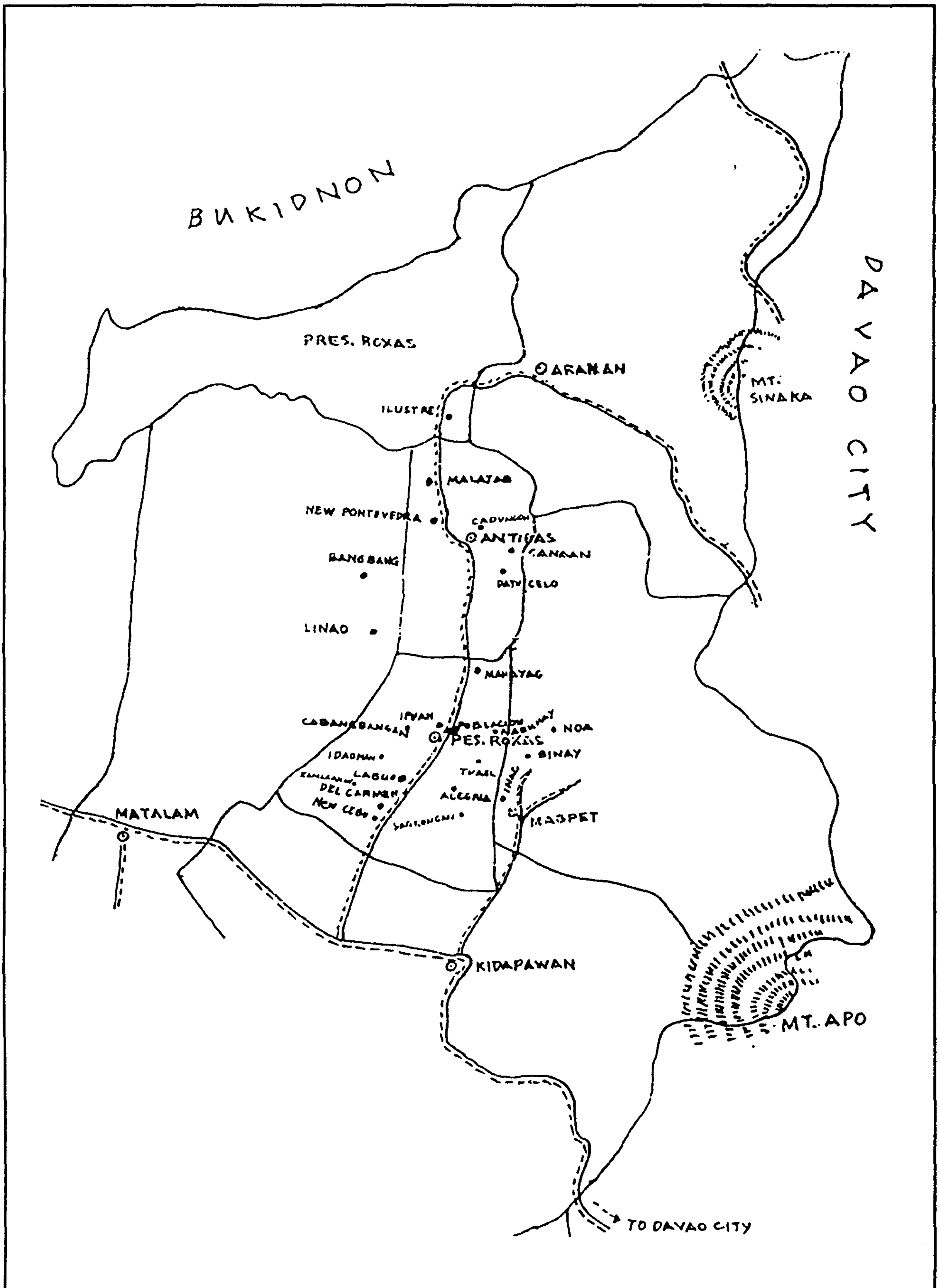
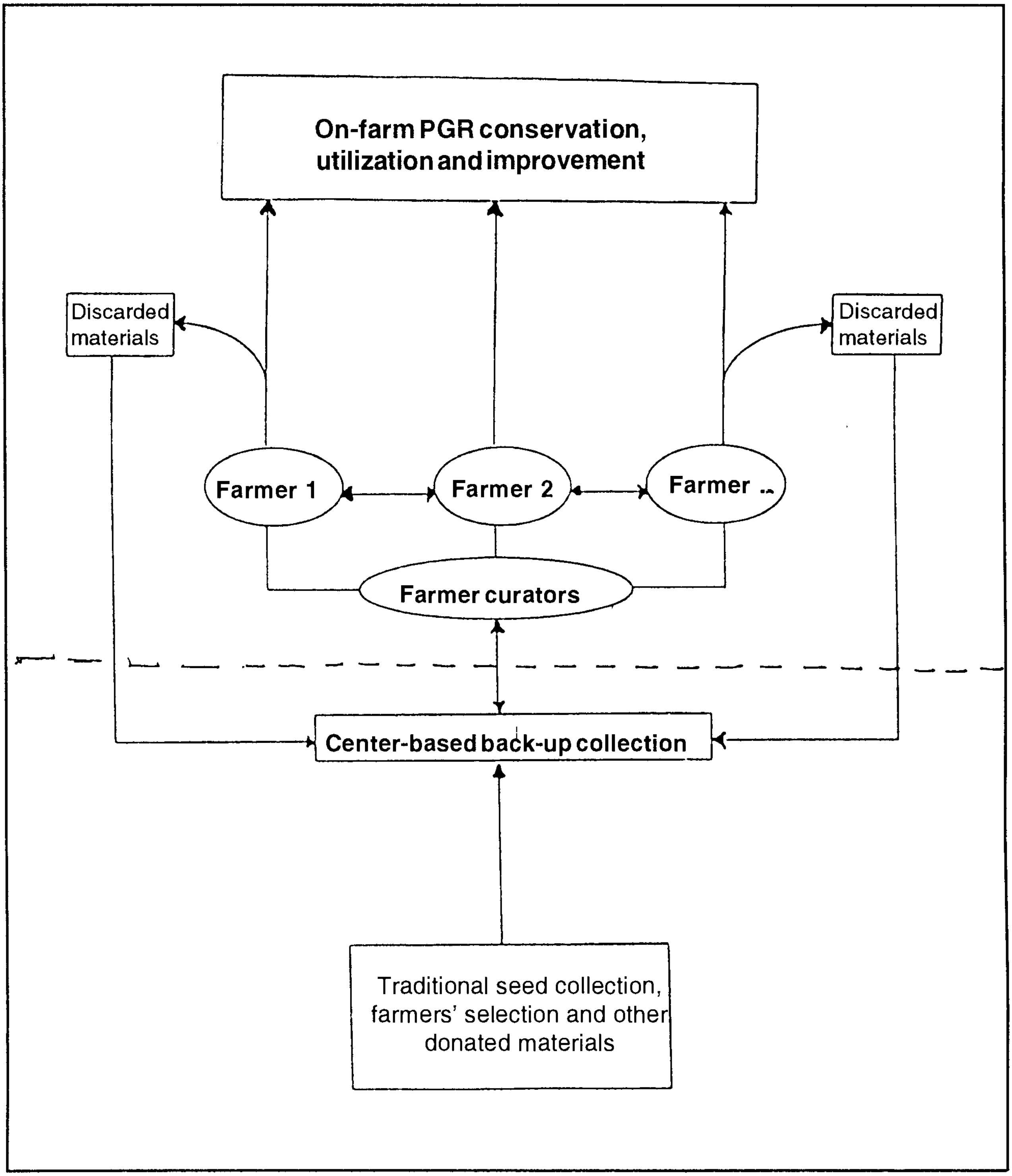


Figure 2 shows CONSERVE's strategy for on-farm PGR conservation and utilization. It is emphasized that the task of the curators is not merely to grow the limited samples of traditional varieties in the fields. There exists a 'dynamic' relationship and flow of materials between CONSERVE and the farmer curators and among the farmer curators themselves. This strategy can ensure the security of PGRs, will allow a continuous supply of valuable/adapted seeds to farmers and will also build a repository of plant genetic resources for future crop improvement.

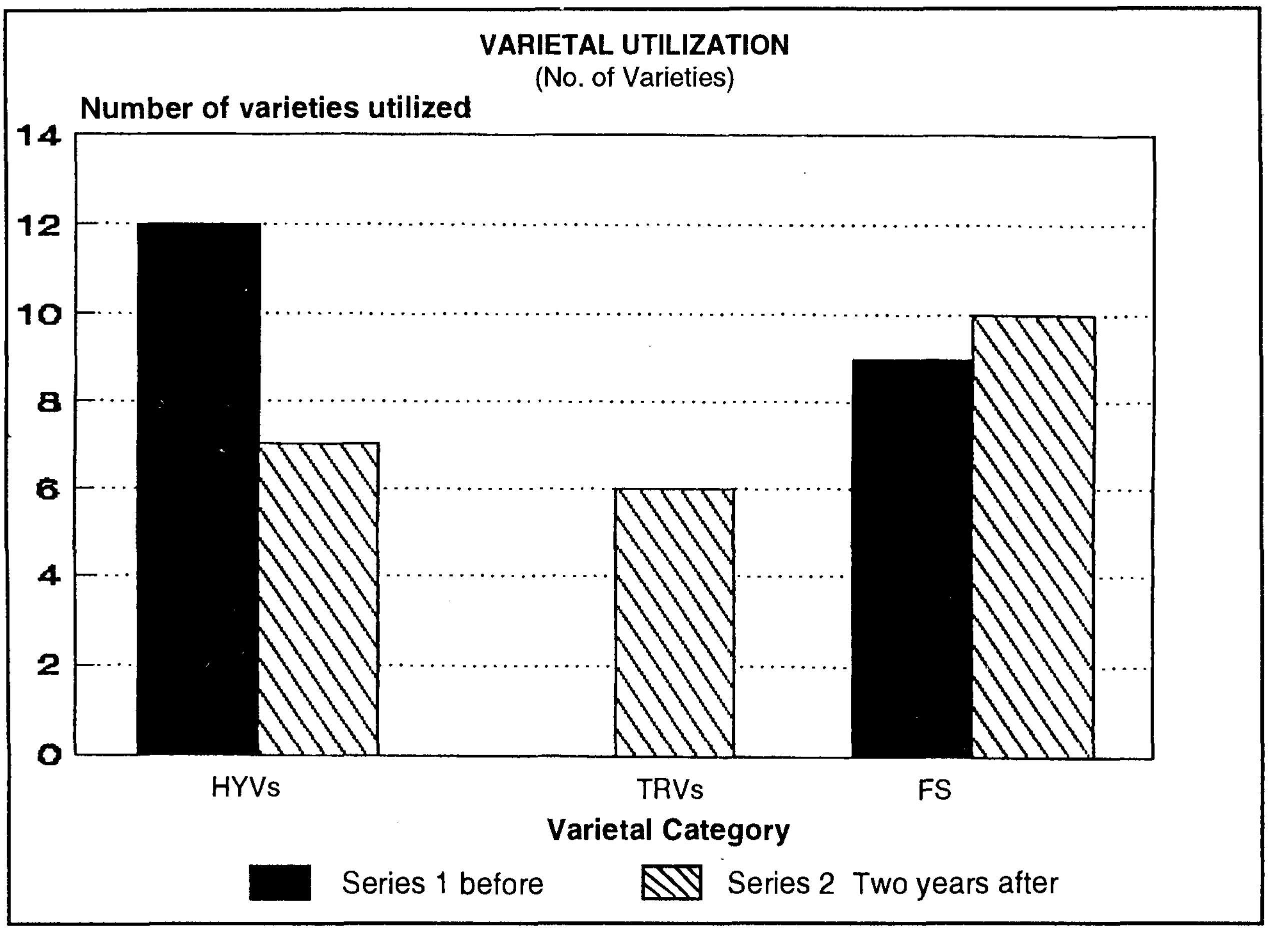
Figure 2: Strategy for on-farm plant genetic resources conservation of CONSERVE



Each farmer is given a sample of ten accessions of different indigenous rice varieties. These accessions are then planted in their fields for conservation purposes and for adaptability tests. At the start, farmers were only given 100 g of seed of each of the varieties. This helped strengthen farmers' appreciation of the value of these resources. Furthermore, this process also served as a means of testing the adaptability of the materials under farmers' conditions and across different environments.

Since the program was launched, a total of 169 indigenous varieties have been distributed to various farmer curators for on-farm conservation. Adaptability of the varieties varies from one farm to another depending on the prevailing agroecological conditions in the area. Varieties which farmers maintain are conserved either as planted or live collections or stored for future use. Of the presently distributed varieties, 8.28% and 42.01% are stored and planted, respectively, while 15.98% are conserved as both. Some exceptional and good performing varieties are being propagated and redistributed to other farmers. So far, six identified traditional varieties have gained acceptance from farmers and are currently being utilized for large-scale production (figure 3). Some varieties however did not thrive in some of the distribution areas. Others were lost due to some environmental factors not within farmers' control. Economic and social limitations also prompted farmers to discard some varieties. Materials which farmers discarded willingly or unwillingly accounted for 33.73% of the total plant distribution. In such cases, CONSERVE then has a role in ensuring that varieties lost and discarded by farmers are redistributed to other farmers in other areas and are maintained as in the back-up collection.

Figure 3: Comparison of the number of lowland varieties utilized by farmers in Arakan Valley Complex



Maintenance of PGR on-farm remains to be the organization's main approach towards conservation. As a support to the on-farm conservation carried-on by farmers, CONSERVE is currently maintaining a back-up base and active collection in its center farm (Table 2).

Table 2: Comparison of CONSERVE's base and active collections

	Base	Active
Purpose	back-up (discards, depository of those not yet distributed)	seed distribution for farmers, seed material for on-farm and center-based experimentation
System/Conditions	storage in glass jars, room temp., w/ silica gel, etc.	stored in bags and cans
Amount	4,000 - 12,000 seeds	1 kilo at the minimum
Frequency of regeneration	regenerate if viability is below 85%	would vary depending on the demand of the center and farmers

This *ex situ* approach complements the on-farm conservation efforts and availability of materials, especially to farmers.

Another activity conducted in the center base is the systematic characterization and documentation of the collected materials. All the rice collections have already been characterized for selected morpho-agronomic characteristics in the central station. After considering the preliminary evaluations of farmers and the central station, some accessions can be released as potential cultivars for commercial production. Other morpho-agronomic characteristics are also noted which can be of potential use for future crop improvement (Table 3).

Table 3: Reason for continued utilization of local varieties

Morpho-agronomic characters	Socio-cultural functions
Good tillering capacity	Tribal celebrations
Aromatic	Cultural gatherings
Good eating quality	To remember forefathers and ancestors
High yielding	Survival crop
Early maturing	For infants and sickly
Resistance to pests and diseases	No need for chemicals, fertilizers and pesticides
Sticky	
Hard and heavy grains	
Good and bigger grains	
Unique taste and color	
Drought tolerance	
Can stay longer in storage	

SUSTAINING CONSERVATION AND AGRICULTURAL DEVELOPMENT

One of the fundamental issues facing farming communities is their survival in terms of food self-sufficiency and the survival of farming itself. Recognizing this reality, CONSERVE's present conservation program is linked to its overall agricultural development agenda. Its approach is anchored on sustainable agriculture, which relies mainly on resource conserving and yield sustaining production technologies. CONSERVE's efforts, aside from promoting the conservation and utilization of traditional crops, are also directed towards the reduction/elimination of chemical farm inputs, a strategy which eventually leads to increased real farm income.

Training on crop improvement, farming systems development and soil fertility management is being conducted on a regular basis to assist those farmers who are adopting local varieties and are gradually steering away from purchased inputs. At present, a season-long farmers' field school on ecological pest management, attended by 126 farmers, is being conducted in six sites. This is made possible with the help and active participation of 16 local farmer trainers, whom themselves have attended the orientations and training conducted by CONSERVE and have completed a season-long training course. Most of these trainers are also actively engaged in PGR conservation as farmer curators.

PROJECT IMPACT

A recent survey of 50 farmer cooperators involved in the project in 15 villages was conducted to assess the impact of CONSERVE's PGR conservation program. To start, even with the 'Green Revolution' program of the government over the last 25 years, it is important to note that, under lowland conditions, only 35.9% of the farmer respondents use modern varieties such as those of IRRI and the Philippine Seed Board. After working with CONSERVE, users of modern varieties decreased to 18.4%. This reduction is reflected in the increase in the number of farmers (20.9%) using traditional varieties (Figure 4).

Further impact can be seen in terms of chemical use, as measured by hectarage. Of the total land area of the 50 farmer project cooperators, 40% is totally chemical-free (apart from the fertilizer-free and pesticide-free areas) (Figure 5). In terms of savings from the cost of fertilizers and pesticides, this would amount to 50,000 pesos per cropping season or 1,250 pesos per hectare on the average (Figure 6). This would mean a 50% reduction in the dependency on purchased chemical inputs, apart from the environmental and health benefits gained.

This recent survey was conducted among 50 farmer households who were close project cooperators of CONSERVE. However, as of April 1995, around 250 farmers in the town of Pres. Roxas have adopted an ecological pest management (EPM) technology. The town has a total of 1,800 hectares of lowland rice farm and around the same number of farmer households.

Although the survey only covered a limited number of farmers and area, it is expected that the number of farmers utilizing traditional varieties will increase. Looking at the farm household level, an increase in the total real farm income was noted. By diversifying his farm, one of the farmer cooperators in Pres. Roxas earned an extra 7,000 pesos this season. Instead of planting a single variety, he planted his own *Bordagol* selection as his main variety and another photoperiodic type as a sustainer crop. He had been practicing organic farming for four seasons.

Figure 4: Degree of rice varietal utilization under lowland condition

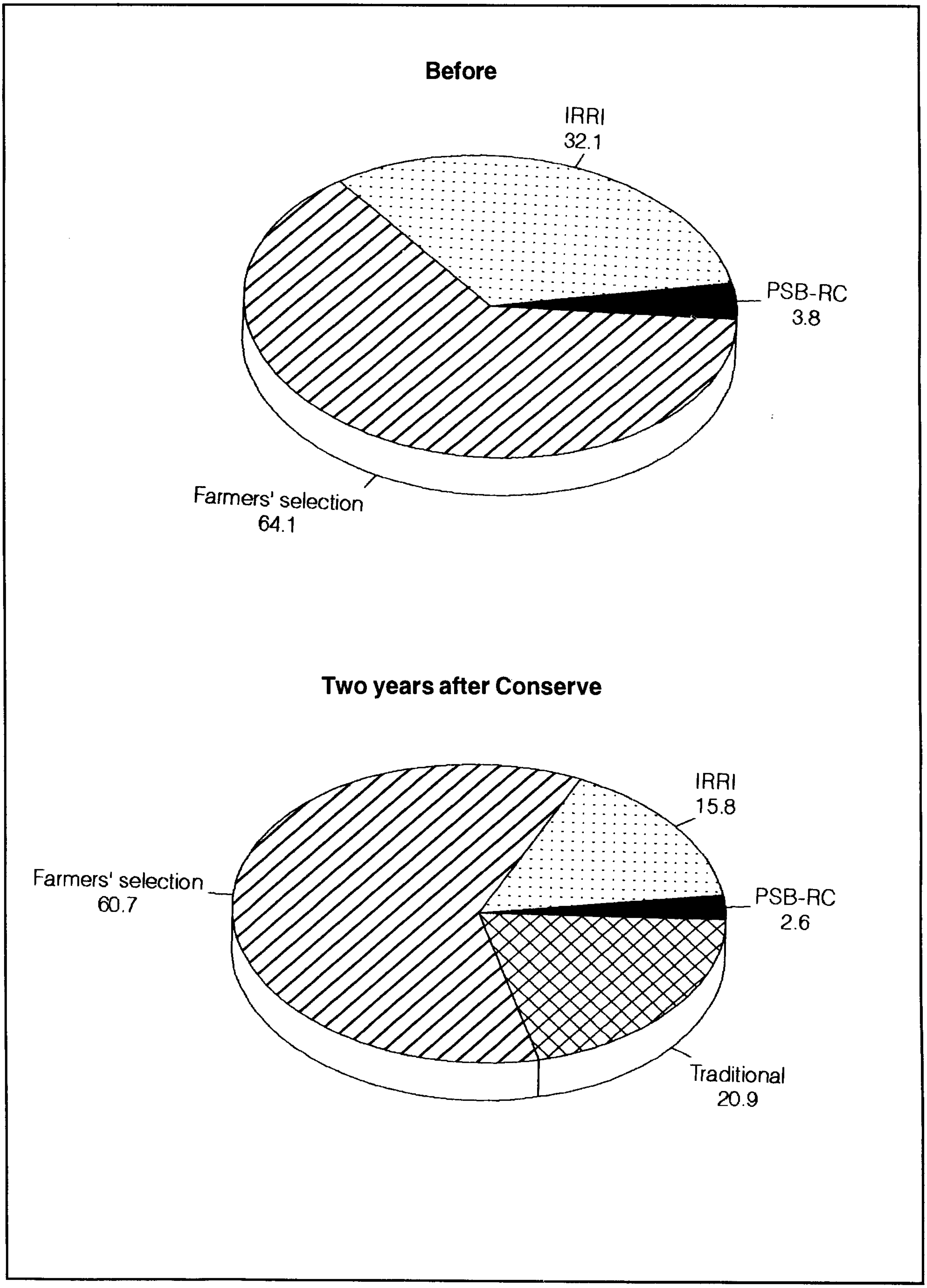


Figure 5: Impact on chemical use in terms of rice area under lowland condition

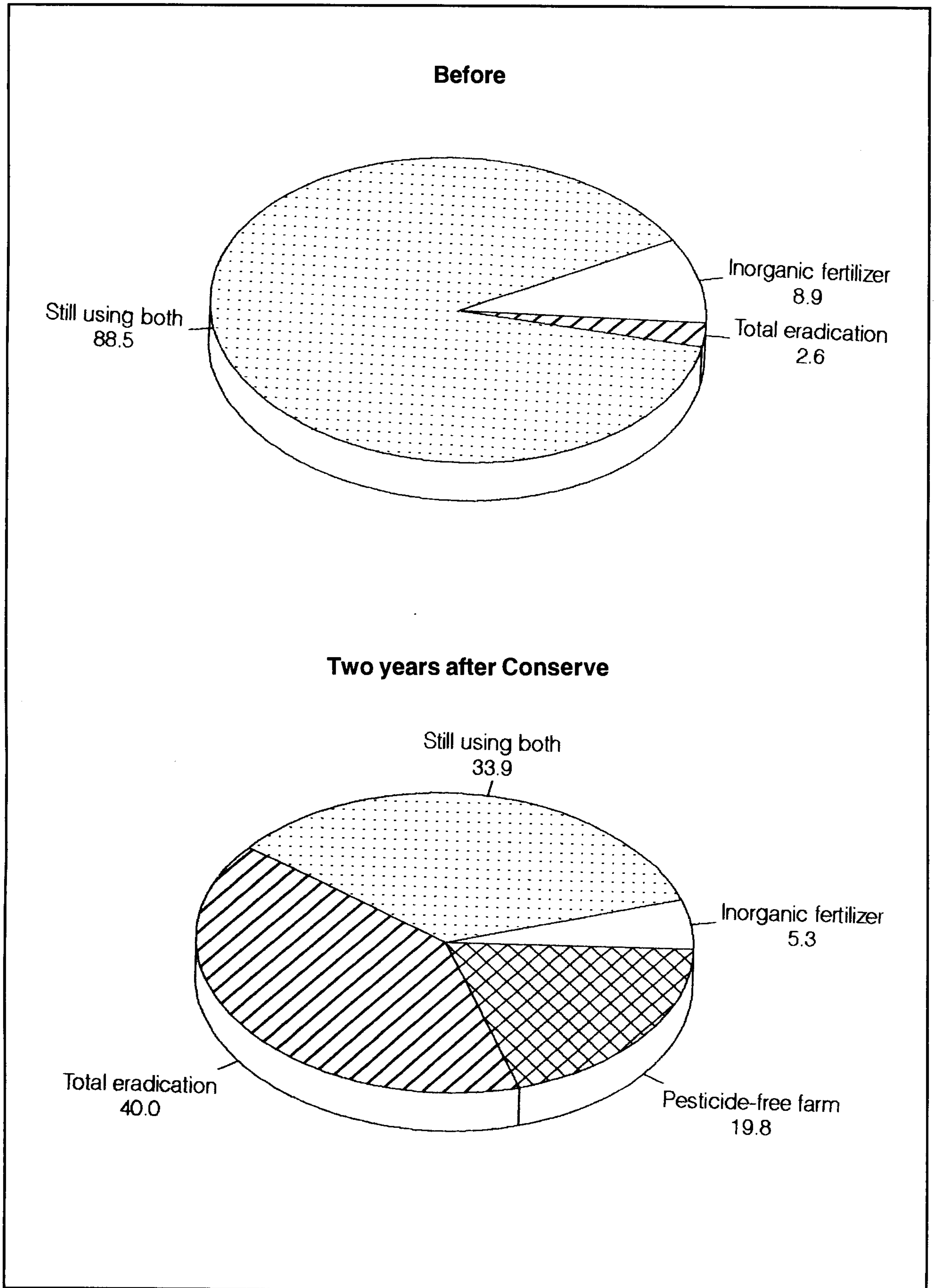
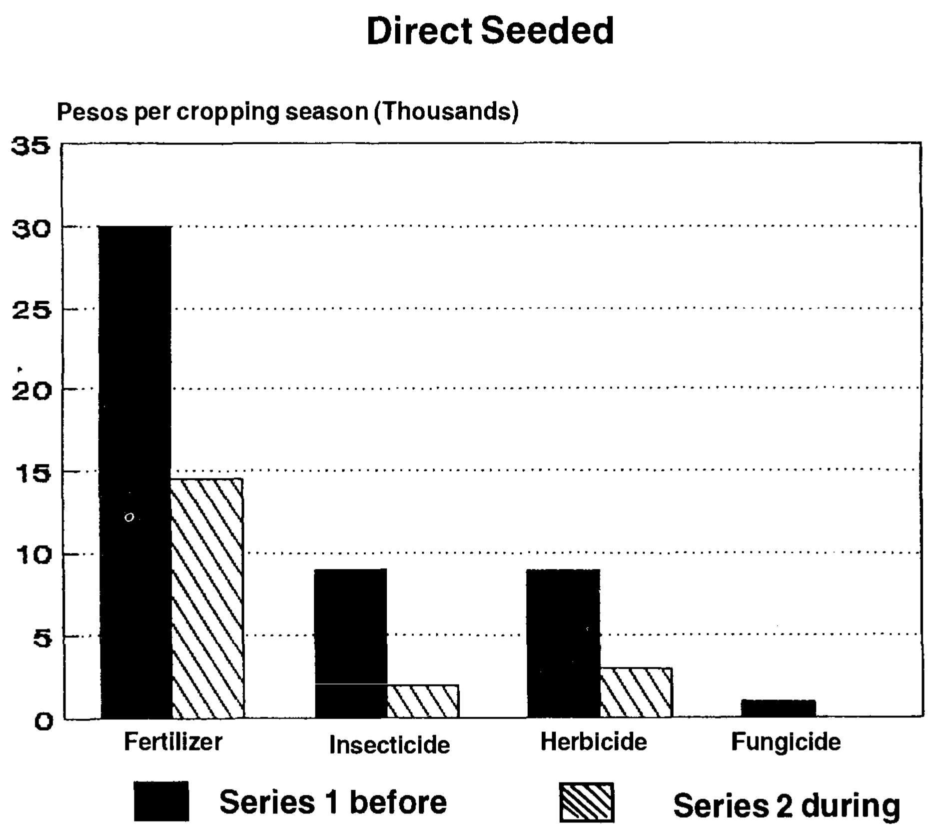
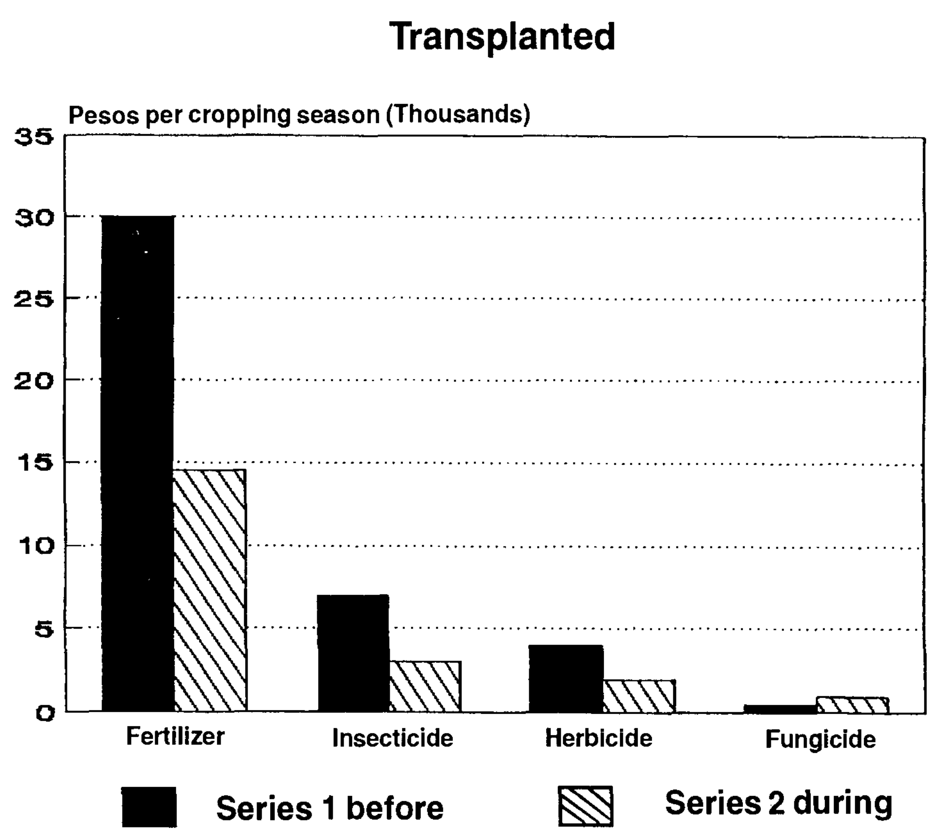


Figure 6: Impact of CONSERVE chemical use in terms of cost of inputs under lowland rice condition





ISSUES CONFRONTING CURRENT EFFORTS IN COMMUNITY-BASED PGR MANAGEMENT

There are many factors that affect a farmer's decision whether to conserve and directly utilize traditional varieties. The spread of modern varieties had displaced many of the traditional varieties. Government policies and programs are still bent towards the use of high yielding varieties (HYVs) coupled with the use of fertilizers and pesticides. The Grains Production Enhancement Program (GPEP) of the government, for example, still adopts the package of technology approach wherein the purchase of modern improved varieties is coupled with chemical fertilizers. This discourages the use of farmers' local varieties and creates dependency on external farm inputs.

Moreover, the government's program for 'industrialization' as envisioned in Philippines 2000, which promotes high value crops meant for export, will likewise hasten the displacement of farmers' varieties.

Another issue confronting farmers concerns marketing. The strong, dominant market forces promote uniformity of agricultural products. The farmers' cooperative in the town, for example, operates a 'big' rice mill to service its more than 1,500 farmer members. Big mills are designed for uniform varieties and cannot handle the different varieties that many farmers now produce. The diversity of rice harvests now also causes additional work in drying, pricing, bagging, labelling, etc.

In fact, farmers are moving towards an alternative trading that would put value on their struggle for the conservation and development of PGR diversity. In fact, it will not be a value that is anchored primarily on the 'price' but rather on the proper recognition of their products.

The problem related to the tenurial status of farmers is considered crucial in community PGR system and sustainable agriculture efforts as a whole. Thirty percent of farmers in the area are tenants. The innovations of these farmers and the use of the indigenous varieties in larger areas therefore, are being hampered by the landowners' decisions.

CONCLUSIONS

In the effectiveness of conservation and the improvement of plant genetic resources, farmers' central role has to be properly recognized. Farmers for a millennia, long before the establishment of the formal systems, have been undertaking various forms of research. In fact, while continuing the utilization of these diverse resources, farmers have not only been engaged in conservation, but have also undertaken research for improvement as well. Crops are likewise allowed to evolve with the ever-changing conditions.

For more than a decade during the implementation of agricultural modernization and centralized forms of research, the whole agricultural system has changed. Hence, conservation and use of genetic diversity, in particular, and biodiversity, in general, should be properly linked with the agricultural transformation process.

The role of the formal systems and NGOs, however, can not be disregarded. These institutions can serve as a better support system in the process undertaken by farmers. NGOs like CONSERVE have proven the effectiveness of this approach--returning back the diversity to the hands of farmers and together building their capabilities as the main actors for sustainable agricultural development. A close partnership with farmers is found to be very essential to the whole process.

CONSERVING AGRICULTURAL BIODIVERSITY: THE CASE OF TEHRI GARHWAL AND IMPLICATIONS FOR NATIONAL POLICY

V. Jardhari and A. Kothari

ABSTRACT

In the face of massive erosion of crop diversity all over India, some farming communities are attempting to conserve and revive their traditional agricultural systems, characterized by the innovative use of a large range of cropping patterns, crop diversity over space and time, and cultural practices oriented towards maintaining this diversity.

Part one of this paper describes one such attempt, from the hilly Tehri Garhwal district of Uttar Pradesh. It briefly examines how agricultural development here has caused serious loss of crop diversity and farmer self-sufficiency. It then describes the efforts of the Beej Bachao Andolan, a farmers' movement, in reviving the use of indigenous crops and cropping systems and encouraging the growth of low-input organic farming.

Par two of the paper analyses the implications of this case study for India's agricultural policy. The paper argues that it is possible to combine diversity, productivity, and livelihood security in future agricultural policy. For this, strategies to be followed should emphasize a mix of high-productivity high-diversity approaches, building on indigenous biodiversity and knowledge, transformation of negative repatriation from genebanks, inter-farmer exchange, appropriate returns for wider use of farmers' knowledge and resources and the protection of critical agro-ecosystems.

AGRICULTURAL DIVERSITY IN TEHRI GARHWAL[1]

Traditions of prosperity

A few decades back, the tentacles of the Green Revolution started reaching farmers in the Himalayan foothills. Though a number of hill-dwellers have small holdings and have taken to employment in the plains, agriculture remains the mainstay of the economy of most of the region's people. True development in such a situation should have increased the agricultural self-reliance and livelihood security of these people, but the model imposed on the hills has resulted in the opposite. Today, the farmers of these hills are heavily dependent on grains and aid from the plains, to the extent that withdrawal of this support could lead to a famine situation.

However, it was not always like this. A brief historical look will show how prosperous the region's farmers were. Uttarakhand's well-known historian, Dr. Shivprasad Dabral, has described Garhwal of a century back as one in which all members of a family participated in agricultural work, had enough to eat, and remained healthy. British officials recorded that though there was little

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[1] The first part of this article is based on Vijay Jardhari's write-up in Hindi, translated and adapted by Ashish Kothari. The second part is written by Kothari, in consultation with Jardhari. We are grateful to Sarika Bhatia for her help.

Apart from Hemvalghati, the BBA is active in a limited way in the Bhagirathi and Balganga valleys of Tehri Garhwal, and in the Rath region of Pauri Garhwal. But though it is succeeding in reviving crop diversity and organic farming, it is also faced with formidable obstacles which have so far limited its spread. Chief amongst these is the present model of development, and the attitudes related to it. Economic and social incentives continue to be geared towards promoting monocultural farming with heavy chemical inputs. Scientists at the Govind Vallabh Pant Agricultural University in Garhwal dismiss the BBA as being ‘emotional’ and lacking a scientific base. However, farmers involved with the BBA reject this view, as they are firmly convinced that organic cultivation with indigenously developed seeds is the only path to self-reliance and prosperity. By now, they also have limited results to back up their claims. These results can be put to scrutiny; the BBA is convinced that its claims will be vindicated if this is done.

IMPLICATIONS FOR AGRICULTURAL POLICY

The unsustainability of the Green Revolution

The analysis of the decline and revival of a biologically diverse, organic, and farmer-centered agriculture in the Tehri Garhwal hills, presented above, is brief and, for reasons of space, necessarily simplistic. But it nevertheless presents elements of a formidable challenge to the current policy of agricultural development in India. This policy, which has remained unchanged in essence since the Green Revolution thrust in the mid-1960’s, emphasizes the intensification of agriculture with a heavy dose of inputs external to the local farming system (chemicals, lab-generated seeds, long-distance irrigation, subsidies and credit, and centralized extension services). The aim is single-fold: to increase grain output, at whatever cost. But while the imperatives of the situation in the 1960s may have forced our agricultural planners towards such a course, and while booming foodgrains output may continue to give this policy an aura of success, we now have three decades of experience to suggest that this success has been built on an increasingly fragile base. Hindsight tells us that this form of agricultural development is simply not sustainable.

The various ecological and social indicators of this unsustainability have been pointed out by many: loss of topsoil and essential soil nutrients which cannot be replaced by chemical fertilizers, waterlogging and salinization of irrigated lands, widespread chemical poisoning of soil, water, and food, rising expenditure on petroleum imports, the financial drain of subsidies, rising regional imbalances and inequities between various agricultural classes, and erosion of the genetic base. In the context of this paper, we will briefly deal with only the last of these.

The Green Revolution has directly led to the widespread loss of the very genetic and biological diversity on which agriculture depends. Unfortunately, there is no available figure of this overall loss in India. Some idea can be gauged by the fact that a handful of HYVs are now grown over 70% of the paddy land and 90% of the wheat land of the country. Some localized studies exist of the loss of traditional varieties. For instance, in the Godavari district of the east Indian state of Andhra Pradesh, an estimated 95% of the rice varieties have been lost. Thousands of varieties of rice, cotton, minor millets, pulses, and other crops are no longer in use. Similar decline has been seen in the case of livestock; it is estimated that 10 (50%) of the goat breeds, five (almost 20%) of the cattle breeds, and 12 (30%) of the sheep breeds are today threatened (Balain, 1992).

This erosion of agricultural biodiversity threatens the long-term stability and sustainability of Indian agriculture itself in many ways:

money with Garhwali farmers, they had adequate food from agriculture, clothing and bedding from various plant materials and sheep, and a barter system which brought them salt and other non-local produce. As far back as 1825, the following items were amongst those reported as going from the hills into markets in the plains: grains like wheat, rice, and buckwheat, millets, pulses, sesame, turmeric, saffron, ginger, tree bark, herbs, leather, cloth dyes, red chili, pomegranate, walnut, chilgoza nuts, horse chestnuts, narcotics, ghee, apricot oil, honey, wax, and musk. People would travel down to markets with these products, and return with jaggery, salt, and clothes.

The prosperity appears to have lasted at least till the end of the last century, indeed perhaps till a few decades back. Even now, one can find huge *datyas* (store-houses of grain) in villages, though there is now much less grain to fill them.

The advanced nature of traditional farming in the region is illustrated by the practice of *barahnaja* (literally, '12 seeds'). This is the name of a sophisticated intercropping system of rainfed hill farming. *Mandua* (finger millets), *ramdana* (amaranthus), *rajma* (common beans), *ogal* (buckwheat), *urad* (green gram), *moong* (black gram), *naurangi* (mix of pulses), *gahath* (horsegram), *bhat* (soybean), *lobiya* (French beans) *kheera* (cucumber), *bhang* (cannabis), and other crops, are grown together in a mixture which is finely balanced to optimize productivity and maintenance of soil fertility, and is geared towards meeting diverse household requirements. In such traditional cultivation, farmers had to spend almost nothing on inputs, since seeds, organic fertilizer and pest control were virtually free. Whenever they realized that conditions were suitable, they would start planting -- now, the first thing farmers do is to head towards the seed shops.

Agricultural progress or decline?

The hills now lack the fragrance of the local paddy varieties. As Antar Singh of Palas village says: "Now, the *maand* (paddy soup) of the new varieties is disliked not only by us but even by our cattle." The prosperous farming of *barahnaja* is being replaced by commercial cropping (soybean and other cash crops), which can feed the ventures of big industrialists (Indian and multinational). Farmers are being brainwashed into believing that traditional crops and cropping patterns like *barahnaja* are 'backward'. What we eat and do not eat, what we grow and should not grow, all this is being dictated from 'above'.

Garhwal's well-established and sustainable farming systems could not have been easily uprooted; the government machinery had to find subtle (and not-so-subtle) means of breaking the resistance. The main guise used was 'development'. Agricultural universities were heavily funded for R&D in 'more productive' agriculture; the electronic, print, and even oral media were used to the maximum to promote so-called high yielding varieties (HYVs), chemical fertilizers, and pesticides. Farmers were distributed free samples of these inputs, and heavily controlled demonstration plots were cited as examples of their efficacy.

Though initially resistant to the new agriculture, farmers were increasingly lured by the dramatic rises in productivity which some HYVs displayed, when fed with fertilizers and protected by pesticides. Unfortunately, what no one foresaw was the short-term nature of this phenomenon. As free inputs taper off, and productivity begins to stagnate, farmers start realizing that they are trapped in an economic treadmill—running harder and harder to stay in the same place. Meanwhile, however, they have abandoned their traditional seeds and practices, and find themselves dependent on the government and private sector to provide them necessary inputs.

They cannot even ignore expensive chemical inputs, since the HYVs are as dependent on them as a newborn child to mother's milk.

Farming was traditionally an important part of culture—perhaps that is why it was called agriculture. Apart from labor and intelligence, the farmer had to put in very few external inputs; seeds, manure, herbicides, all came from the agricultural system itself. Social practices, rituals, festivals, and relations were intertwined with farming operations. But the new agriculture—or rather, agronomy —is changing the whole value system. Farming is now commerce: make an investment and hope for maximum profits. Cropping for domestic consumption gives way to cropping for the money market. Animal husbandry, once an integral and valued part of agriculture, is relegated to secondary importance, as chemical fertilizers replace dung, machines replace draft power, and the cattle that are kept are seen only as factories for milk or wool or meat production. HYVs yield little fodder, in some cases almost none (e.g. soybean or dwarf wheat), whereas traditional crops like millets fulfilled at least 25% of the fodder needs.

Reviving bio-diverse agriculture

The realization that the Green Revolution has become a trap has forced many farmers in Garhwal to seriously reconsider their options, and at least some are turning to their traditional systems for answers. Village elders recall their old seeds and practices; unfortunately, many are simply no longer locally available.

Responding to this crisis around them (and in their own lives), workers of the Chipko Movement have initiated the *Beej Bachao Andolan* ('Save the Seed Movement'). Individually, some of them started reusing and conserving indigenous seeds about a decade back, but the *Beej Bachao Andolan* (BBA) was started in 1990-91.

At the time the BBA began, the Hemvalghati region of Tehri Garhwal had only two to three indigenous rice varieties left in cultivation, and most of the *barahnaja* fields had been converted to new soybean. BBA workers traveled extensively through Tehri Garhwal and Uttarkashi districts, and found several remote areas where agronomy had not replaced traditional farming. Here, indigenous crop diversity survived. The BBA workers collected these crops and began growing them on an experimental basis in the Hemvalghati region. Today, some 126 varieties of rice, 8 of wheat, 40 of finger millet, 6 of barnyard millet, 110 of common beans, 7 of horsegram, 8 of traditional soybean, and 10 of French beans, are being grown. No chemical inputs are being provided. The characteristics of each—growth, resistance, special properties, and so on—are being carefully observed. Varieties with desirable properties, like high productivity and resistance, are being propagated amongst other farmers. Seeds are given to these farmers in return for an equivalent amount of their seeds. Practices like *barahnaja* are being revived and encouraged in place of the new soybean.

The aim of the BBA is to revive and maintain the prosperity represented by traditional agriculture in which humans, other animals, and nature can live in some harmony. The earth is considered a mother from whose breasts humans can drink, and not as an inanimate object to be butchered and exploited. After all, if varieties once disappear, how can they be brought back? It is said that even if seeds disappear from farmers' fields, they can be conserved in genebanks. But a seed is alive only on a farm, and the mechanisms of increasing diversity, such as farmer exchange and evolutionary modifications, are possible only when seeds continue to be in active use. Farmers fields are living genebanks.

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The various ecological and social indicators of this unsustainability have been pointed out by many: loss of topsoil and essential soil nutrients which cannot be replaced by chemical fertilizers, waterlogging and salinization of irrigated lands, widespread chemical poisoning of soil, water, and food, rising expenditure on petroleum imports, the financial drain of subsidies, rising regional imbalances and inequities between various agricultural classes, and erosion of the genetic base. In the context of this paper, we will briefly deal with only the last of these.

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traditional cropping areas could be promoted. Typically, the former has been more successful in irrigated plains, while the latter has held out in rainfed plains and hilly, marshy, or otherwise 'marginal' lands. Foodgrains productivity from the former would be needed in the transitional phase to sustainable farming; eventually, however, even Green Revolution areas will need to switch to organic inputs and diversified production patterns. This would include a change from monocultures to the use of diversity within species (e.g., varieties of rice), between crop species (e.g., fish and paddy), and so on. An immediate task would be to encourage the continued use of traditional seed varieties and livestock breeds for domestic consumption, which many farmers even in Green Revolution areas are practicing.

2. Building on indigenous biodiversity: Intensified research is needed on indigenous crops and crop varieties, and livestock breeds, for their desirable characteristics like productivity and resistance. The BBA farmers report, for instance, that Thapachini paddy variety, traditionally grown in Garhwal, yields as much as modern HYVs, with much less inputs. The early work of scientist R.H. Richharia on paddy is famous for this focus. Some government and non-governmental agencies have more recently also emphasized this, but a more systematic national policy thrust is lacking. The research will also necessarily have to be site-specific, sensitive to the enormous ecological and social diversity found in India. Most critically, maximum initiative for R&D (including breeding) must be placed in the hands of farmers themselves.

3. Transforming economic incentives: A whole host of disincentives to biodiverse, organic farming will have to be withdrawn, and changed to positive incentives. Subsidies for Green Revolution inputs should change to subsidies for organic inputs, at least temporarily during the transitional phase, till organic farming becomes self-sustaining. Bank loan policies and credit systems, extension services, pricing strategies, media promotion, farmers' training programs, social recognition and economic rewards ... all of these, currently geared to promoting the Green Revolution model, should be focused on the new sustainable farming models. As suggested by a number of people, even the Public Distribution System (PDS) should be geared towards promoting the consumption of a variety of foods, rather than only rice and wheat. Several traditional cereals, for instance, could be included in the grains picked up and sold through the PDS, thereby providing incentives for their continued cultivation.

4. Producer-consumer links: Direct links between farmers and consumers who want safe and diverse food, need to be established. There is increasing concern among urban consumers about the ill-effects of food laden with pesticide residues. This concern could easily be transformed into a willingness to purchase organic food, even if such food is slightly more costly. The *Beej Bachao Andolan*, for instance, has established such links with Kalpavriksh, a Delhi-based environmental group, which is helping it to market some of the surplus organic produce from the villages BBA is active in.

5. Repatriation from genebanks: A considerable diversity of indigenous crops no longer used in farmers' fields is stored in various genebanks, established by the Indian government or by international agencies. Technically, this material is freely available to farmers. However, most farming communities are not even aware of these banks, and even those that are rarely have the wherewithal to approach the banks for varietal material. There needs to be an active process of repatriation and distribution of this material, even in its unmodified form ('unimproved', to use the biased terminology of formal seed breeders), for farmers to try within new or revived organic cultivation practices. This should include repatriation from international genebanks.

6. Farmers' exchange: Revival of crop diversity can also be facilitated by encouraging across-the-fence and long-distance exchange and transfers among farmers and farming communities.

Such practices, which are age-old and are still the major mechanism by which seed is made available to farmers, are threatened by the moves towards introducing intellectual property rights (IPRs) in plant materials. These moves have to be firmly rejected in any agricultural policy which claims to be sensitive to biodiversity concerns.

7. Returns to farmers: Considerable agricultural advances have taken place on the basis of genetic characteristics derived from varieties developed by farmers, or on the basis of farmers' knowledge. The profits derived from such use have, however, been largely restricted to the formal agricultural sector (governmental and corporate). Ensuring returns to the farming community is an important means of providing incentives for conservation and innovation. These returns can be in cash (germplasm collection fees, royalties, etc.) or in kind (natural resource rights, developmental inputs, seed repatriation, social recognition, etc.), but must be built on the principles of prior informed consent of the farmer/farming community, and mutual agreement between the parties concerned. The Philippines has recently promulgated guidelines on collection and transfer of genetic material, with important provisions for ensuring returns to local communities. Also, a range of Material Transfer Agreements are being proposed in international circles as contracts between providers and recipients of genetic material. The relevance and suitability of these developments should be analyzed for Indian situations.

8. Protecting critical areas: There is an increasing recognition in India of the need for a comprehensive land/water use policy and strategy, in which areas important for conservation are identified and declared off-limits to exploitative use. A concern for agricultural diversity is, however, still missing from this thrust. We would recommend urgent identification of areas in India which still retain indigenous agricultural biodiversity, and their declaration as special conservation areas. Farmers in such areas should be at the center of planning, and be specially targeted to receive incentives for biodiversity conservation and use.

All these steps will have to be placed within a model of agriculture which has, as its central principles, the following: farmer self-sufficiency, ecological (including genetic) sustainability, socio- economic equity, and cultural pluralism. Unfortunately the new move towards integrating Indian agriculture into the global market, with its attendant thrust towards turning farming into an export-oriented, large-scale, corporate industry, violently militates against these principles--so do developments like the General Agreement on Tariffs and Trade (GATT), and the International Convention for the Protection of New Varieties of Plants (UPOV). On the positive side, there is increasing recognition of *in situ* conservation and local community rights in international treaties like the Convention on Biological Diversity, and FAO's International Undertaking on Plant Genetic Resources. Within India, agricultural community rights have found a place in the proposed Plant Varieties Protection Act, though the fundamental premise of the Act itself is problematic, as it encourages private monopoly over biodiversity elements. Principles of conservation and of providing returns to communities are included in the proposed biodiversity conservation legislation currently being considered by the Government of India. The bottom line, however, is provided by efforts such as those of the *Beej Bachao Andolan*; farmers' own assertion of ecological and economic self-reliance is the strongest base for a sustainable agriculture.

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MAINTENANCE AND CONSERVATION OF 'HEIRLOOM' VARIETIES IN INDIAN AGRO-ECOSYSTEMS

J.K. Maheshwari

ABSTRACT

India is one of the megadiversity zones of the world, showing wide agro-climatic, geophysical and ethnic variation. At least 167 crop species and 320 wild relatives of crops have their primary, secondary or regional centers of diversity here. The tribal-inhabited belt is particularly the center of domestication and has remarkable genetic diversity in food crops.

In recent decades, the Green Revolution of modern, high yielding varieties (including hybrids) has displaced the vast mosaic of traditional crop varieties. There is no systematic information on the loss of genetic diversity in Indian agriculture, but the available data indicate an advanced stage of genetic uniformity in crop plants. Despite such a trend, many 'heirloom' varieties are still maintained by gardeners, farmers and tribals in isolated rural and tribal areas, and are also available in the tribal markets - 'hat'. Due to rural-urban migration, tribal acculturation and constantly shrinking rural populations, there is a real danger of extinction of many traditional varieties. Home gardens (variously termed as kitchen gardens, forest gardens or heritage farms) can be encouraged and should play a major role in the conservation and maintenance of living 'heirlooms'.

The concept of farmers' rights aims to recognize the past and present contributions of farmers and tribal communities, especially in the developing world, to the creation, conservation and availability of biodiversity. The domestic patent and intellectual property rights legislation should include provisions to maintain the farmers' privilege of planting saved seed in successive seasons. A dynamic farmer-based approach to landrace conservation, enhancement and utilization is recommended and agro-ethnobotanical knowledge must be tapped, in conjunction with modern scientific advances. With changing socio-economic structures, this knowledge may not be passed from generation to generation and may be lost forever.

INTRODUCTION

Over the past few decades, the Green Revolution of modern, high yielding varieties (HYVs) (including hybrids) developed by the national and international agricultural research centers has quickly displaced the vast mosaic of traditional crop varieties in many Third World regions. In India, the first maize hybrid was released in 1961 for general cultivation, followed by hybrid varieties of sorghum, pearl millet, and non-hybrid, high yielding varieties of rice and wheat. By 1991, the rice-wheat cropping system covered nearly 10 million ha in India. The new cultivars emerging from various agricultural research centers and private companies were, from the very beginning, uniform and very few in number, compared to the great diversity and number of landraces or folk varieties. Today, farmers only grow landraces in small pockets and many have disappeared forever in the wake of modern agriculture, although some have been collected and stored in genebanks. The erosion of crop genetic diversity poses a serious threat to food supplies. The Food and Agriculture Organization (FAO) estimates that, since the beginning of this century, about 75% of the genetic diversity of agricultural crops has been lost. In developing countries, the Green Revolution is being criticized on the grounds that marginal and smallholder farmers could not afford intensive use of external inputs, increased irrigation and mechanization of labor. It increased landlessness, and resulted in loss of income for women, promoted inappropriate technology, environmental degradation and, in places, even the elimination of small farmers. It is projected that in India alone, there will be 44 million landless rural households by the year 2000.

As an alternative strategy to the Green Revolution, traditional agro-ecosystems, based on the cultivation of a diversity of crops in time and space (varietal mixtures, inter crops, multiple crops, home gardens and polycultures), have proved to be sustainable in their historical and ecological contexts. This is illustrated by a once-common practice of the Garhwal Himalaya, the *barahnaja*, involving the sowing of a mixture of 12 or more crops (common bean, black gram, green gram, horse gram, amaranths, finger millet, barnyard millet etc.) in a single plot of land, and harvesting the same at different times to ensure a constant supply of food. It is said to give a higher overall productivity, apart from meeting diverse needs, as compared to the agricultural agencies' recommendation of converting the same fields to soybean monoculture. (Kothari, 1994). Over much of India, the traditional agro-ecosystems have been disrupted (Figure 1). About 175 million ha, or over 50% of the total geographical area in the country, is affected by problems of land degradation, through salinization, flooding, drought, accelerated erosion, water logging, etc. (Table 1).

Table 1: Soil Erosion and Land Degradation in India

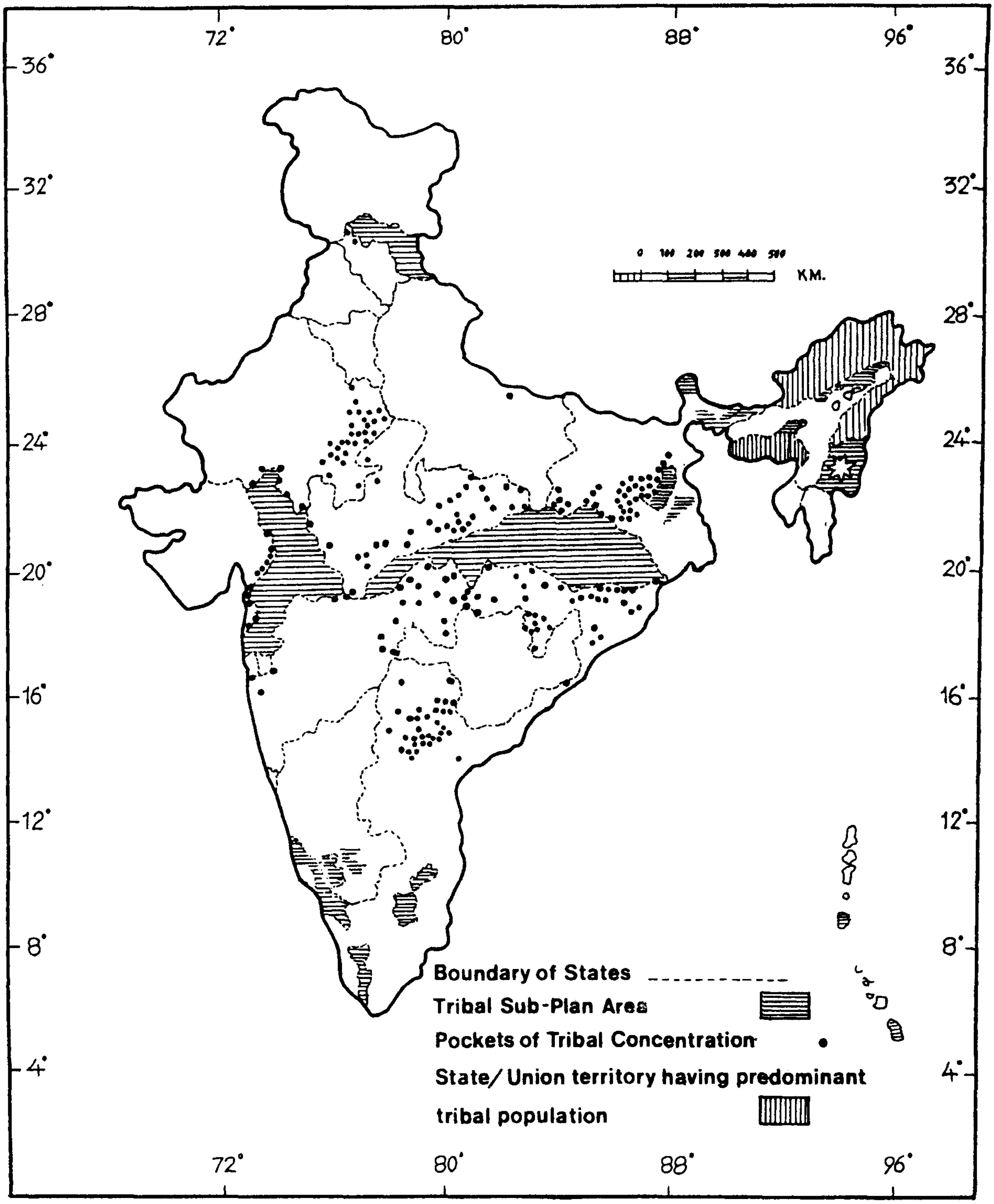
1.	Total geographical area	329.0 [1]
2.	Area subject to water and wind erosion	150.0
3.	Area degraded through special problems	25.0
	Water logged	6.0
	Alkaline soil	2.5
	Saline soil, including coastal sandy areas	5.5
	Ravines and gullies	3.9
	Area subject to shifting cultivation	4.4
	Ravine and torrents	2.7
4.	Annual average loss of nutrients from land estimated in 2 and 3	5.4 to 8.4 mt
5.	Total flood-prone area	40.0
6.	Total problem area	175.0

[1] Except where noted, figures represent area in m ha.

Source: Fertilizer Statistics, 1987-88

There is, at present, no systematic information on the loss of genetic diversity in Indian agriculture, but the available data indicate an advanced state of genetic uniformity in crop plants. It is estimated that just a few decades ago, Indian farmers grew more than 30,000 different varieties of rice, but in another 15 years, this enormous diversity will be reduced to no more than 50 varieties, with the top ten accounting for over three-quarters of the subcontinents' rice acreage

Figure 1: Map of India showing predominantly tribal areas



(Mooney, 1983). Unless their seeds are replanted by the farmers, these outstanding varieties will be lost forever. Many of these 'heirloom' varieties (seeds passed down from generation to generation) are still maintained by gardeners, farmers and tribals in isolated rural and tribal areas, and are often available in the kitchen gardens, courtyards or home gardens. Today, due to rural-urban migration, tribal acculturation and extinction, and constantly shrinking rural populations, elderly farmers and seed savers often cannot find anyone who will continue growing their living 'heirlooms'. The rapid disappearance of many traditional varieties of grain and vegetable crops (rice, wheat, sugarcane, cotton, minor millets, pulses etc.) has been described as a botanical holocaust.

An all-India Coordinated Research Project on Ethnobiology was recently designed under the Man and the Biosphere Program to identify the plant and animal wealth in tribal areas which are under serious threat of extinction and to suggest strategies for their conservation and management. These studies have revealed that over 9500 plant species are used by the tribals for food (3900), medicine (7500), fibre and cordage (525), fodder (400), pesticides and piscicides (300), gums, resins and dyes (300), incense and perfumes (100), and other material and cultural requirements (700). This role of peasants, subsistence farmers and tribals in the conservation, promotion and dissemination of crop genetic diversity is being formally recognized by the international community. By conscious and continuous selection, farming and tribal groups have created and maintained many traditional varieties of different crops. It is in these traditional societies that an immense genetic diversity has persisted unimpaired for millennia, even after a crop has highly evolved elsewhere.

The preservation of genetic diversity in genebanks has short-term utility for research and development and is easily susceptible to accidents, such as power failures, and to genetic drift and loss of seed viability. More than 60 genebanks were built and more than 3 million seed samples were placed in storage, offering both temperature and humidity controls. In the 1980s, studies showed that these banks were mere tombs, rather than storehouses, and that the rate of genetic erosion was actually greater in storage than in the field. The only way we can hope to save the crop genetic diversity is to protect the diverse ancestral genotypes in their cradle region and on farmers' fields by 'freezing' the genetic landscape, even to the extent of subsidizing the traditional agro-ecosystems. In the case of truly wild progenitors and relatives of crops, we need to preserve them outright and manipulate their habitats, as in a wildlife preserve, *in situ*. It is only by the rigid protection of specific local agro-ecosystems and genetic landscapes that we may be able to preserve the vast array of potentially valuable landraces or folk varieties, and provide long-term success in continuing the evolution of our crops.

INDIAN REGION--A CRADLE OF AGRICULTURAL BIODIVERSITY

India is the seventh largest (3,290,000 km^2) and the second most populous country in the world. Its wide agro-climatic, geophysical and ethnic diversity, and its location at the confluence of three biogeographic realms (Palaeractic, Afro-tropical and Indo-Malayan) contribute towards making India one of the megadiversity zones of the world. It has also got two hot spots areas for biodiversity, one being in the northeast and the other in Western Ghats. There are 16 forest types and 251 sub-types in India. The region has been divided into 21 agro-ecological zones, which offer nearly every ecological situation in the world, and which are separated by natural features and crop growing periods, namely the arid zone with a growing period of less than 90 days, the semi-arid region with a growing period of 90-150 days and the sub-humid region with a growing period of 150-210 days. The humid and hyperhumid regions correlate well with a growing period of 210-270 and more than 270 days per year, respectively. Each of these agro-ecological zones is in turn comprised of myriad micro-habitats. It is within this diversity of habitats that an amazing variety of crops and livestock has been developed over the millennia of Indian farming.

The diversity is amply reflected in about 75,000 species of animals and 45,000 species of plants existing in India. At least 167 crop species and 320 wild varieties of crops have their primary, secondary or regional centers of diversity in the region. These include fruit trees (mango, banana and citrus), vegetables like eggplant, okra and cucurbits (melons and gourds), legumes (mung bean, urd or black gram and cowpeas), rice, pepper, cardamon, ginger, turmeric, sugarcane, jute and various medicinal and oilseeds, spices, vegetables, fodders and plantation crops. To give some examples, one species of rice (*Oryza sativa*) has diversified into at least 50,000 distinct varieties, and one species of mango (*Mangifera indica*) into over 1000 varieties ranging from the size of the peanut to a small pumpkin. Finger millet or *ragi* (*Eleusine coracana* ssp. *coracana*), after its introduction from East Africa several thousands years ago, developed important characteristics in South Asia; and the region is now an important source of its genetic diversity. Several landraces of drum wheat (*Triticum durum*) known under the names Kathia types, Jalalia, Bansi, Tambai katha, Kala-salu and Malwa types, and varying in grain quality and lustre occur in Madhya Pradesh. Ethnic diversity has played a major role in the diversification of crop genetic resources in the region. The ancestors of many of our crop plants and landraces or folk varieties are interwoven with tribal cultures (Maheshwari, 1991; Khoshoo and Sharma, 1991; Paroda and Arora, 1991).

HOME GARDENS AND AGRO-BIODIVERSITY

The tribal-inhabited belt is more often the center of domestication and genetic diversity of food crops (cereals and pseudocereals, millets, grain legumes, vegetables, spices and condiments, oil plants etc.), being maintained by peasants and subsistence farmers. These areas hold unique and important genetic materials which should be strictly protected against heavy grazing, intensive farming, commercial logging, construction of highways, dams and hydro-electric stations, resettlement projects, mining operations, etc. The genetic diversity is held by the tribals in their dooryard gardens, *baris* (land attached to their houses and huts), kitchen gardens and in fields. Some examples of such cultivated crops are *Piper peepuloides*, *Parkia roxburghii*, *Moghania vestita*, *Vigna umbellata*, *Inula racemosa*, *Coix lacrymajobi*, *Digitaria cruciata* var. *esculanta*, *Hodgsonia heteroclita*, and several species of *Alocasia*, *Colacasia*, *Amorphophallus* and *Dioscorea* cultivated by the tribes in northeast India.

The primitive cultivars grown by farmers are valuable sources of genetic material for modern plant breeding. IR-72, a modern variety of rice (*Oryza sativa*) was developed by crossbreeding 22 landraces from seven nations: India, Indonesia, China, Philippines, Vietnam, Thailand and Malaysia (Table 2). In 1969, *O. nivara*, a wild rice from India, was discovered to resist grassy stunt virus (GSV). It was crossed and backcrossed with IR 24 three times to produce a variety resistant to GSV and with IR 24 grain qualities.

Harshberger (1896) for the first time outlined the purpose of ethnobotanical gardens. The plants of ethnobotanical importance like maize, sunflower, tomato, potato, tobacco, rice, pumpkin, yam, taro, arrowroot, cassava, sweet potato, amaranths etc. associated with tribal people were grown over the ages as part of the life-support system for survival, subsistence and livelihood of tribals.

Table 2: Pedigree of IR-72 - A modern variety of rice

Twenty-two ultimate landraces	
INDIA	**CHINA**
Oryza nivara	Cina
Arikarai	DGWG
Eravapandi	Pa Chiam
Gowdalu	Tsai Yuan Chan
Kitchili Samba	
Latisail	**PHILIPPINES**
Mudgo	Marong Paroc
Thekkan	Sinawpagh
Vellai Kar	Tadukan
Unknown Variety	
Unknown Variety	**VIETNAM**
	Tetep
INDONESIA	
Benong	**THAILAND**
	Gam Pai
MALAYSIA	
Seroup Besai	

In modern times, these gardens, also referred to as indigenous gardens, home gardens, forest gardens and heritage farms, should play a major role in the conservation and maintenance of 'heirloom' varieties of economic plants. People in rural communities could been encouraged to construct ethnobotanical nurseries where locally useful species could be cultivated. This would not only provide a source of medicinal and edible plants, but would also serve to familiarize younger people with the herbs that were traditionally used in the community. The cultivated plots could serve as demonstration gardens where over-harvested wild species could be brought into cultivation and eventually integrated into home gardens or managed forests.

Home gardens, are generally characteristic of the humid tropics. They represent intensive, multi-storied combinations of crops, trees and livestock, and are the dominant form of land use in Kerala and northeast India. These gardens have many variations, but all are designed to supply family requirements of food, fodder, fuel and timber, and to generate additional income through the sale of surplus products. A typical example of a multi-storied system might include coconut + black pepper + cocoa + pineapple, grown primarily for sale, in addition to family food crops. The most important crops are coconut and cassava in upland areas and rice in the lowlands. Other tree crops include cocoa, jackfruit, cashew, arecanut (betel), nutmeg and clove, as well as teak, *Pterocarpus marsupium*, *Erythrina variegeta*, *Artocarpus hirsuta*, *Bombax ceiba*, *Albizia falcataria*, *Ailanthus excelsa* and bamboo grown for timber, fodder and fuel, and to support vines. Agricultural crops include sugarcane, sweet potato, colocasia (taro), yams, pulses, vegetables, sesame, ginger and turmeric. Livestock form the third component with cattle, goat and poultry the most common domestic animals. Home gardens are economically viable, ecologically sound and biologically sustainable (Abdul Salam and Sreekumar, 1991).

TRIBAL MARKETS- 'HATS'

The tribal markets, as seen in tribal areas of the country, represent a distinct organizational structure in the tribal societies. The *hat*, as it is known locally, is a weekly marketing facility evolved by the tribals for the sale or barter of minor forest produce (MFP), seasonal vegetables, fruits, seeds, tubers and other commodities. It is the only center of economic activity in the tribal area, and to attend the weekly markets, the tribals may have to cover a distance of over 25 km on foot. They collect wild and cultivated plants, forming the basis of several cottage and rural industries like those of herbal drugs, fibers and flosses, bamboo and canes, oils and fats, cordage, mats and basketry, oilseeds of forest origin (*mahua*, *sal*, *neem*, *karanj*, etc.), gums, resins, tanstuffs, guggul or incense materials, dyes, fermented drinks, soap and cosmetics, toys, drums, musical instruments, Kattha extraction, agricultural implements, brooms and brushes, perfumes (sandalwood oil, Khus oil), etc. *Tendu* (*Diospyros melanoxylon*), leaves of which are used as wrappers for cigarettes (*bidi*), is another important non-timber product of the forests. These products are derived from over 1000 plant species (FAO, 1994).

With a view toward helping the tribals in their economic development, tribal cooperative societies have been organized in different states. At the national level, the Tribal Cooperative Marketing Development Federation of India, Limited (TRIFED) was set up in 1987 to handle items of tribal produce. It has also been declared as the central, nodal agency for organizing collection, processing, storage and development of oilseeds of tree and forest origin (Maheshwari, 1990).

CONCLUSIONS

There is a growing recognition of the need for a crash program of agro-ethnobotanical studies in every agro-ecological zone of the country, before land degradation leads to the permanent loss of genetic diversity of crops. The systematic study of the botanical knowledge of indigenous people and other ethnic groups, and of the use of locally available domesticated plants and their landraces or folk varieties has been called 'agro-ethnobotany'. (Agro-ethnobotany might cover realms of foods, medicines, clothing or religious rituals.) Until recently, *in situ* conservation programs have focussed on forest genetic resources, both at the national level and internationally under the leadership of FAO, while there has been little attention to the *in situ* conservation of crops and their wild relatives. The landraces and other farmer varieties would not meet the criteria for Plant Breeder's Rights (PBR) protection under the Union for the Protection of New Varieties of Plants (UPOV) Convention that varieties must be distinct, uniform and stable. Because the traditional varieties are often variable and, therefore, important sources of genetic diversity, they cannot be protected under existing PBR schemes. Hence, the domestic patent and intellectual property rights (IPR) legislation should include provisions to maintain the farmer's privilege of planting saved seed in successive seasons.

The role of small-scale farmers and their traditional varieties, farming systems and knowledge in developing a truly sustainable agriculture may have been neglected by the formal research system over the past decades. Agro-ethnobotany provides an useful tool in determining the amount of agro-biodiversity present, its current status and future strategies. India is inhabited by about 450 tribal communities, constituting about 8 % of the total population of the country. Their knowledge about specific plant usage is transmitted largely through word of mouth and tradition. Much of this agro-ethnobotanical knowledge has, therefore, remained endemic to certain regions or tribes, and needs to be systematically surveyed, documented and utilized (Maheshwari, 1988). Agro-ethnobotanical information is key to preventing the loss of irreplaceable genetic resources. There are still 74 primitive tribal groups in the Indian region, who were identified on the basis of their pre-agricultural level of technology, low level of literacy, and stagnant or diminishing population (Table 3). They are the traditional conservators of biodiversity at the grassroots. A dynamic farmer-led approach to landraces conservation, enhancement and utilization is recommended.

Table 3: Primitive tribal groups of India

	State/UT	Primitive Tribal Groups	Total No. of Households
1.	Andhra Pradesh	Bodo-Gadaba, Bondo Poroja, Gutob Gadaba, Khond Poroja, Parangi Poroja, Thoti , Dongaria Khonds, Konda Savaras, Kutia Kondhs, Chenchu, Kolam, Kohda Reddies	21563
2.	Bihar	Asur, Birhar, Birjia, Savar, Hill Kharia, Korwa, Malpaharia, Parhaiyas, Sauria Paharia	33788
3.	Gujarat	Kathodi, Siddis, Kolgha, Kotwalia, Padhar	12101
4.	Madhya Pradesh	Abujhmarias, Baigas, Bharias, Hill Korwas, Sahariyas, Kamar	103362
5.	Maharashtra	Maria Gond, Katkari, Kolam	40622
6.	Orissa	Birhor, Didayi, Mankidias, Lodha, Bondo, Dongaria Kondhs, Kutia Kondhs, Lanjia Saora, Paudi Bhuyan, Saora, Kharias, Juangs	36144
7.	Rajasthan	Sahariyas	7000
8.	Tripura	Riang	12935
9.	West Bengal	Birhor, Tota, Lodha	9378
10.	Uttar Pradesh	Rajis, Buxa	2074
11.	Karnataka	Jenu Kuruba, Koraga	2652
12.	Kerala	Cholanaickans, Kadar, Kurumbas, Kattunaickans	1373
13.	Manipur	Maram, Nagas	908
14.	Tamil Nadu	Kattunaickans, Kotas, Todas, Irulas, Kurumbas, Paniyans	4000
15.	Andaman and Nicobar Islands	Great Andamanese, Jarawas, Onges, Sentinelese, Shompens	102
	TOTAL	72	288002

There is also a clear need for enhanced collaboration and closer ties between the farmer-based informal system of varietal diversity associated with traditional agroecosystems and formal systems of research laboratories, plant breeders and private companies. The involvement of small-scale farmers and tribals in the future conservation of domesticated biodiversity needs to be strengthened and expanded to cover a broad range of agro-ecological conditions and strategic sites in the region. Agro-ethnobotanical studies are needed in areas where traditional farming is still widely practiced to learn new uses for wild and domesticated plants, to improve communication between farmers and scientists, and to provide long-term continuity in national research programs. Traditional knowledge about local varieties and landraces must be tapped, in conjunction with modern scientific advances. With changing socio-economic structures, this knowledge may not be passed on through the generations and may be lost forever.

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a variety which will behave like the Brahmin's Cow, which will eat less and produce more grain. Even the variety mentioned, Kapachini, gives 74 Qtls per hectare--yet it also impoverishes soil fertility. They are not synthesizing nitrogen. There are others which are giving consistently about 4 tons per hectare.

JARDHARI: [Editors' note: translated from Hindi]. Pantnagar University has spent a great deal of time and effort in trying to produce soybean to replace the kind of cultivars that are being grown in the hills. Why has Pantnagar not spent equal time and effort to improve the '*Barahnaga*' [agricultural system of sowing twelve crops]. Why has this traditional system been ignored to improve upon as a mode?

GHILDYAL: The reason is that if you grow five or six crops together--rice, pulses, maize, sorghum--then the total yield becomes very very low. If the yield of maize can go up to 80 tons per hectare, then it may be giving eight tons only. ...Soybean was recommended because it was found to be a solution for oilseeds and proteins, both.

SAHAI: In fact, nobody wanted it.

GHILDYAL: Because 'bhatt' is being grown in the hills, the rhizobium culture is available and the production of soybean has been excellent. The question is that soybean cannot be eaten by farmers nor can it be marketed, unless you have a processing factory. So we started a processing factory at Nainital and that factory is now taking all the soybean and producing oil and soybean cake.

JOSHI: I want to comment on monocropping. While it may give the best returns from optimum environments, the same is not true when you are talking of stress situations. We have calculated economic benefit in mixed cropping systems (like maize-millet, wheat and barley) and it is also beneficial, in Nepal, to have two component crops in rainfed and stress environments.

SPERLING: A question on the work of CONSERVE. You are doing something very different from others here in that you have a back-up bank and then an intermediary group of farmer curators who then pass on seed to farmer users. My questions are on these farmer curators. What kind of people are they? Are they subsidized? What kind of role do they have in the community? Why do you feel that this intermediary group is necessary?

MAGNIFICO: These farmer curators are actually the original farmers. They are members of the farmers' cooperatives, the farmers' organizations and they have been trained by us, the staff, about conservation: some technical aspects, crop improvement. In the beginning, with about 45 cooperators, we distributed only 100 gms. of seeds, but at least ten different varieties per farmer, and no compensation was given. At the start, we even had a budget to compensate for some loss to the farmers. But realizing the value of these genetic resources, the farmers said there was no need to subsidize because they were sowing very small plots and that, even if the varieties failed, there would be no great loss. But in the process of propagating and observing these seeds, farmers were able to select the better potential varieties. So eventually they increased the area under this organic system and because of that other farmers were eager to join. As of the end of 1994, we have 106 cooperators.

SPERLING: Are they men or women? Does it make a difference?

MAGNIFICO: Most of the farmer cooperators are men, but in terms of farm work, women also have their role. Even the whole family might be engaged in breeding: the children are participating, the wife is participating in the decision on what variety to be crossed and what should be planted on a larger scale. So, the whole family is actually involved.

BERG: I would like to draw attention to one point which was made in Jardhari and Kothari's paper. They said that seeds in communities were traditionally considered as communal property and that this kind of virtue in a community is about to be lost. This is something which we see everywhere. I think it has a universal value in traditional communities and it is a logical consequence of the fact that the seeds are evolving through communal achievements and once the traditional seed systems are being replaced by a modern seed system, these values are, obviously, being lost. Now when we start discussing and experimenting with participatory breeding, there is a possibility of reversing this trend in erosion of values because in participatory breeding, we are dealing normally with organized farmer groups. Again, we reconstitute a kind of communal nature and participatory common nature in the improvement of seeds and then we have a chance of maintaining a feeling of having seeds as a common property within the community.

RILEY: A question to all those who are seedbanking. Many of papers are talking about seed genebanks which seem to be either very short-term or to protect heirloom varieties or some other types over a longer period. What is the range of the number of years in which various groups would like to protect their seed: from one year, two years, tens years? That would give us a good estimate about what kind of seed banks we need to look at.

WELTZIEN: Also a question to all groups. I understand most of these seedbanking efforts are fairly new and so experience is building up. I was wondering whether any of these you have a concept of introducing some more dynamics into your conservation efforts towards letting farmers improve what they have in these traditional varieties. Conservation per se is a valuable goal, but I think most farmers would also be interested in improving their conditions. They don't live in a static situation, for instance, the environment is changing. So are there any plans to introduce more dynamics into their local systems?

SAHAI: (Chairman). Both these questions, on dynamics and duration, should probably be answered in the interactions later on because several groups want to express their opinions.

LOEVINSOHN: There is a strong sense from several presentations this morning that what is being lost is more than just material--that it is a sense of involvement and control over the process, the life-giving processes in which people work. The genebanking and seedbanking efforts that are being described, some in embryo, are an attempt not just to conserve the material, but also that sense of control. Participants have said that farmers are not prejudiced against modern varieties or HYVs *per se*, it is the way in which they are presented; people don't believe they control how the choices are made. It is that sense of involvement that has to be maintained. Coming back to the approach proposed by J. Witcombe, if we only restrict attention to the varieties that have been released, I think that may do very little to help preserve the sense of people's involvement in the process. The recognition of what farmers have accomplished through generations of selection of local material has to be maintained and an even playing field in which local and modern varieties are compared has to be preserved.

KOTHARI: A question for Dr. Maheshwari. There has been some concern about the information and knowledge you having been gathering in these last ten years of your project, which is currently being stored at Trivandrum. Who controls this incredible amount of knowledge that you have? What is the guarantee that it will not misused by commercial or government interests? Is there any conscious policy of returning benefits, knowledge or something like that to communities from whom all this originated? And so on--the whole range of issues involved with the control over a knowledge system.

MAHESHWARI: The All India Coordinated Project on Ethnobiology was formulated in 1977. I prepared a draft report and submitted it to the department of Science and Technology. There were two other great scientists involved: Dr. M.S. Swaminathan and Dr. K.N. Khoshoo. At the time this working group was formed, there were no such problems. The problems have come after the post-GATT developments about protecting IPRs, etc. So, it started as a Government of India Project; we collect the material and whatever material has been collected is safe. Research reports have been prepared and submitted. During the transitional period, there has been some talk about IPRs but nothing has been mentioned in drafts.

For example, at the Central Drug Research Institute (CDRI) at Lucknow, they have already gone ahead with the product patents because the product patents are apart from the process patents. But as far as the biological material is concerned, I think we are still in the nascent state. We have to formulate and sort out ideas and make a strategy known.

INSTITUTIONAL REFLECTIONS

A ROLE FOR ICRISAT IN ENHANCING AND MAINTAINING GENETIC RESOURCES ON-FARM

J. Lenné, E. Weltzien R. and J. Stenhouse

ABSTRACT

CGIAR centers have made a major global contribution to ex situ conservation of crop genetic resources. Some centers have also made detailed socio-anthropological studies of mandate crops in traditional farming systems and, more recently, farmer participatory research is becoming part of crop improvement programs. Centers can expand these studies to develop strategies for on-farm conservation in close collaboration with national agricultural research and extension systems, NGOs and farmers. A specific role for ICRISAT is firmly based on its locations in centers of crop diversity and traditional agriculture; its complement of experienced crop scientists and extensive databases; its capacity to analyze genetic, environmental, and genotype x environment interactions as determinants of crop productivity; its close relationships with national programs; and its growing involvement in farmer participatory research. The expertise and experience of ICRISAT and other CGIAR centers can make a major contribution to the dynamic conservation, enhancement and utilization of agrobiodiversity on-farm for the benefits of farmers and global food production.

INTRODUCTION

The immense genetic diversity of traditional varieties of crops is the most directly useful and economically valuable part of global biodiversity. Traditional varieties - or landraces - are used by subsistence farmers as a key component of their survival strategies. Such farmers account for about 60% of agricultural land use and provide approximately 15-20% of the world's crop production. In addition, landraces were and, in some cases, still are the basic raw materials used by plant breeders in the production of modern varieties, which provide the remainder of the world's crop production, on which most of us depend for food.

During the last 20 years, ICRISAT and other centers of the Consultative Group for International Agricultural Research (CGIAR) have made a major contribution to the *ex situ* conservation of crop genetic resources, particularly for wheat, rice, maize, barley, sorghum, pearl millet, potato, cassava, common bean, groundnut, chickpea, pigeonpea, lentil and other crops by establishing genebanks in which hundreds of thousands of germplasm samples have been assembled for both active use in breeding programs and for long term storage. Assembling germplasm samples is only a small part of the CGIAR crop conservation effort. Centers have made substantial efforts to characterize samples for many different parameters including: reaction to diseases and pests; physiological characteristics; and grain quality, for example, starch, protein and oil content. During this process, crop scientists have developed methodologies for evaluation of important characteristics and a good understanding of the crop-specific diversity, its geographical distribution, and potential for adaptation. In recent years, more attention has been paid to documenting information on indigenous knowledge at the time of collection. Thus collections held by the CGIAR are not just <u>seed</u> collections but valuable sources of genetic information required for effectively utilizing available crop resources.

In highly variable environments which are often marginal for crop growth, subsistence-oriented farming systems predominate over both space and time. Such systems are particularly common in the semi-arid tropics which is ICRISAT's mandate region. Many of the principal crops grown in such environments are not globally important staple crops but 'poor peoples' crops, for example lentil, chickpea, pigeonpea, pearl millet, minor millets. These include many of ICRISAT's mandate crops. These farming systems are undergoing profound changes due to increased population pressure, economic and environmental changes. Recognizing farmers' untiring enthusiasm to improve their lot, if possible through improving their genetic stocks, and in view of these profound changes in farming conditions, the utilization of genetic diversity on-farm is of particular importance for both crop evolution and crop improvement. This paper will define a role for ICRISAT in this process and suggest necessary areas of research to enhance and maintain genetic resources on-farm.

A ROLE FOR ICRISAT

A role for ICRISAT in enhancing and maintaining genetic resources on-farm is firmly based on the following facts:

- its locations in centers of crop diversity and traditional agriculture;
- its maintenance of global *ex situ* collections;
- its recent re-focus on eco-regions, to allow a more intensive targeting on specific production systems;
- its close working relationships with national programs;
- its complement of crop scientists with detailed familiarity with specific crops and regions over many years;
- its specimen databases and in-house technical ability to determine the history of the movement of landraces;
- its capacity to evaluate genetic variation and genotype x environment interactions which are major factors determining the effectiveness and direction of selection processes on-farm;
- its experienced economics group with linkages to national policy makers; and
- its considerable experience with on-farm research and growing involvement in farmer participatory research, presently in breeding and watershed management and with an excellent and relevant model for farmer involvement in integrated pest management (IPM) research evolving.

RESEARCH NEEDS

There has been remarkably little technical research specifically directed at on-farm conservation of agrobiodiversity, despite the paramount value of such resources in feeding people. There is an urgent need for clear objectives which will identify necessary areas of research to both enhance farmers' existing ability to manage crop genetic resources and to meet the future needs of farmers through *in situ* and *ex situ* germplasm enhancement. We suggest the following areas of research:

Identification of benchmark sites

The development of guidelines for selecting geographical areas is urgent. Ecological conditions; cropping system complexity; varieties used; communal tradition of varietal maintenance and experimentation; and sociocultural factors need to be considered. Priority attention should be given to cropping systems rich in species and varietal diversity. Another priority would be systems with a history of dynamic traditional management. Marginal conditions, where diversity many be low, but adaptations to extremes of constraints prevalent, will also need attention.

Varietal and genetic characterization

There have been efforts by botanists and crop geneticists to classify sub-specific variation within crops, however, a simple and precise technique for measuring the overall genetic diversity of a crop is not yet available. Without such techniques, the taxonomy and nomenclature of traditional varieties cannot be established, except at a very local level, using the farmers' own folk-classification. Such local classifications, although usable locally and meriting much further study, cannot be transferred to other regions. This lack of broadly usable methodology for describing intra- and inter-population variation of a crop species is a serious constraint facing efforts to understand and enhance on-farm conservation and management of genetic resources. The formal system can help here with basic descriptor methods coupled with isozyme and molecular techniques (e.g., genetic finger printing) to complement key farmers' input.

Varietal demography

Little is known about varietal demography - the movement of varieties into and out of cropping systems. This information is vital to understand the dynamic nature of on-farm germplasm management. There is a need to know the source of new varieties and how the farm complement of variability changes over time. A minimum time span of at least ten years is recommended. It is of considerable importance to study the reasons for loss of variability; whether accidental and random, through natural selection pressures, or through deliberate rejection by farmers.

Complementarity between on-farm and ex situ conservation

Farmers are proven experts at evaluating and managing variation: their bottleneck is in obtaining sufficient diversity to evaluate. In contrast, the formal *ex situ* system has in store enormous resources of plant diversity, but faces a bottleneck to adequately evaluate samples for a wide range of conditions. We need to combine the varietal management ability of farmers with the resources of samples in genebanks. There is opportunity for *ex situ* stores to return germplasm to farmers when farming communities have lost varieties through war or drought (e.g., recent efforts in Rwanda through the Seeds of Hope initiative). As an absolute right, farm communities should have easy and continued access to germplasm collected from the community and now held *ex situ*. In addition, genetic resources threatened on-farm should be collected and stored *ex situ*. Productive interaction will depend on a greatly enhanced documentation capability - an obvious role for formal genebanks. If the intention is to transfer local knowledge and germplasm to other areas, then the ability and willingness of farmers to act as trainers will be important.

Enhancing farmer management

There is a wide range of possibilities for enhancing the traditional management of varieties. Farmer participatory breeding has an important role to play in some environments. The opportunities for interaction and complementarity between formal breeding work on-station and farmers' expertise need to be fully explored. Research is also needed on the transfer of appropriate technology between farming systems known to manage great diversity. Research support is needed for traditional seed production, with an emphasis on the role of the farmer and natural selection pressures (e.g., insect pests, diseases, storage conditions, soil fertility factors etc.).

Strong emphasis should be placed on the impact of pests and diseases on farmers strategies to manage and enhance their agrobiodiversity. At all levels of management on-farm - characterization, selection, enhancement, storage - pests and diseases may have profound effects on the variability within and between varieties. The intensity of natural selection for characters such as pest and disease resistance in diverse ecosystems may be considerably lower than in less diverse systems. The diversity of traditional farming systems may therefore allow survival of inferior components of the crop population and may reduce the selection intensity for the evolution of disease resistance. In addition, farmers are unable to select for characters which are cryptic, as resistance to diseases and pests occurring at low incidence, or for resistances occurring at low frequencies in the population. It is here that formal research can identify and promote useful variation. Once genetic sources for characters of value have been identified by formal evaluation, they can be multiplied and fed back into the cropping systems. Attempts should be made to enhance the farmers' abilities to recognize, promote and utilize genetic diversity for future evolution.

CONCLUSION

We have defined a role for ICRISAT in increasing the quantity and improving the quality of the genetic resources being maintained by farmers through a research agenda which would underpin the efforts of other key players including national agricultural research and extension systems, non-governmental organizations (NGOs) and farmers. The expertise and experience of CGIAR centers can make a major contribution to the development of methodology for the dynamic conservation, enhancement and utilization of agrobiodiversity on-farm for the benefits of farmers and global food production.

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DISCUSSION

[Editors' note: Several presentations were given in the last session, only one of which, the ICRISAT work, was submitted in paper form. The comments recorded below raise issues not addressed elsewhere. We give a snapshot of two of the presentations in order to make the subsequent discussion intelligible.

I. B.R. Ghildyal outlined a Swiss Development Cooperation (SDC)-funded rice diversity program recently launched in Asia. IRRI will work with national programs and NGOs toward the goal of long-term preservation of the rice germplasm genepool. Three specific objectives were presented:

Collection, ex situ conservation and preservation of wild and cultivated rices;

In situ, on-farm conservation of traditional rice varieties;

Strengthening germplasm preservation by the National Agricultural Research Systems.

II. S. Halim of 'Sristi' spoke on the issue of compensation to farmers for their biodiversity efforts. The organization argues that "four kinds of compensation strategies can provide incentives to farmer individuals as well as to communities in the short and long-term for conserving diversity. These are: Material-Individual, Material Collective, Non-Material Individual, and Non-Material Collective."]

SPERLING: Dr. Ghildyal, in your beginning remarks you mentioned that this rice biodiversity program was a joint action of IRRI, national programs and NGOs. Your discussion of activities at the farm level focused on KVK's [the adaptive testing/demonstration units of the India's national testing system]. These KVK's have done important work in extending improved technologies: HYVs, fertilizers and pesticides. I was wondering if you could expand on the role that NGOs may play.

GHILDYAL: KVKs now have the responsibility of carrying on on-farm research for the Indian Council of Agricultural Research. Some of the KVKs are run by NGOs and one of the best in the country is run by the Ramakrishna Mission. Other KVKs are run by agricultural universities and research institutions but, I must say, their work is not as good as that of the NGOs.

KVKs are in constant contact with farmers of their region and have training programs. I believe, with them, we can now initiate germplasm conservation.

RILEY: I would like to add that the project does have a steering committee which includes several countries in South Asia. The national representatives of Sri Lanka, Nepal and Bangladesh, as well as India, have all been specifically requested to identify appropriate NGOs to join this steering committee. We have gone farthest in Vietnam where, with the South East Asian Regional Institute for Community Education (SEARICE) and others there, NGOs have had some important discussions about specific activities. The Swiss have very strongly emphasized NGO involvement and it is very important.

KOTHARI: I want to connect the presentations of ICRISAT and IRRI, two of the many international agricultural research centers. There has been a lot of discussion about the fate of the existing germplasm collection, its commercial use, Intellectual Property Rights associated with it, and so on. What is the policy on the new collections being made. Are there Material Transfer Agreements with the people with whom it is being collected and from the countries from whom collections are taking place? I know there has been a great deal of internal debate within the system: where are you currently?

WELTZIEN: As far as I am aware, ICRISAT does not have a policy on these issues, mainly because they are in a high state of discussion and there is no consensus as yet. This is especially true with the recent transfer of holding of all genetic resources within the Consultative Group on International Agricultural Research (CGIAR) to the auspices of the Food and Agriculture Organization (FAO). The implications of this transfer of responsibility are still being worked out. As for Material Transfer Agreements, as far as I am aware, there is no single CGIAR collection mission anywhere which takes place without the partnership of national Institutions. All collection missions are collaborative between the national system and the international institution. So agreements would go along the rules of the country. As there are different countries involved, we are probably dealing with very different kinds of policies. There are country-specific policy issues which the CGIAR system will have to follow.

RILEY: Maybe I can add that IRRI has an Intellectual Property Rights Bulletin which does specify the kinds of Intellectual Property that they may or may not seek on various kinds of technology and germplasm.

In terms of the Material Transfer Agreement, under the new trusteeship mentioned, work is going ahead with a form of Material Transfer agreement which would be acceptable either to all Centers or to the individual Center. This has been formulated jointly with FAO. Certainly this is seen as a very important step which has to be recognized and needs to be taken forward.

BERG: I would like to make a comment on the issue of compensation. In my mind, the interest of local communities consists firstly in certain customary rights and, secondly, in compensation. If these two are reversed, if we go for compensation first, it might function, legally speaking, as a kind of sell-out and the community might lose their customary right to the traditional use of their germplasm. I think the first and the primary concern should be to legally enact the customary rights of communities. Their interest is to still have access to germplasm, to have the right to use their germplasm, reproduce it and manipulate it, breed it in their traditional ways and also exchange and sell it in non-commercial ways within the communities. But that right should not be limited to their own community germplasm but also to other germplasm. This is another form of compensation. Since they have allowed the flow of germplasm out of their communities, they should also have the right to receive a return flow of germplasm from the formal sector and to use it in customary ways. If these rights are not enacted as citizens' rights, they might all be lost. The loss of those rights could be reinforced and could be catalyzed if we go for monetary compensation, which would be perceived by many as a sell-out.

HALIM: I want to say that compensation is basically for the people who have already helped or worked for the compensation of biodiversity. The first thing is that the individual persons who have done some relevant work and valuable work get the benefit of compensation. The public sector, at a later stage, might implement something, but you cannot wait until this whole issue settles. We want to initiate this first step so that the creativity of the person, innovative capacity of the person does not get lost; it must be motivated.

SPERLING: Just a question on this issue of individual recognition. Let's take the case of a single variety. It may have been bred by a number of people through hundreds of years. The people who select the seed may be different from those who maintain the soil fertility--which helps the seed to grow. And the people who ensure that the cows are well fed and give the dung--which goes to those who help maintain the soils--may be a still different group. So the question is how we might even conceive of individual compensation? And a related question. Might individual compensation clash with community compensation? You presented four options, but I sense that some of them might be at odds. I would hypothesize that individual compensation could destroy community systems.

HALIM: I will generally say that if landraces have been developed by a group of people, then we should go for the collective system. Let it be through the formation of trust funds. Apart from that, an individual's contribution to the conservation of biodiversity or germplasm might be compensated for by the Venture Capital Fund. In some of our programs, groups have been involved, but there was also a case where a singular contribution was very much there. We gave him a Venture Capital Fund. In some instances, we may have to combine some of our four models.

KOTHARI: I was just asking Vijayi what his reaction might be to something like this issue. Vijayiji comes from a village where a lot of people have worked on developing, maintaining and enhancing crop diversity, but his own personal work is obviously of a special nature in the sense that he is trying out 110 varieties, which no other farmer has done. I was asking him whether he would want individual compensation or whether compensation should go back to the community. Secondly, whether he would want to obtain a patent on a new variety or not.

He has not yet given me a full answer, but his initial reaction was, as for patent, No. He feels even if it is a new variety there is so much history that has gone into it from the community that he does not feel he owns the seed.

SANTHAKUMAR: I would like to suggest that there may be different levels of involvement, for example, the traditional community and certain active members within the community. We might consider the possibility of unequal forms of compensation, that is, compensation at different levels.

MAZHAR: We are really talking about two different systems of rights: one is common property and one is the formalized privatized system based on recognizing the individual as the actor and the contributor of innovation. I don't think the two can be in any way balanced. How would you possibly enact common property within the formal system, the constitution, in legal statutes?

I will give an example. There is a clause in the biodiversity convention which says that the sovereignty over natural resources lies with the State. We again have to define what is the role of the State and what is the role of the community. In countries like Bangladesh, the whole resource ends up with the bureaucrats and they are the ones who are going to sign the contract with Cargill and other companies.

GHILDYAL: When you consider compensation, you have to consider the process as well. There are two: one is the formal research and development (R&D) work and another is the informal R & D--which up to now has not been paid. Formal R&D is done by the government or private countries; both are paid, but differently. Now informal R&D is for the survival of human beings, the community who lives there, and we have to find a way to compensate that.

OOSTERHOUT: I think this is an issue which farmers themselves need to decide upon and we need to go back to the farmers and put these points to them so they can know the implications. The main thing that farmers lack is knowledge about the outside world. If informed, they can really select what is important to them.

SATHEESH: I am interested in what Rajeev Khedkar thinks because he has done a lot of work on this. And we should also come back to V. Jardhari.

KHEDKAR: When we talk to tribal farmers about compensation, they say: "we do not want to get into this because we would be destroying the spirit in which we have been doing this work."

JARDHARI: [*Editors' note: translated from Hindi.*] This whole issue of compensation, who is to compensate whom, that is the issue. If you want to get into this track of compensation with individual farmers or the community, it is like passive smokers: they will start getting the same habits as the chain smokers--or, here, as the multinationals. Again, who is at what part of the hierarchy? If the farmers are to get compensation, who will compensate? If they are working with an NGO, the NGO will move ahead and get the compensation from international donors. Or if it is the national government, the government may go to FAO and get the compensation. So it's a kind of rat race in compensation--very dangerous. The procedure of patenting is itself wrong. Seed has been evolved after an effort of thousands of years. This knowledge is not what we have earned. Rather, it is our duty to improve it. Seed belongs to the community, whether of the village or of the country.

APPENDICES

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DISCUSSION

WITCOMBE: I would like to make a comment on extrapolating from Nepal to India in terms of cultivars. In India there are more than 500 cultivars of rice which have been released and, in Nepal, there have been less than 40. When you consider the agro-ecological diversity of Nepal, this is totally out of proportion. It is therefore unsurprising to me that if you look at Nepal and compare the so-called HYVs with the traditional varieties that there is absolutely no alternative to the traditional--because the release system has been so strict. There is insufficient biodiversity within the released material to find suitable alternatives for farmers. But I would also say that if you look at the cultivars and the distinctions we have been using here, traditional and high yielding varieties, at least in India, there is a complete continuum. That continuum goes from landrace to what many people are defining here as HYVs, but which are in fact the product of landrace-landrace crosses right through to landrace-exotic crosses and to exotic-exotic crosses. Therefore, I think we should be very careful when we extrapolate from one country to another in terms of distinctions between landraces and the products of breeders and also about the fact that farmers prefer traditional cultivars and giving all the reasons as to why they prefer them.

I am referring specifically to the two papers on India in which reasons for farmers' preferring traditional varieties were elaborated. There might be something missing in the scientific argument here. If you do a search process and you utilize the biodiversity amongst released cultivars, then you will probably find that many of the released cultivars satisfy all the criteria that you have described as characteristic of the local.

GHILDYAL: I want to comment of Vijayalaksmi's paper. High-yielding rice varieties have been primarily limited to irrigated agriculture. When IRRI started in 1962, the objective was clear: our target was the irrigated eco-system and our yield target was for six or eight tons. IRRI has now produced special types that can yield up to 15 tons per hectare. Their target was not to remove poverty among rainfed farmers. The Indian Council of Agricultural Research (ICAR) really only started a project on rainfed rice last year with, a coordinated project in Eastern India.

MAURYA: I want to clarify what Ghildyal has said. We have been able to breed varieties for the rainfed ecosystems, but these systems are highly heterogeneous and a single or few varieties cannot satisfy the needs of many micro-niches. One of the reasons that farmers in these situations are risk-prone is that they have not been able to purchase costly seed. Because of that, seed is not spreading and the impact has not been as visible as in the irrigated system.

WITCOMBE: If you make an analysis of releases over the last ten years, there have been about 40 a year and about ten of them are for upland rainfed conditions....We have focused on the biodiversity of traditional material, but there is also a huge biodiversity amongst released material, which is unexploited because it is not being given to farmers.

GHILDYAL: We have not been able to convince the National Seed Corporation or, the State Seed Corporation to produce seed for upland rices. They do not want to produce small quantities. They want large quantities of high-yielding varieties so they can make money. So I have asked breeders to produce seed, because the government is not prepared to produce. But breeders say: 'that is not my job.'

MANDAL: The upland varieties are problematic, there is no denying that. But even some of the new upland varieties have been found to be superior to the local varieties. Yet we cannot expect

- It erodes the genetic base on which scientists are depending for continuous improvement of crops and livestock. The majority of HYVs themselves have been developed from genetic material taken from traditional varieties and wild relatives of crops. These HYVs, in particular hybrids, are not very long-living: they tend to lose their viability and productivity, or become increasingly susceptible to pest/disease attacks, within a few years. This necessitates the infusion of fresh genetic material, which is again obtained from existing traditional varieties or wild plants. But then the introduction of these HYVs is itself a major cause of the erosion of traditional crop diversity. As has been said, modern agriculture is somewhat akin to building the roof of a house by taking the bricks from the walls.

- The failure of a single HYV crop due to any natural calamity is a crippling blow for a farmer who has no other crop to fall back on. And since the same variety may now be grown over thousands of hectares, its failure entails suffering and destitution for a vast number of farmers. Some degree of security against such eventualities can be artificially achieved by expensive measures like protective irrigation, subsidies, and credit schemes, but such measures are expensive and prone to failure. For the country as a whole, the increasing reliance on a narrow genetic range of crops represents a high-risk proposition.

- Both the above features result in an increasing dependence of the farmer on the industry-dominated market and the government. Virtually everything that is required for farming, except land and labor, is now obtained from outside: seeds, irrigation, fertilizers, pesticides, credit. And despite huge subsidies on these inputs, e.g., support prices and the like, an increasing number of farmers are facing the economic treadmill, spending more and more to achieve the same output.

- Several other effects of the Green Revolution have brought insecurity in the lives of farmers. For instance, the traditional paddy field provided not only rice but also fish, frogs, and other elements of biodiversity which were an important part of the diet of several communities, especially tribals. Modern paddy fields, which require large amounts of chemical fertilizers and pesticides, are devoid of much of this biodiversity, with a resultant loss of nutrition for farmers.

Biodiversity conservation, productivity, and livelihood security

The work of the *Beej Bachao Andolan*, and of dozens of similar groups and networks across India, shows that there may not be any contradiction between the objectives of productivity, biodiversity conservation, and the economic livelihood of farmers. Indeed, it suggests that these may be inextricably linked, especially if a long-term perspective is taken, and if productivity is redefined to include the overall ability of agriculture to provide the food, fodder, fuel, and other (including cultural) requirements of society. From this point of view, all the varied outputs of biologically diverse farming practices, which fulfill different human needs, add up to the productivity of agriculture. And the longer these outputs can be produced, the more sustainable is the agriculture.

Based on the experience of farmers involved with the BBA, and of farmers from other regions of India, we present below a sketchy outline of how productivity, diversity, and livelihood can be combined in a new agricultural policy:

1. A mix of strategies: In the short term, since conditions suitable to biodiverse organic farming may not be available everywhere, a geographical mix of conventional HYV cultivation areas with

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are likely to have greater impact on the loss of genetic diversity than the farmer- driven changes that are regularly occurring in farmers' fields.

A large portion of varietal diversity in plants can be attributed to the eco-geographic features of the habitats and agricultural practices associated with them. Mindanao's terrain varies from flat fertile plains to an irregular landscape of wide valleys, scattered hills and interminable mountain ranges. The spatial distribution of rainfall also varies to a great extent. These differences, as well as the very diverse peoples and cultures, may have resulted in very diverse rice genetic resources. Exactly how diverse these materials are would be difficult to determine.

Collection expeditions for this region, however, have been limited by its long history of civil unrest. Most of the collections made by formal institutions were restricted to accessible areas. The International Rice Research Institute (IRRI), for example, only holds 137 rice accessions for the entire area of Mindanao. Mindanao is composed of 18 provinces. Failure to conserve these genetic resources may eventually result in the loss of a substantial reserve of genetic variation necessary for crop improvement.

The growing threat to genetic erosion and the continued disappearance of local varieties in farmers' fields led to the establishment of the Community-Based Native Research Center or CONSERVE. Its main thrust is to collect, conserve and enhance plant genetic resources (PGRs) through a participatory approach whereby farmers take the central role in the whole process. Even more importantly, the project looks into the links and integration among farming systems, political and economic conditions, environmental situations and the efforts towards just and sustainable development. It looks at the conservation of the seeds not as the goal in itself, but realizes that the conservation of the seed is crucial to development efforts in marginalized farming communities. With this, a community-based seed program, anchored on sustainable agriculture, was started in 1992.

LINKING THE SEEDS AND THE FARMERS

One of the key elements in initiating on-farm plant genetic resources conservation is the access of farmers to diverse genetic materials. In an effort to salvage the remaining plant genetic resources in the region, CONSERVE was set-up in 1992 in Pres. Roxas, one of the five municipalities of Arakan Complex of Cotabato province in the southern part of Mindanao.

Out of 18 mainland Mindanao provinces, only one province, North Cotabato, was surveyed relatively well for its remaining indigenous rice and corn varieties. One village each in the adjoining provinces was also visited and surveyed. Collection expeditions in these areas yielded 300 traditional rice varieties and 14 corn varieties (Table 1).

Upland varieties constituted 74.9% of all the rice collections. Most of these varieties were obtained from indigenous farming communities. The small number of lowland collections can be partly attributed to the higher adoption rate of modern varieties, since the main focus of rice research and development has been on irrigated areas.

real potential due to encroachment on and breakdown of traditional water management practices. Last year, farmers who planted high yielding varieties (HYVs) in Pudupet village near Chengam, suffered heavy yield losses while those who planted the traditional variety (Vadan Samba) were quite successful. This year, many farmers in the same village have cultivated the traditional rainfed variety.

- Traditional rainfed paddy fares well on marginal lands, at least assuring farmers food security for the year.

- Under good soil conditions, certain farmers grow particular traditional varieties like Kitchidi samba, which gives 35 bags per acre, a good yield.

- The pesticide requirement is nil, or very low.

- They are extremely tasty and delicious. Most farmers grow a traditional variety for their own consumption and a high yielding variety for the market.

- When rain fails, local varieties seem to do better; farmers switch over to them.

- A number of traditional varieties can be sown by broadcasting and the labor is reduced.

- Soil constraints also contribute towards looking toward the local varieties. The term '*cheru*' is used by the farmers to denote the mud created by flooding and plowing in the paddy field. This is essential for transplanting the paddy. The depth of *cheru* varies on different soils. On deeper *cheru*, high yielding varieties do not grow well. Local varieties may also do well under 'soil-stress' conditions. For example, in saline soils, only the traditional variety Kalar palai grows. *Kalar* denotes saline soil.

- Certain varieties like Sirumani, Neelam samba etc., are specially preferred for lactating mothers. They are preserved for this reason.

Table 3 shows the reasons for farmers not adopting high yielding varieties in the areas of North Arcot district (Farmer, 1977).

SETTING UP A SEEDBANK IN CHENGAM

From the surveys, studies and meetings with the farmers it has become quite clear that there is a great demand for traditional rice varieties in Chengam Taluk. Seeds of traditional rice varieties have been purchased from different parts of the taluk and stocked for the season starting in August 1995. In the first phase, about 50 farmers will be supported to raise the traditional varieties. They will be given seeds and other organic inputs and will be expected to return seeds after harvest (a larger quantity than what was given to them). This returned seed will be used by more farmers the next season. The exact amount of seeds that farmers will be asked to return is still being discussed. Constant monitoring of the cultivation of these varieties will be done by The Centre for Indian Knowledge Systems. More generally, in meeting the growing demand for traditional varieties, non-governmental organizations (NGO) could play a major role in helping to set up rural seedbanks.

product of several years of on-station breeding effort. Rather, there have been lines being used as breeding material which have shown promising resistance to stress in the early stages of screening (Maurya, Bottral and Farrington, 1988). By short-circuiting the official breeding and release procedures in this way, a dozen distinctly promising lines have identified by farmers within a much shorter period than normally is necessary to produce only one (and, at that, perhaps unacceptable) official release (*Ibid.*).

This breeding approach is decentralized and participatory in character and comprises six stages:

1. Whole village emphasis
2. Diagnosis of the real farmers' concerns
3. Analysis of farmers' materials, methods and resources
4. Matching new lines/technology with farmers' materials and techniques
5. Sharing small batches of improved materials with farmers through participatory trials
6. Joint evaluation (farmers and scientists)

<u>Whole village emphasis</u>

The general practice so far in rural and village research and development program has been to select a few farmers or farm families to conduct experimentation. The leftovers in this approach feel social discrimination or dissatisfaction. Keeping this fact in view, we at Faizabad have adopted 'the whole village concept'. Equal opportunity is provided to everyone in the village to participate in experimentation. Such an approach provides researchers an opportunity to explore various issues; the whole range of ecological, management and socio-economic variability within the village are encompassed. The village is taken as a coherent and integrated system.

<u>Diagnosis of farmers' real concerns</u>

Apart from the differences in the cropping techniques and levels of stress to which plants are exposed between on-station and on-farm trials, detailed discussions with farmers indicated specific differences between their selection criteria and those of the NDUAT/on-station program. Not uncommonly, farmers grow several varieties to suit different agro-ecological conditions. By contrast, the University had been concentrating on selections that performed well when line-sown in pure stands, under a narrow and favorable range of soil moisture conditions, and for short or medium-short growing periods.

<u>Analysis of farmers' materials, methods and techniques</u>

A baseline survey has been completed for each farmer, assembling details of the varieties used by area (whether local or improved), method and time of planting, whether grown under rainfed, irrigated, upland or lowland conditions, and other soil characteristics. Further, data have been collected on the practices of fertilizer/ manuring, pest and disease control, weeding, cropping sequences and rotations, inter-cropping, harvesting, grain types, and yields.

<u>Matching, parallel processing</u>

Participating farmers are asked to supply samples of the traditional seed varieties they grow, so that the local varieties can be grown together with improved germplasm under homogeneous conditions at the research station. The station has already generated a large number of advanced lines, with a particular focus on testing for resistance to stress situations and for an adequate

(W.R. Lechner, Mahanene Research Station, Oshakati, Namibia, 1991, pers. commun.) used farmer evaluation of pearl millet in on-station trials. The farmers selected a cultivar that was subsequently released and became popular. In collaborative research between The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Rajasthan Agricultural University farmer participatory research was used to identify pearl millet cultivars suitable for Rajasthan (Weltzien *et al.*, 1995, this volume). All of these examples can best be defined as participatory varietal selection, since farmers were given near finished or finished products to test in their fields. In contrast, participatory plant breeding involves farmers selecting genotypes from segregating generations. There are few examples in the literature of participatory plant breeding. Sthapit *et al.* (this volume) have carried out PPB with farmers in Nepal to select chilling tolerant rice from F_5 bulk families. Joshi and Witcombe have created a broadly based maize composite for participatory plant breeding in India, and the first selection by farmers will be in Gujarat in the *kharif* (rainy season) 1995.

PARTICIPATORY VARIETAL SELECTION

Participatory varietal selection always has three phases:

- a means of identifying farmers' needs in a cultivar,
- a search for suitable material to test with farmers, and
- experimentation on farmers' fields.

Identification of farmers' needs

A number of methods can be used, separately or in combination, to identify farmers' needs. Important methods are:

- participatory rural appraisal (PRA),
- the examination of the type of crops in farmers' fields at or near to maturity, or
- the pre-selection by farmers of cultivars by the inspection of trials of many entries grown on a research station or in farmers' fields.

Employment of such methods will help to reduce the possibility that farmers will be given obviously unacceptable varieties to test.

Search process

After the farmers' needs have been identified, the search process is carried out to identify suitable cultivars for testing with farmers.

Amongst already released cultivars

One method, employed by the authors in India, is to include in the search cultivars that have already been released. A key assumption made in participatory varietal selection on released cultivars (Joshi and Witcombe, 1995) is that cultivar replacement rates are lower than optimal because farmers have not been exposed to a range of new cultivars. It is therefore assumed that amongst the released cultivars there are ones that will be preferred by farmers over those they are currently growing. All that is required is to expose the farmers to the suitable cultivars for the project area that already exist, but have not been released or are not available in that area. For

Through support for research, Canada's **International Development Research Centre (IDRC)** assists scientists in developing countries to identify long-term, workable solutions to pressing development problems. Support is given directly to scientists working in universities, private enterprise, government, and nonprofit organizations.

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Le Centre de recherches pour le développement international (CRDI) soutient des travaux et des activités de recherche dans les pays en développement de manière à assurer un développement durable et équitable à l'échelle mondiale.

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Le CRDI contribue au renforcement des connaissances et des capacités de recherche des pays en développement pour lutter contre la pauvreté et pour améliorer les conditions de vie et l'environnement des populations affectees.

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Con el fin de asegurar un desarrollo sostenible y equitativo a escala mundial, **el Centro Internacional de Investigaciones para el Desarrollo (CIID)** financía trabajos y actividades de investigación en los países en desarrollo. Las investigaciones están a cargo de científicos que trabajan en instituciones, empresas, gobiernos u organismos dedicados al desarrollo. Estos científicos reciben regularmente la colaboración de sus colegas canadienses.

Los proyectos apoyados financiera o técnicamente por el CIID favorecen el uso de recursos locales y se apoyan en el talento, la inteligencia y el sentido de innovación de los investigadores de los países en desarrollo.

El CIID contribuye al fortalecimiento de los conocimientos y a la capacidad investigativa de los países en desarrollo para luchar contra la pobreza y mejorar las condiciones de vida y el medio ambiente de las poblaciones afectadas.

Un Consejo de Gobernadores Internacional tiene a su cargo la dirección del CIID, cuyos fondos provienen del Gobierno de Canadá. La Conferencia de Naciones Unidas sobre el Medio Ambiente y el Desarrollo (CNUED) ha seleccionado al CIID para participar en la realización del desarrollo sostenible a escala mundial. El CIID se encargará de hacer realidad el programa Agenda 21, elaborado durante la Cumbre de la Tierra.

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Conservation of threatened, farmer-developed varieties and the breeding and selection of new cultivars are often seen as distinct activities and the concerns of different organizations. The *Using Diversity* workshop explored the common ground between the two approaches. It brought together scientists, farmers and NGO workers from across South Asia who share the conviction that genetic diversity, on-farm, is key to rural people's food security and that farmers must be involved in its maintenance and enhancement. These are the proceedings of that workshop.

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