14 Rice, Farmers and Genebanks: a Case Study in the Cagayan Valley, Philippines

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Introduction

The current debate on the release of transgenic crops is a useful reminder of how complex the deployment of new varieties is. Not only must the expected benefits be taken into account but also all the potential consequences at very different levels: agroecological, social, economic and political. Long before genetically modified organisms, the release of semi-dwarf high yielding varieties by rice breeders had a tremendous impact on the life of rice farmers and consumers. The first modern rice variety, IR8, was released in 1966. In Asia, rice production increased by 114% between 1966 and 1996, surpassing the 82% population increase during the same period (Hossain and Pingali, 1998). The breeding of high-yielding varieties made this increase possible, but was also associated with dramatic changes in rice farming practices and economy. The release of modern rice varieties has had an impact on which varieties rice farmers grow, why they grow them and how they grow them.

For a long time, only the first point really mattered to genetic resources conservationists, as *ex situ* conservation was receiving most of their attention. Priority was given to the collection of local landraces threatened by the adoption of modern varieties, in order to make them available to all rice genetic resource users. Given the increasing interest in *in situ* conservation on-farm, the conservation of rice genetic resources must include new research activities in agroecosystems that can lead to a better understanding of what this approach means and how it can be implemented (Bellon *et al.*, 1997). This is particularly needed in rapidly changing agroecosystems, where the conservation of agrobiodiversity needs to be supported by providing farmers with the appropriate options. This is a matter of urgency. The risk of genetic erosion is higher in agroecosystems submitted to changes in their cultural, economic or technological environment. While cases of coexistence of local and modern varieties are reported for several crops worldwide (see the examples cited in the next section), it does not mean that such 'equilibrium' situations can be reached in all cases, nor are they durable. Furthermore, developing *in situ* conservation strategies for rapidly changing agroecosystems is an important issue as it may eventually result in the preservation of diversity and its integration in agricultural development policies in much larger areas than those of traditional agroecosystems.

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In the Philippines, two main research institutions are involved in rice biodiversity conservation, the International Rice Research Institute (IRRI) and the Philippine Rice Research Institute (PhilRice). PhilRice maintains the national collection of rice genetic resources. IRRI holds in the International Rice Genebank the world's largest rice collection (Jackson *et al.*, 1997). In 1996, IRRI and PhilRice implemented collaborative research activities to study rice diversity and its management by farmers in the Cagayan Valley, and identify opportunities to involve farmers in the overall framework of rice genetic resources conservation (Pham *et al.*, 1996).[1]

This chapter presents some of the results of this work. It shows how the survey of the on-farm diversity of rice varieties of the Cagayan Valley allowed the description of diversity in terms of genetic groups and of agronomic and cultural functional groups. Then, the identification of the constraints and threats to this diversity resulted in the definition of testable strategies to sustain it. This research illustrates the role that genebanks and research institutions can play in the maintenance of genetic diversity on-farm.

Study Sites

Despite the intensity of the Green Revolution, rice agriculture intensification has not been uniform all over Asia. As observed in other major crops and countries, for example potato in Peru (Brush *et al.*, 1992), and maize in Mexico (Bellon and Brush, 1994; Louette *et al.*, 1997) and Burkina Faso (Sanou, 1996), agroecosystems can be found where modern varieties coexist with traditional ones.

The Cagayan Valley, located in Northern Luzon, the Philippines, is a good example of these situations. Three different rice ecosystems are present in the Cagayan Valley: rainfed upland, rainfed lowland and irrigated lowland. A differential impact of modern varieties was observed from the upland to the irrigated lowland ecosystem from a survey of 16 households by ecosystem (four villages/ecosystem, four households/village) (Bellon *et al.*, 1998). The ratio of modern to traditional varieties was 24:61, 20:19 and 43:5 in the rainfed upland, rainfed lowland and irrigated ecosystems, respectively. The analysis of the genetic polymorphism at 16 isozyme loci of 149 accessions of traditional and modern varieties showed that a gradient of genetic diversity followed a similar pattern, as the Nei's heterozygosity index demonstrated, that is 0.25 in the upland, 0.21 in the rainfed lowland and 0.15 in the irrigated ecosystem.

The results presented in this chapter mainly come from the study of the rainfed lowland ecosystem. Although not as genetically diverse as the upland ecosystem, we considered this ecosystem represented the main target for maintaining genetic diversity on-farm because of the much larger production areas it represents in Cagayan. Because of the obvious competition between traditional and modern varieties and the changing agroeconomic conditions, in particular the development of irrigation, the rainfed lowland ecosystem offers a unique challenge to study the dynamics of on-farm rice diversity, and to develop strategies to sustain this diversity.

The study sites were located in three municipalities adjacent to each other, in the centre of Cagayan Province. On the western side of the Cagayan river were the municipalities of Solana and western Amulung. On the eastern side were those of Iguig and eastern Amulung. In these municipalities, 15 barangays (villages) and 207 households were selected to represent a diversity of agroecological, economic and ethnic conditions.

The selection of study sites was done with the help of local officials from the Philippines Department of Agriculture Region and the Cagayan Valley Lowland and Marine Research Outreach Station.

Methods

Farmers' classification of varieties

In order to complement the study on farmers' perceptions of varieties presented in Bellon *et al.* (1998), we conducted an analysis to understand the farmers' classification of rice varieties. Given the high number of variety names encountered in the Cagayan Valley, we suspected that farmers have their own classification of the varieties they use, and perceive and manage these varieties as elements of larger groups.

The primary methodology used for identifying variety classes was successive pile-sorting, where an informant is asked to sort a set of items into smaller and smaller piles until each pile is a single item

[1]This project was conducted within the component 'On-farm conservation' of the project 'Safeguarding and Preservation of the Biodiversity of the Rice Genepool' funded by the Swiss Agency for Development and Cooperation.

(Bernard, 1988; Borgatti, 1992). If two varieties are split on the first split, their relationship is one, on the second split two and so on. Higher values (later splits), imply greater perceived similarity between individual varieties. From pile-sorting a similarity matrix can be produced in which pairs of varieties with a higher mean value are considered more similar than those pairs with a lower mean value. The resulting matrix was plotted using multidimensional scaling and only the 20 most commonly known varieties were used.

Farmers were asked to give the reasons for splitting at every split. The earlier splits (especially splits one and two) are indicative of more general criteria for distinguishing all available varieties and the later splits tend to be more precise and variety-based details.

Changes in diversity over time

In 1996 and 1998, two surveys were conducted in the rainfed lowland ecosystem. Among the questions that were put to the households were the name of the varieties that they were planting, and the origin of the seeds.

Microsatellite polymorphism analysis

Two distinct sets of accessions were studied for microsatellite polymorphism: the same set of 149 accessions collected in the three ecosystems previously studied for isozyme analysis, and another set of 205 accessions collected in the rainfed lowland ecosystem.

DNA was extracted from healthy leaves of 4-week-old plants using the CTAB (cetrimide-trimethylammoniumbromide) method. Polymerase chain reaction (PCR) was carried out in 1× PCR buffer (100 mM Tris-HCl, 500 mM KCl, 0.1% gelatin); 1 mM $MgCl_2$; 0.1 mM dNTP mix; 0.2 μM primer-reverse and forward (Research Genetics); 1 unit *Taq* polymerase and 20 μl genomic DNA. Amplification was carried out using an MJ Research thermal cycler with the following profile: initial denaturation for 5 min at 94°C; 35 cycles of 94°C for 1 min, 55°C for 1 min, and 72°C for 2 min, and a final extension of 72°C for 5 min. PCR products were viewed using silver staining after electrophoresis on a 6% polyacrylamide gel.

Eighteen microsatellite primers were used for the first set of 149 accessions: RM 1, 2, 3, 5, 6, 9, 11, 12, 13, 15, 16, 17, 18, 122, 148, 164, 167, 168. For the second set of 230 accessions, the following eighteen primers were used: RM 1, 3, 6, 11, 12, 18, 25, 26, 27, 60, 122, 167, 168, 169, 254, 255, 258 and 261. This set of primers slightly differed from those used for the first set of accessions because of practical and technical reasons. All primers (Panaud *et al.*, 1996; Temnykh *et al.*, in press; Cho *et al.*, in press) were purchased from Research Genetics.

Diversity Assessment

The analysis of farmers' classification of the 20 most frequent varieties in the study villages gave a clear picture. The clusters of varieties could be interpreted as functional groups: varieties were clustered together because farmers recognized them as having similar traits and patterns of use.

Three primary sorting groups came out from the multidimensional scaling (Fig. 14.1), which can be interpreted as follows from the reasons farmers gave for splitting:

- The group of glutinous varieties: Imelda, Imelda Diket, Diket, Bongkitan. These varieties all share the fundamental characteristic of being glutinous varieties. Glutinous variety grains are sticky when cooked. In Cagayan Valley, glutinous varieties are used for special cakes and sweets.
- The group of short growth duration varieties: IR68, C22, IR66, BPRI10, PSBRc12 and PSBRc10. The short duration group includes those varieties that mature in a relatively short period, usually between 90 and 130 days. The members of the short duration cluster are all modern varieties. Short duration is a characteristic that is valued by farmers because it allows for multiple crops per season.
- The long duration group includes the varieties Elonelon, Java, Wagwag pino, Wagwag, Wagwag tawataw, Wagwag bilog and Wagwag red. Long duration varieties are those that mature in more than 130 days. The long duration group is characterized by traditional varieties. It is possible to further classify the long duration group by recognizing that it includes a major subgroup of all the Wagwag types.

The Wagwag Varieties

The Wagwag variety type is prevalent throughout the region and it can be found in 14 of the 15 research villages. Figure 14.2 shows that out of the 72 variety

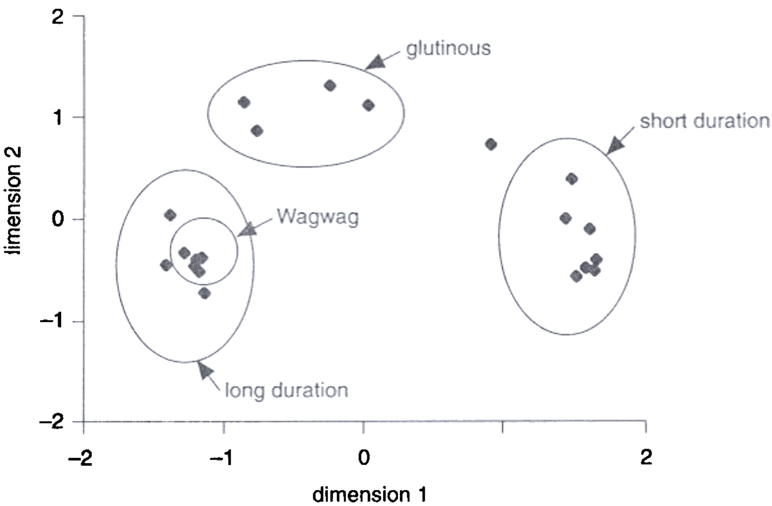

Fig. 14.1. Cultural perception of most frequent rice varieties in the Cagayan Valley. First two axes of a multiscaling analysis of the similarity matrix resulting from the successive pile-sorting.

names that were collected in the rainfed lowland ecosystem in Cagayan, four accounted for more than 50% of the plots. Out of these four varieties, two were modern varieties (IR66 and PSBRc10) and two were Wagwag varieties (Wagwag and Wagwag pino). Wagwag varieties are long duration photosensitive varieties. They are valued for their taste, cooking quality and adaptation to the variable local growing conditions. These varieties generally command a better price at the local and regional markets. Breeders have long recognized the agronomic value of Wagwag varieties but their use in breeding programmes has been hampered by their low combining ability.

The genetic analysis showed that the Wagwag varieties bring an original contribution to the overall rice genetic diversity in the Cagayan. Although not all accessions of Wagwag varieties clustered together – in that respect, the microsatellite analysis tended to blur the image previously obtained from isozyme data (Bellon *et al.*, 1998) – a large group of them were clearly separated from the rest of the accessions (Fig. 14.3). To illustrate what the genetic loss would be if all Wagwag varieties were to disappear, the genetic diversity at each of the microsatellite loci was computed for the second set of samples collected in the rainfed lowland ecosystem, and for this set minus the Wagwag varieties (Fig. 14.4). It shows that a decrease in genetic diversity would be observed at the majority of studied loci.

Threats to Rice Diversity

Double cropping with short duration varieties

The survey on farmers' perceptions conducted in 1996 demonstrated that long duration is the main reason for farmers in the irrigated and rainfed lowland ecosystem to discard varieties (Bellon *et al.*, 1998; Fig. 14.5). The analysis of the cropping calendar shows that the use of long duration varieties by farmers precludes the shift to double cropping (Fig. 14.5). Thus, the development of irrigation, which makes the double cropping of short duration varieties possible, appears to have potential negative consequences on rice diversity in Cagayan. This is an example of how the development of a technology (irrigation) induces perturbation of the agroecological niche occupied by particular varieties.

Threats to genetic diversity revealed by natural catastrophes

In 1997 and 1998, two major weather phenomena affected the Cagayan Valley. In 1997, El Niño caused a severe drought that affected Cagayan Valley and much of the Philippines. The total amount of rain in 1997 was lower than usual and

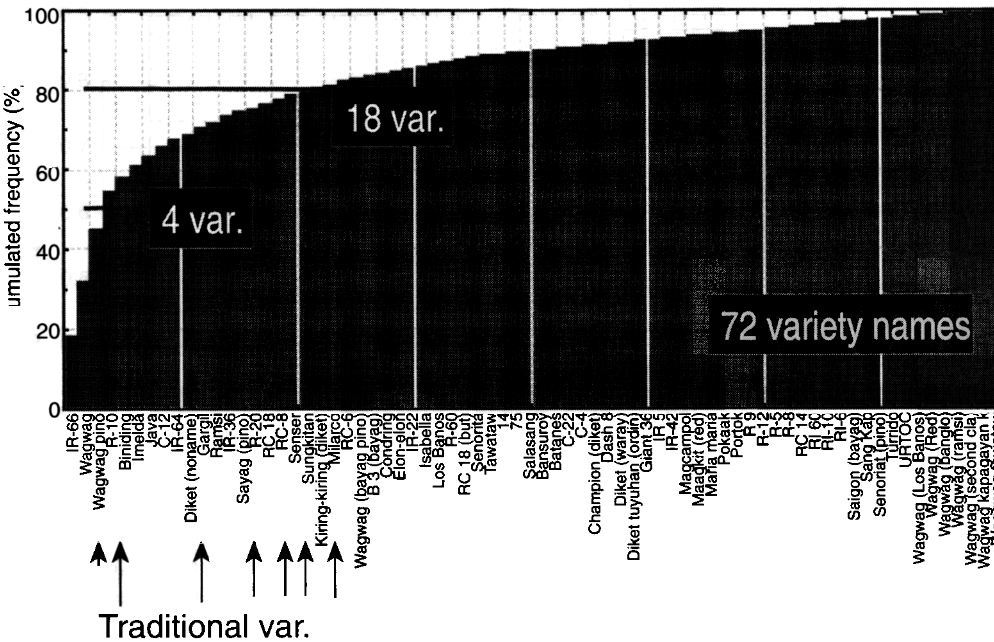

Fig. 14.2. Distribution of varieties in the Cagayan Valley (rainfed lowland ecosystem, wet season 1996, 15 villages, 14 farmers per village). The relative frequency of each variety name was computed.The bars represent the cumulative frequencies. The most frequent varieties are on the right-hand side of the graph.

the timing of rain was not good. The drought came when the rice plants were at the seedling stage, a stage when the tolerance to drought is nearly nil. Some farmers who had decided to wait for more rains were never able to plant.

In September and October 1998, the typhoons Loleng and Iliang hit the valley and caused severe infrastructural damage and early season flooding. The level and intensity of these floods was devastating. Again, rice seedlings were lost and even plants in later growth stages were badly affected.

Our surveys demonstrated that these catastrophes had a major impact on the frequency of traditional and modern varieties in Cagayan. The use of traditional varieties by farmers decreased from roughly 45% in 1996 to about 25% in 1998 (Fig. 14.6). The surveys and discussions with farmers and extension ager provided four main explanations for this rapid ange in the varieties grown by Cagayan farmers.

household seed storage technology. Due to climate conditions, the normal seed nditions in farming households in Cagayan do not permit farmers to maintain the germination ability of seeds for much longer than 6–9 months. This means that farmers cannot 'jump' a production season: if they do not produce seeds for a given variety during a given season, they will have to find an external source to get seeds to be able to plant the variety at the next season. Obviously, another option for them would be not to plant the variety.

2. *Lack of infrastructure for seeds of traditional varieties.* In a situation where seed stocks of most farmers were affected, farmers had to rely on external sources to obtain seeds for the next planting season. The seed stores generally carry only modern varieties, and certified seed growers, part of the Department of Agriculture's system of seed procurement strategy, grow only modern varieties.

3. *Support for the use of modern varieties.* In 1997 and 1998 the Municipal Agriculture Offices sponsored a 'plant now pay later' scheme. In this programme farmers are given seeds at no cost and, on harvest, are expected to pay for them. The seeds given in the scheme are from the certified seed growers and are always modern varieties, and sometimes only the

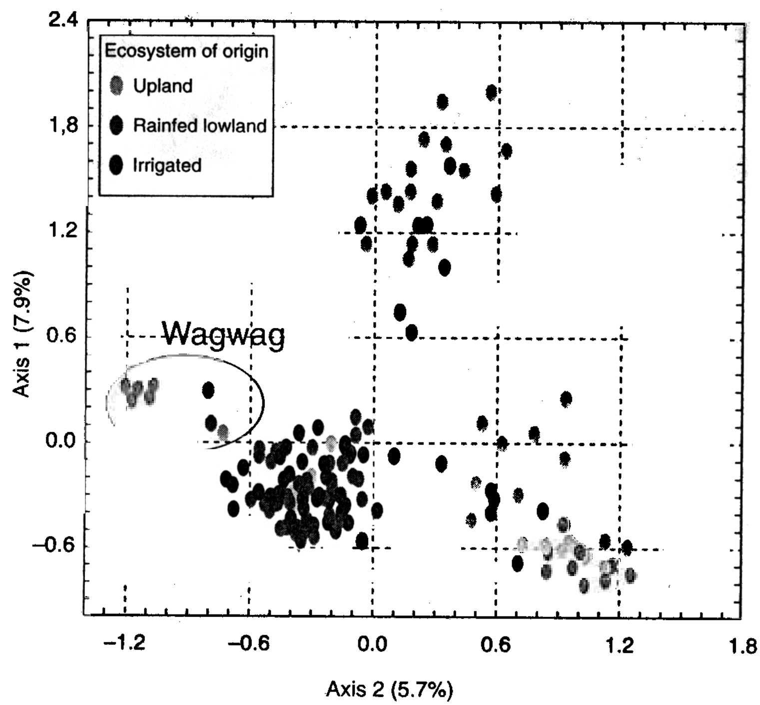

Fig. 14.3. Microsatellite polymorphism of 149 accessions from three rice ecosystems in the Cagayan Valley: first two axes of a correspondence analysis (data from 18 loci).

recommended varieties. The varieties available in 1998 were IR66 and PSBRc28, the former a popular but older modern variety, and the latter a new and currently recommended variety. Traditional varieties are not planted by certified seed growers and were not included in the scheme.

4. *Resilience of irrigated plots.* The varieties that were planted on irrigated plots were obviously less affected by the drought than the varieties planted on rainfed plots. Therefore, irrigation sustains the use of the modern varieties, as farmers plant only modern varieties on irrigated plots (Morin *et al.*, 1998).

Strategies to Sustain On-farm Diversity

The research in Cagayan shows the importance of a continuous monitoring of the rice varieties being grown. While genebank scientists can provide the methodology to do the surveys and initiate the collection of baseline data, they may lack the proximity to the field or the resources to perform the survey at regular intervals. The implementation of 'diversity lighthouses' managed in collaboration with farming communities and local extension offices is needed to provide data on the changes of diversity over time, whether due to particular climatic circumstances or not. These data would also be useful to help farmers obtain seeds from a variety they have lost. Community-based projects in Vietnam and Nepal were successful in developing the use of biodiversity registries in farming communities (Sthapit *et al.*, 2000). In Cagayan Valley, the assessment of the diversity of rice varieties and the analysis of threats to this diversity indicate that strategies need to be identified to sustain the cultivation of long duration varieties in the rainfed lowland agroecosystem.

Making diversity a viable option for farmers

There is a general consensus that farmers are not conservationists by nature but are 'conservationists' through use. In other words, farmers have to be pro-

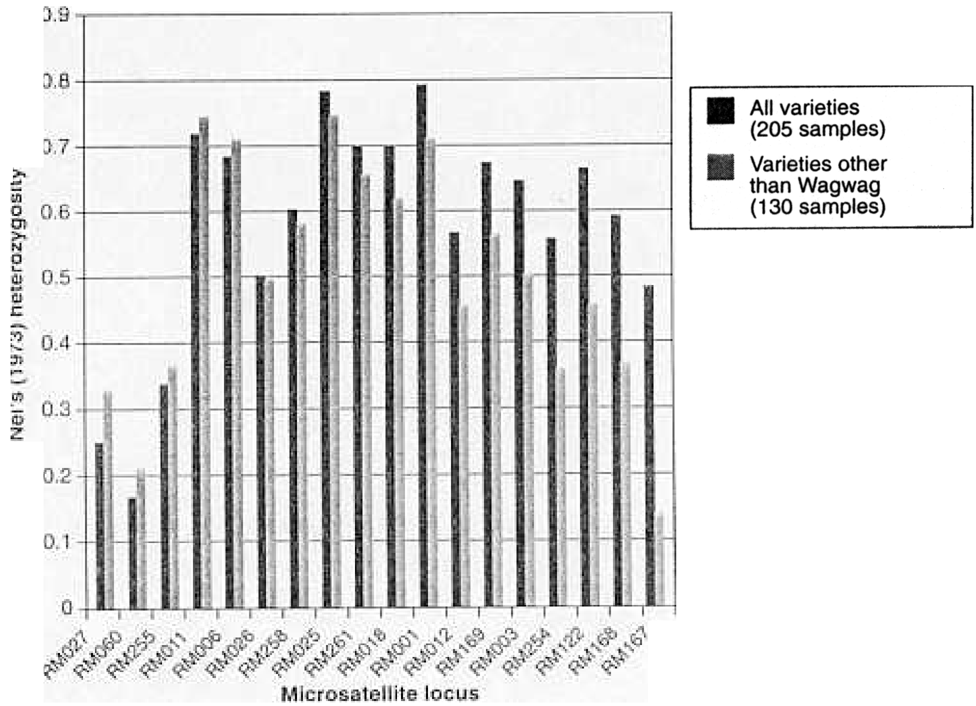

Fig. 14.4. Comparison of the genetic diversity at each of the 18 microsatellites for two sets of accessions: set of 205 accessions from the rainfed lowland ecosystem and subset of 130 accessions other than Wagwag varieties.

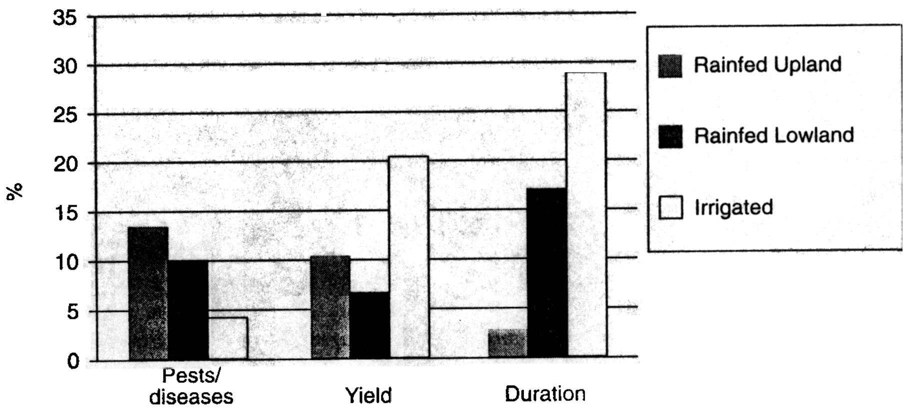

Fig. 14.5. Farmers' reasons for discarding traditional varieties in three rice ecosystems in the Cagayan Valley (from Bellon *et al.*, 1998).

vided with the right technical and economic options, so that they see the advantages in growing the varieties targeted by the conservationists. Cagayan farmers cannot afford to maintain long duration varieties if this results in a loss of income.

The idea of investigating new cropping patterns came from the observation of the practices of a farmer who was planting his traditional varieties in late October, a full 3 months after his neighbours. According to him, this practice posed no risk and

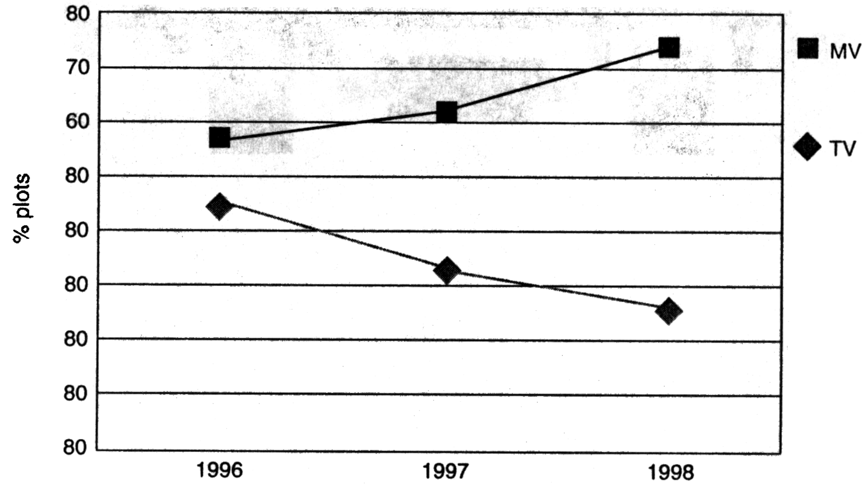

Fig. 14.6. Changes in the proportion of cultivated modern (MV) and traditional (TV) varieties, in selected municipalities in Cagayan Province, 1996–1998.

he felt he achieved higher yields with his traditional varieties than his neighbours. Field trials conducted on the experimental fields of IRRI in Los Baños confirmed these observations. Late planting not only permitted a decrease in maturity of the Wagwag varieties, but there was also an increase in yield (Figs 14.7 and 14.8). Consequently, it is possible to propose a new cropping pattern, which would allow farmers to do double-cropping with both modern and traditional varieties (Fig. 14.9). However, large-scale tests need now to be conducted. It will be extremely important to assess the potential impact of this pattern on the occurrence of pests and dis-

Strengthening farmers' access to seeds

The seed supply system is considered by both breeders and conservationists to be a key element in the deployment and management of crop varieties in agroecosystems. The development of local genebanks managed by farming communities, and of local seed markets, has been the objective of numerous non-governmental organizations (see for example Salazar, 1992) involved in on-farm conservation activities. More recently, the IPGRI-coordinated project for *in situ* conservation on-farm has also integrated the development of local seed markets into its research agenda. It is, therefore, of no surprise when we conclude that it is necessary to strengthen farmers' access to seeds to sustain on-farm diversity. However, in this chapter, we will not discuss the possible implementation of local genebanks or the implementation of seed flow mechanisms within and between farming communities. We present two activities in which institutional genebanks can play an active role.

Improve on-farm storage

As discussed in the analysis of the consequences of the natural catastrophes in Cagayan, poor storage conditions are a cause of genetic erosion. We are developing a simple and cheap seed drying and storage device that farmers could use to store the seeds for several years. With a simple plastic drum as a container, and old rice seeds as a drying medium agent, preliminary tests show the moisture content of fresh-harvested seeds could be brought down to 12%, that is, at a level that would permit the conservation of seeds in the closed drum for several years. A prototype of the device is currently being tested by a pilot group of farmers.

Linking farmers and genebanks

In November 1998, we went to Cagayan Province to take seeds back to farmers who had participated in our project. The seeds had been collected from

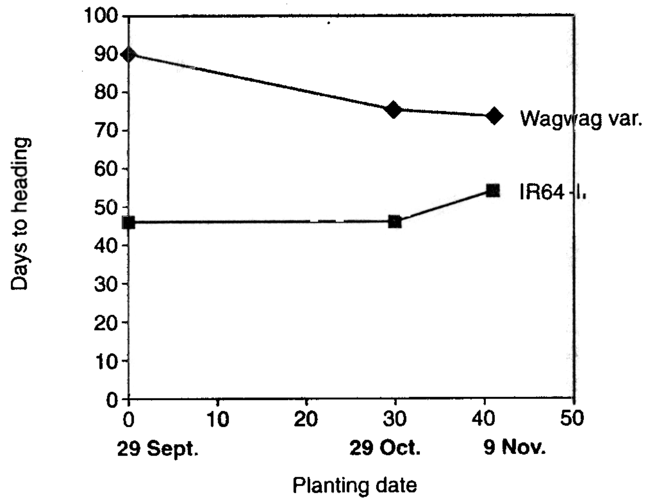

Fig. 14.7. Effect of planting date on the heading date of Wagwag varieties (from Calibo *et al.*, unpublished). Five Wagwag varieties (Wagwag, Wagwag pino, Wagwag red, Wagwag bilog, and Wagwag tawataw) and two IR varieties (IR64 and IR66) were studied in 1998 (4 m × 5 m plots, split-plot design, six repetitions). As no significant differences were observed among Wagwag varieties and among IR varieties, only the mean values for each of these two groups are shown.

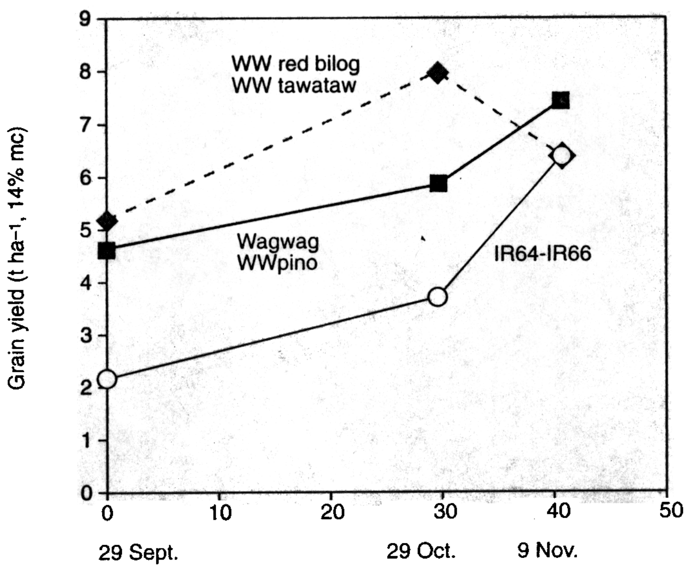

Fig. 14.8. Effect of planting date on the yield of Wagwag varieties (from Calibo *et al.*, unpublished). Same field trial as Fig. 14.7. Mean values are shown for groups of varieties that significantly differ from each other.

farmers in 1996 and planted and characterized at IRRI in 1997. No multiplication had been purposely conducted with the objective of seed distribution, which explains the relatively small amount of seeds distributed for traditional varieties. A total of 28 varieties, including both modern and traditional types, were distributed to farmers in 15 villages. In all, about 1.5 t of seeds were given. A

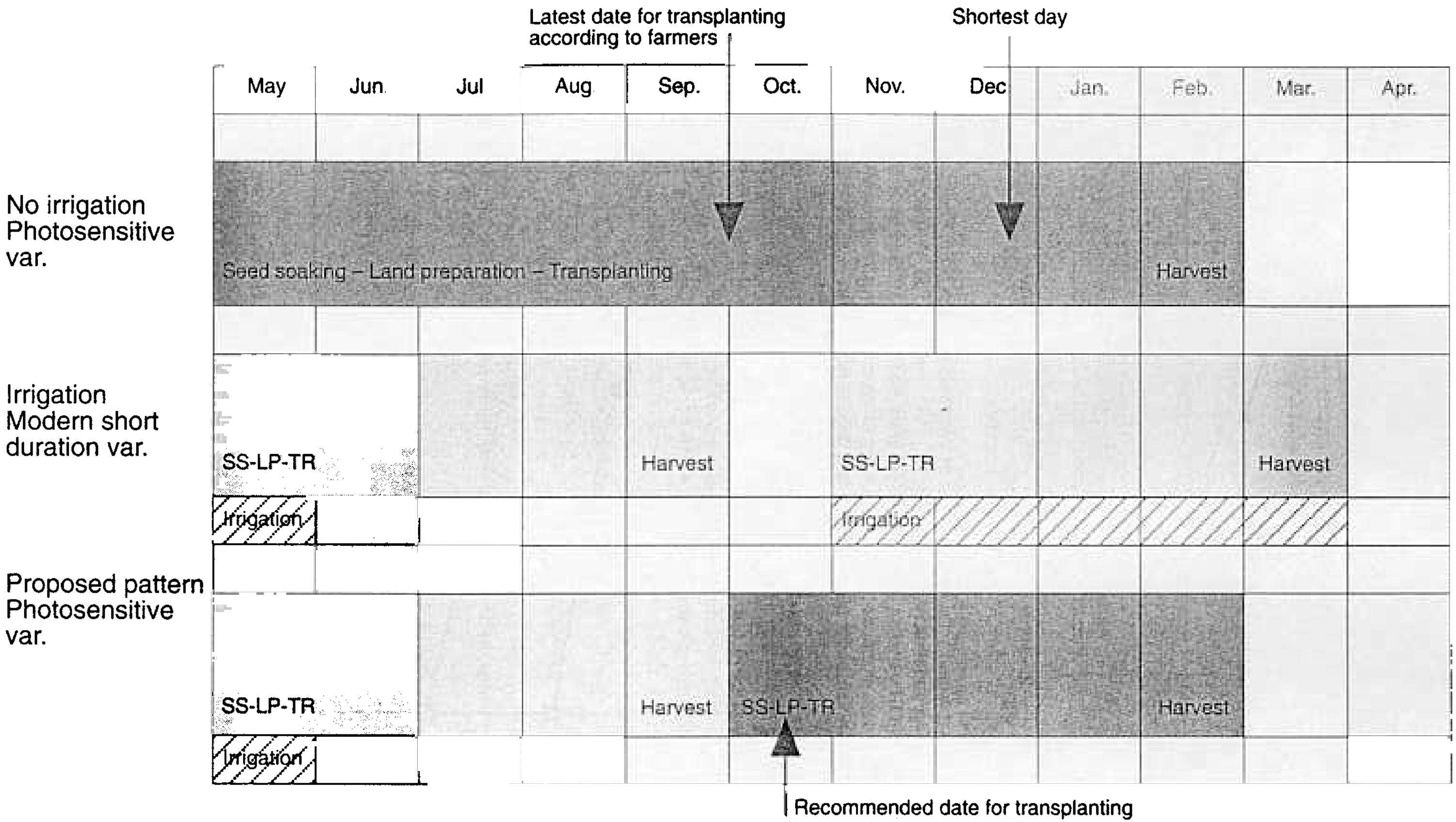

Fig. 14.9. Current and proposed rice cropping patterns in the Cagayan Valley. From the top: (1) current single crop pattern for late maturing varieties without irrigation; (2) current double crop pattern for early maturing varieties; (3) proposed cropping pattern: by delaying the sowing and transplanting of late maturing varieties, these varieties can be used in a double cropping pattern in combination with early maturing varieties.

total of 609 bags of modern variety seeds (2 kg) and 105 bags of traditional variety seeds (1 kg) were distributed.

It appeared 2 years later that the small amount of seeds distributed had limited the efficiency of the distribution. Only 57% and 32% of the bags of modern and traditional varieties respectively, were successfully multiplied. In particular, the small multiplication plots implemented by individual farmers were affected by limited floods, while larger plots, possibly conducted at the community level, would have been more resilient. Nevertheless, the distribution helped to change the ongoing trend of decreasing number of farmers growing traditional varieties (175 in 1996, 110 in 1997, 84 in 1998) as it went up to 148 in 1999.

Although this distribution was not organized in response to the catastrophes in Cagayan, its impact illustrates the need for genebanks to develop an expertise in the restoration of local diversity. One of the activities included in the FAO's Global Plan of Action is the assistance to farmers in disaster situations to restore agricultural systems. The example of the Cagayan Valley shows that disasters do not necessarily happen on a very large scale. The design and logistics for local operation of diversity restoration might have to be very different from that conducted at a national or regional level.

On-farm Conservation: an Additional Role for Genebanks

The increasing interest in *in situ* conservation on-farm makes the institutional genebanks face a new challenge. While being mainly familiar with the closed, controlled environment of cold rooms and multiplication fields and the uninterrupted flow of seed requests, genebanks must now face the open, changing agroecosystems where farmers are not only the end-users but also the decision-makers. On-farm conservation cannot be imposed on farmers. The idea of freezing genetic lanscapes (Iltis, 1974) has long been abandoned. The research activities of the Genetic Resources Centre of IRRI and PhilRice illustrate the role these genebanks and research institutions can play in collaboration with other stakeholders to contribute to the development of the right balance of incentives for farmers to maintain diversity.

The role of genebanks and research institutions is to:

- assess existing *in situ* on-farm diversity and its structure;
- assess the potential benefits of this diversity to both farmers and conservationists;
- identify endangered varieties or varietal groups, and the threats to these varieties.

Their role is then to develop options to make diversity a viable option for farmers:

- to identify technical or policy opportunities for the continued cultivation of these varieties (or to change policies that negatively affect diversity);
- to contribute to the transfer of knowledge/technology to farmers through the appropriate channels.

Finally, genebanks and research institutions have an important role to play to strengthen farmers' access to diversity:

- to understand the impact of seed policies on farmers' access to genetic diversity;
- to understand the technical constraints faced by farmers in conserving genetic resources and to improve or develop seed technologies at the local level;
- to develop channels for the reintroduction of lost varieties when needed, and develop links between farmers and genebanks not only to sustain the diversity on-farm but also to improve its management by farmers.

Understanding the processes that affect the dynamics of diversity in ecosystems goes far beyond the conservation objective. It may provide plant breeders and extension agencies with new options for better deployment and management of diversity in agroecosystems.

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