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Establishing Community-Based Seed Systems: A Training Manual

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David E. Johnson

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Contents

Preface

The **Consortium for Unfavorable Rice Environments (CURE)** seeks to develop community-based seed systems (CBSS) in rainfed rice areas as a delivery system for technologies and capacity enhancement strategies on seed health management, crop diversification, crop management options, and other demand-driven interventions. The aim is to increase productivity and enhance livelihoods.

With these in mind, CURE has developed this manual on the concept of CBSS. This publication is replete with information on the role of seed banks in rice production systems, their context, methodology, and requirements, and on delivering appropriate seed technologies and management practices to ensure seed and food security, and enhance agricultural biodiversity. Also included are seed health management techniques, crop management practices, and various technologies in seed-to-seed production systems. Further, socioeconomic/cultural dimensions are captured in the cases presented in the manual.

This manual is a product of learning, feedback, and additional knowledge derived from interactions with participants of the series of training programs on CBSS conducted in the Philippines. Inputs on learning in similar training programs conducted in Laos and Indonesia also form part of the rich information contained in these modules.

CURE's goal is to capacitate development partners for supporting sustainable development in the marginal uplands. We hope that this manual will help support and realize this purpose.

Acknowledgments

This training manual is a compilation of knowledge, learning, and feedback from the series of Community-based Seed Systems' (CBSS) training programs conducted in the Philippines. Digna Manzanilla, the Coordinator of the Consortium for Unfavorable Rice Environments (CURE) spearheaded the conceptualization, preparation, and packaging of this manual. Joel Janiya provided invaluable roles in coordinating and conducting the training programs; as well as, in editing and packaging the modules. Eleonor de Leon, Priscilla Grace Canas, and Christian Umali provided assistance in coordinating with the authors for copy editing, final arrangements, and presswork of this publication. Former CURE Coordinator, David Johnson and leader of the working group for upland rice systems, Casiana Vera Cruz provided technical guidance throughout the planning and implementation stages of the training and publication. With the able support of the International Rice Research Institute's (IRRI) national program relations, headed by Julian Lapitan and staff, Manuel Alejar, links to Philippine's national rice programs were made possible; thus, paving the way for the series of regional/national training of trainers on CBSS in the Philippines.

The authors and editors wish to extend heartfelt thanks to Director Asterio Saliot and Elsa Parot of the Philippines' Department of Agriculture – Agricultural Training Institute (ATI) through the AgriPinoy program and the International Fund for Agricultural Development (IFAD) for respectively funding the training and the publication components of CBSS. The dedicated scientists and researchers of IRRI and the Philippine Rice Research Institute (PhilRice) are likewise acknowledged for their technical expertise and insights shared in this manual. CURE provided the overall leadership in building the foundation and essence of CBSS, developing related human resources capacity, and documenting the course modules in this manual.

How to use this manual

This training manual serves as a guide in facilitating the establishment of an effective and efficient community-based seed system (CBSS). Included as Appendix 1 (see page 209) is a short survey on rainfed rice ecosystems. The conduct of the initial survey prior to training can help assess the situation in the community before the introduction of a CBSS. The target users, participants, and partners are guided through this survey in terms of existing practices in seed-to-seed production, seed systems, and general farming practices. The information gathered through this survey provides a better understanding of the farmers' and community's preparedness to embrace the concepts and workings of a CBSS. This manual is by no way complete, and should be used together with other materials, references, and knowledge sources available on the specific topics, particularly on the formation and strengthening of farmers' groups or associations.

Module 1 provides some concepts related to a CBSS, with sample cases on the experience of Arakan Valley, Philippines; Lamjung, Nepal; and other useful information from other studies used to better illustrate how a CBSS can be established and implemented. This is followed by Modules 2 and 3, for discussions on the common components and suggested general steps that can be followed in establishing a CBSS, along with the importance of support systems, socioeconomic considerations, and strategies in disseminating varieties and other technologies through a CBSS. Most of these concepts, applications, and examples have emerged from the CURE experience, and these have worked for us and our partners and beneficiaries. Other models, cases, and experiences can be used as references to enhance knowledge on community-based seed systems.

Modules 4 to 14 guide readers on the necessary steps in ensuring an effective and functioning CBSS. They contain discussions on seed health and pest management, rainfed rice varieties and technologies, production of quality seeds, rice weeds and their management, rodent management, proper postharvest management, control of pests and diseases in storage, and crop diversification.

After the series of technical and management topics of the training, participants should be able to devise action plans as an application of their learning. This is guided by the suggested template for Action Planning as indicated in Appendix 2 (see page 212). The major indicator of success of this training is the formation of a CBSS at target sites/areas through the initiative and guidance of the trainees.

Module 1

Introduction to Concepts and Types of Community-Based Seed Systems

Digna O. Manzanilla

Module objectives:

1. To provide an overview of the concept of community-based seed systems (CBSS), some basic definitions, and why they are important in securing food and enhancing livelihoods in unfavorable rice environments, particularly in marginal uplands.

2. To provide different types and examples of CBSS to guide their establishment in many upland areas and for better appreciation of these systems.

LESSON 1: RELATED CONCEPTS AND DEFINITION

OBJECTIVES

1. To discuss the concept of CBSS, their importance, and guiding principles
2. To understand related concepts and definitions

Good seed underpins more sustained rice production and livelihoods. In marginal rice-based upland ecosystems, seed sourcing is generally a major concern. With low productivity, low income, and limited economic opportunities, farmers have limited access to seeds sourced off-farm or from formal seed systems; more so, their seeds are of inferior quality. Also, private seed growers usually do not find it feasible to invest in uplands and remote rainfed areas. Thus, securing good seeds means securing farmers' livelihood.

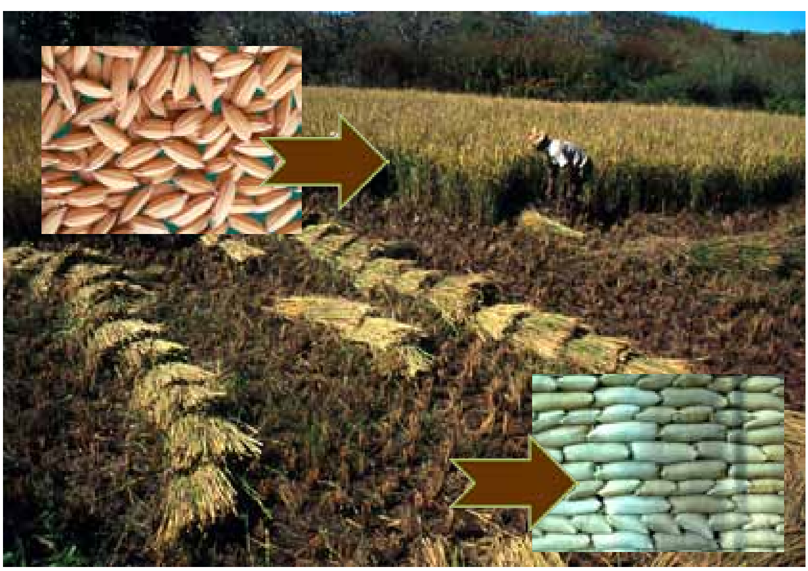
Inaccessibility, lack of a market, and elusive agricultural information add to farmers' problems. Thus, it comes as no surprise that upland farmers are considered the poorest among the poor.

Informal seed systems protect biodiversity in uplands. This is one reason why this seed sector has drawn much attention among rural development workers.

Definitions

Community-based seed systems (CBSS), or what is commonly known as a "community seed bank" (CSB), are evolving but certain commonalities in objectives, scope of services, elements, and processes govern many models. This system is defined as an informal arrangement wherein a farming community or a group of farmers has established a scheme or collective system of producing and exchanging or selling good-quality seeds, especially in times of disasters or seed shortages.

This arrangement can vary, from simple exchanges on agreed terms and conditions to a more systematic selling or trading of seeds within a locality or an extended geographic reach, such as in a "seed network or seedNet."



A better harvest of good-quality seeds.

Quality seeds refer to seeds produced in either formal or informal seed systems that pass a set of standards (formal) or their equivalent (agreed purification standard for an informal system).

As differentiated from a formal seed system, good quality of seeds is ensured under a "community-established guarantee" system that approximates seed certification under a formal system. In different countries, good-quality seeds are oftentimes labeled or referred to as "truthfully labeled seeds," "extension seeds," "R3 seeds," "farmers' quality seeds," or "quality seeds," as differentiated from formal or commercial "certified seeds."

Formal seed systems cover seed production and supply mechanisms that are ruled by defined methodologies and controlled (stages of) multiplication, and are backed by national legislation and international standardization of methodologies. This also includes research, multiplication, processing, distribution and uptake, transport, and storage of seeds. The role of the formal seed sector (private and government) normally concentrates on seed production and marketing, with appropriate compliance with government policies and regulations (Department of Agriculture, Philippines). This may include direct government involvement and the public sector via national, provincial, or state seed corporations, accredited seed growers, multinational or transnational companies and seed movement, the local private sector with or without its own R&D, and joint ventures of local and foreign entities.

Informal seed systems are systems wherein the farmers themselves produce (a certain portion of their own harvest), disseminate, or access seeds directly through exchange, barter, or purchase from within their communities or neighboring villages through relatives, friends, and neighbors. The seeds may be of variable quality and the distinction between seeds and grains is not always clear (Department of Agriculture Memorandum Order No. 20 Series of 2011). This may include nongovernment organization (NGO)-supported seed multiplication and supply programs, community seed production, CSBs, seed fairs, farmers' associations, farmer-to-farmer exchanges, and participatory plant breeding. These, in many developing countries, supply more than 80% of their seed needs (Redoña 2011).

Lewis and Mulvany (1997) provide another definition, wherein a CSB usually stores seeds from a wide range of individuals, informal groups, and NGOs that share seeds among themselves, although at times only occasionally. In this case, farmers retain from their own harvests certain amounts for seeds for the next cropping season. CBSS can have as its secondary objective the in situ conservation of traditional farmers' varieties; but the overriding objective is the supply of good quality seeds within the farm reach.

In situ conservation refers to "the conservation of ecosystems and natural habitats and the maintenance and recovery of viable population and species in their natural surrounding and in the case of domesticated or cultivated species in the surroundings where they have developed their distinctive properties" -- Article 2, International Treaty on plant genetic resources for food and agriculture, 2009. FAO.

The CSB as adapted by the Philippine Department of Agriculture (DA) is an extension tool that aims to increase farmers' access to quality seeds, controlled and operated by farmers within the community, which encourages seed production and exchange among farmers within and outside the community and between farmers and breeding institutions for greater diversity (Memorandum Order No. 20 Series of 2011 signed by DA Secretary Proceso J. Alcala on 15 September 2011—Subject: Guidelines on the implementation of CSBs).

DA Secretary Proceso Alcala mentioned that the country has achieved significant results through the Department's rice production program in his presentation at the Food Security Strategies Forum on 14 March 2012. He noted that the "community seed banks installed that ensure seed availability at the right time and place" is one of the program's key results. He also mentioned at the forum that IRRI has "supported the training of trainers for the modality for seed dispersal."

Farmers inspect the rice fields for any sign of pests and diseases, as part of ensuring better quality of seeds being produced.

A CSB established in Arakan Valley, Mindanao, Philippines, refers to the CSB as "a network of seed producers who agree to follow proper seed health management practices to ensure a reliable supply of healthy seed to the community" (Arakan Community Seed Bank Organization brochure, University of Southern Mindanao). A group of farmers was trained on seed health management and other appropriate technologies to make rice production in the uplands more productive and sustainable. This model is now touted as the basis of many efforts in community seed systems, particularly in the Philippines. The model was borne out of the CURE project in the uplands of Mindanao with the stewardship of a husband-and-wife tandem from the University of Southern Mindanao (Manzanilla et al 2011). (See Case 1 as an example.)

CBSS in rice-based upland ecosystems as a concept that evolved based on the CURE experience can be defined as "a modality or a delivery system for demand-driven varieties and technologies for small-scale farmers aimed at *in situ* conservation and making available rice genetic resources (farmer-preferred traditional and climate-ready varieties) and upland food crops with appropriate management practices toward increasing seed security and food security, improving livelihoods, and preserving agro-biodiversity" (Fig. 1).

CBSS house consolidated technologies—varieties and management practices—that are available, adaptable, and easily disseminated. The elements in Figure 1 are very common in many models and can serve as a guide in establishing a CBSS in a community.

This farmer-to-farmer seed flow is imperative in genetic conservation and in introducing and spreading new technologies and information toward rural innovations. Hence, CBSS serve as an avenue for interventions that can drive livelihood improvements and can capitalize on the organized systems of farmers to reach a wider scale even outside intervention or project support. Farmers not only exchange seeds but also information, derived from either external sources or their own "experimentation." Through the CBSS mechanism, any transaction is built on trust and in-field trials with results that can be easily shared with other farmers.

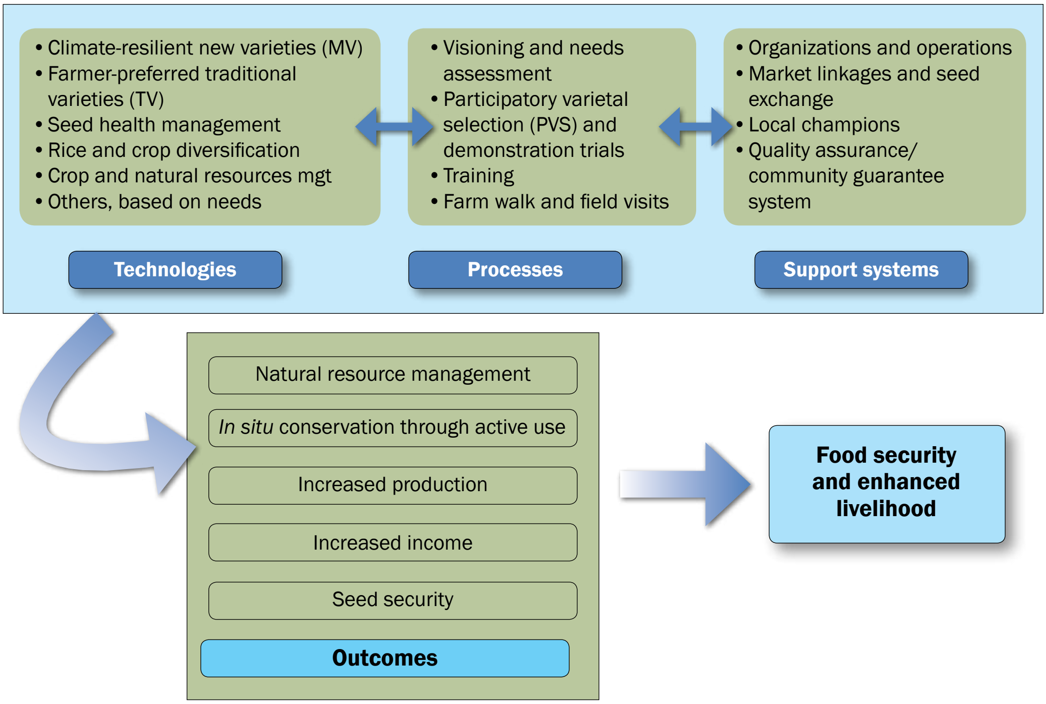


Fig. 1. The community-based seed system (CBSS) model as captured in CURE experience.

For this concept to work, the modality includes introduction through the participatory varietal selection (PVS) process and dissemination of a basket of options to meet varying farmers' preferences for a modern variety (MV)–farmers' variety (FV) combination. Many communities combine the conservation of time-treasured traditional varieties that exhibit traits of significant socioeconomic value to farmers (FVs). This allows for the introduction of new climate-ready or stress-tolerant varieties (MVs) and the corresponding natural resource management options that maximize gains from the new varieties. Lewis and Mulvany (1997) define MV and FV as follows:

- **MV** refers to the products of the formal plant breeding systems currently followed by universities, national and international research centers, and private companies. MVs are genetically distinct from each other, uniform, and stable (i.e., they meet DUS—Distinctness, Uniform, Stability—criteria for good-quality seeds).
- **FV** refers to the products of careful and extensive selection by farmers that represent a wide range of characteristics. FVs include landraces (material indigenous to the area) and varieties that have elements of exotic material, incorporated either deliberately or by accident.

Activity

1. For this activity, make use of the data format initially distributed prior to the training on "Upland rice production: survey of production practices" (see Annex 1). Make use of the information collected to discuss the seed system in your locality. Discussion can focus on the existing practices for seed sourcing, production, and storage.
2. Also, discuss the role of men and women farmers if some particular farming and decision-making activities can be differentiated.

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LESSON 2: IMPORTANCE AND GUIDING PRINCIPLES

OBJECTIVES

1. To discuss the issues related to seed source, quality assurance, and availability
2. To understand how CBSS can contribute to solving problems on seeds in uplands

Seed security = food security

A CBSS aims to examine the problems related to seed insecurity and erosion of the diversity of rice genetic resources.

Problems related to seed availability

1. Available seeds are of poor quality.
2. Farmers use traditional varieties that are low-yielding but may have the traits desired by farmers.
3. Farmers use seeds from their own harvest for the next planting season.
4. Because of low income, farmers use seeds reserved for their home consumption.
5. Farmers have difficulty getting access to the new seeds they desire. Although there is an influx of seeds from seed companies in lowland agricultural areas, there is a lack of sources of seeds in marginal uplands.
6. Droughts, floods, and inadequate storage facilities put pressure on the supply.
7. Limited seed exchange takes place mostly within a village or at times between villages but this is seed normally given as a gift, and mostly among close family members (parents, brothers, and sisters).
8. Women in the village play an important role in the production, health, maintenance, and storage of seeds, but they are hardly recognized for their role.
9. Areas planted to traditional varieties are on the downtrend, yet these are important to farming communities as a source of livelihood and food security. Also, the loss of useful plant species is rapid.

10. Farmer-to-farmer seed exchange is slow because of the poor road system, usually accessible by horse or motorbike.

Concerns related to the need to conserve biodiversity

1. Erosion of the genetic diversity of rice is occurring in the uplands due to the use of modern/introduced varieties that replace traditional varieties.
2. Poverty is eroding both the quantity and variety of seeds.
3. There is a growing clamor for maintaining agro-biodiversity.
4. Varieties in the village are mostly sourced from within (local traditional varieties).

Importance of the community establishing and strengthening the seed system

1. Keeping many varieties available to farmers and the community; maintaining seed security and conserving agro-biodiversity
2. Encouraging community quality seed production for planting
3. Preserving and conserving traditional varieties with characteristics important to farmers as sources of germplasm collection
4. Understanding the negative effect of converting to monocrop farming and farmers losing plant diversity on their lands
5. Strengthening the informal seed system in the community that can provide economic value

> "**A community-based seed system** is seen as an effective mechanism to enhance *in situ* conservation of good-quality seeds, particularly in the resource systems."

Outcome of activities

1. Increased production of high-value traditional varieties for consumption and niche markets
2. Increased income from sale of seeds and economically important crops
3. Enhanced system resilience through appropriate management practices and technologies
4. Enhanced diversity of rice germplasm on-farm
5. Improved characterization of traits of landraces
6. Enhanced food security through increased production and reduction of losses
7. Increased awareness and participation of communities in variety and crop selection

Benefits that can be derived from CBSS components

Access to information and technologies to improve rice productivity through CBSS can provide the following benefits to farmers:

- Climate-ready rice varieties could attain a yield advantage of 100–300 kg/ha over traditional ones under field conditions, based on farmers' feedback during focus group discussions (FGDs).
- The CBSS contributes to the *in situ* conservation of high-value traditional upland rice varieties that command premium prices in niche markets.

- A 10–15% yield advantage can be gained by adopting seed health management practices (Mew et al 2004).
- Farmer participatory experiments in the Philippines using good-quality seed as opposed to farmers' own seeds of the same variety showed increased rice yield by nearly 20% (if in low-yield environments) (Diaz et al 2001).
- In Bangladesh, farmer-friendly technologies in seed drying and preservation gave a 20% increase in germination rate and 41% reduction in required seeding rate (Mia et al 2008).
- Disease reduction from genetic diversification contributes to a 5–7% yield increase.
- A yield gain or price increase is sufficient to feed an average upland family of 5, with a farm size of 1.5 ha.
- Income from nonrice crops and rice yield gains help reduce hunger months from 4 to 2.
- Suitable nonrice crops for a rice-based system serve as a buffer against rice crop losses, provide food during preharvest rice shortages, or can be sold for additional income.
- Soil conservation technologies can prevent land degradation and at the same time improve production.
- Conservation of the diverse genetic resources in a diversified farming system improves system resilience.
- Other short-term impacts are crop management systems that would resist stresses, crop establishment systems using less labor and providing better management of weeds and soil nutrients, community empowerment, more equitable sharing of benefits, and enhanced role of, access to, and control of resources by women and other marginalized groups in uplands.

FGDs with farmers in Arakan Valley indicated that the use of preferred varieties has doubled average rice yields from 1.2–2.1 t/ha to 2.4–4.2 t/ha. With the net income saved, farmers were able to buy other food items and pay for household expenses. Overall, their involvement in CSB technology adoption reduced "hungry" months from 6–8 to 2–3 only (Zolvinski 2008).

As experienced in Arakan Valley, CSBs contributed to *in situ* conservation of traditional upland rice varieties that can command premium prices in niche markets. Also, as a component of a CSB in the villages, nonrice crops in rice-based systems served as a buffer against rice crop losses, provided food during preharvest rice shortages, or were sold for additional income. Arakan Community Seed Bank Organization (ACSBO) farmers indicated that they benefited from new crop establishment systems using less labor and providing better management of weeds and soil nutrients.

CSB guiding principles

- Emphasis on social dimensions is as important as the knowledge and skills in identifying biophysical conditions
- Greater understanding of the complexity of the nature of agricultural development necessitates the use of multidisciplinary techniques
- Involvement of people in activities initiated by development actors and entities
- Ensuring there is networking among citizens that builds on the strengths of each individual or group and makes them a formidable force
- Adoption of strategies that enable marginalized groups to have a voice in the development process
- Greater participation of women in development and attention to equal access to and control of resources

Collection of primary information on social and biophysical conditions at target CBSS sites.

Activity

For this exercise, form a group of four to discuss the following topics:

1. What are the common issues and concerns that are raised by the farmers in your locality or community with respect to the availability of seeds, quality, and variety?
2. How are these concerns being addressed and who are the actors involved?

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LESSON 3: TYPOLOGY AND EXAMPLES

OBJECTIVES

1. To gain knowledge on the different types of community seed systems
2. To learn about the experience in establishing a CBSS under different models
3. To draw some lessons from the CURE project as implemented in Mindanao, Philippines

Typology

CBSS can be categorized according to storage methods and the institutional arrangements needed to set up and maintain these seed banks (Lewis and Mulvany 1997).

Seed banks are typically considered to fall into two broad categories:

- **Individual seed storage**. Seed is retained on-farm by millions of separate farming households throughout the world. This is by far the most prevalent method of storing seed.
- **Collective seed storage**. This type of seed storage occurs when farmers, either self-organized or assisted by outside organizations, coordinate the storage of the seed they need for planting. There has been an increase in NGO-led, farmer participatory collective seed storage projects in the last decade or so (Berg 1996).

Lewis and Mulvany (1997) further provide other criteria used to categorize seed banks:

- **Type of seed**. As observed in many countries, farmers store individually or collectively seeds that are mainly “generative.” This seed can be either MVs or FVs, or a combination of both, depending on farmers’ preferences and the socioeconomic situation faced by the farmers.
- **Seed exchange mechanisms**. Transferring seed between individuals, households, and the seed bank entails a variety of exchange mechanisms. These are mainly informal mechanisms: community seed systems based on seed fairs, in-kind seed loans, barter and transfers based on social obligations, but also through cash sales and purchases (Cromwell 1996). They are also based on religious practices or indigenous cultures.
- **Seed multiplication mechanisms**. The required quantity of seed has to be produced or collected from a group of suppliers either growing seeds locally or sourced abroad. In some communities, this may be the task of self-appointed individuals. In some cases, the community may nominate or contract individuals to do this.

Combining these criteria, Lewis and Mulvany (1997) identified five types of seed banks. Examples are provided in case studies.

1. De facto seed banks—the sum of all seed storage in a community. They have been in existence for a long time, operate informally, and are made up of separately stored, locally multiplied FVs and MVs of seed, kept in individual households. This type of seed banking is typical in many far-flung communities not easily reached by commercial seed growers and where the poor farming communities generally do not have the capacity to purchase seeds from formal sources.
2. Community seed exchange—the organized exchange of some stored seed from de facto CSBs. They operate semi-formally and are made up of individually stored, locally multiplied FVs and MVs. An example of this is the ACSBO.
3. Organized seed banks—new institutions of organized collection, storage, and exchange of seed. They operate formally and are made up of individually and collectively stored, locally multiplied MVs and FVs. Case 2 in Lamjung, Nepal, provides an example.

4. Seed savers' networks—new networks' organized storage and distribution of seed, mainly farmers' and noncommercial varieties, between individuals and groups in a wide spread of geographic locations. Case 3 in Bangladesh is an example.
5. Ceremonial seed banks—sacred groves and reserves. The seed (usually vegetative) is a common property resource collectively managed and exchanged according to local (often religious) customs and traditions. Seed conservation is not the primary function of these systems but does occur as a consequence of their existence. An example is the "*patil*" storage found in the mountain areas in the Arakan Valley.

"*Patil*." A storage structure (*patil*) found in the mountain areas in the Arakan Valley is a repository of farmers' seeds collectively managed and exchanged according to customs and traditions.

Activity

For this exercise, form a group of four to discuss the following topics:

1. The existing seed exchanges in your locality or if you have any knowledge of an example of a CBSS.
2. What are the common characteristics of the models that you know of?

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CASE 1. CAPITALIZING ON SEED EXCHANGES: CSB IN ARAKAN VALLEY, PHILIPPINES

Rose Hondrade, Digna Manzanilla, Casiana Vera Cruz, Joel Janiya, Isabelita Oña, and David Johnson

The CSB model in Arakan Valley is composed of trained male and female farmers who are committed to producing good-quality seeds of Dinorado and modern upland rice varieties as well as other crops.

Formally organized in 2006, ACSBO serves as a network of seed producers who agree to follow proper seed health management practices to ensure a reliable supply of healthy seed to the community.

ACSBO's objectives include evaluating options for coordinating and designing storage, multiplying, and delivering improved and landrace seeds at the target sites. The target markets for good-quality seeds are the local growers and the immediate vicinity and neighboring provinces.

The beginnings

In 2002, a project under CURE started with a baseline survey jointly implemented by a team from the Philippine Rice Research Institute, USM, IRRI, and the local government units (LGUs) at the village, municipal, and provincial levels.

Prior to the ACSBO, the communities were suffering from declining areas for rice, low and unstable average production of only 1.58 t/ha, rural household production good enough for only 4–6 months, low-quality seeds, and a decrease in seed supply of their favored Dinorado variety.

A CSB was the only solution identified to overcome the scarcity of good-quality seed in the valley. The CSB emanated from the need for training on seed health management. The project introduced new varieties, upland rice seed production technologies, and the concept of community efforts in seed exchange.

Community vision: to be a thriving center for traditional variety Dinorado, known for its rich aroma, taste, and good eating quality.

The ACSBO was borne out of this project and started in cooperation with 23 farmer partners. This resulted in 14 upland rice lines/varieties planted in four barangays of Arakan under USM's supervision. The following year, an additional 129 CSB farmers were assisted by the LGUs. To date, the ACSBO has more than 100 members. New sites are also being considered for putting up other CSBs.

Dinorado was chosen as their banner commodity. Identified as a pinkish grain, this variety has distinct aroma and good eating quality favored by many. Moreover, it can command a high market price.

The project partners also engaged in mixed cropping to improve food security. This ensured rice genetic diversification and diversified farming (rice plus other cash crops or rice plus mungbean/peanut maize (corn) under immature rubber or other plantation crops) to alleviate disease risk and crop failure. Short-cycled livestock such as poultry and goats were also integrated depending on the resources and preferences of the farmers.

Some of the project's activities were the seed fair and seed quality evaluation, and seed diffusion of CSB harvest to six villages in the Arakan Valley and four other municipalities of Cotabato—Pres. Roxas, Antipas, Kabacan, and Alamada.

Capacity-building activities included farmers' walks to various rice farms and the CURE technology demonstration farm, and the conduct of field days and a mini seed fair where CSB farmers displayed their products. Farmers also benefited from their participation in training activities, briefings, and farmers' field schools (FFS).

The training activities that the farmers attended exposed them to the requirements of having their CSB formalized, including the Barangay Agricultural Technician (BAT) Training. This was done in Arakan to support the role of the LGU technicians since the whole town had only four technicians.

The season-long training was conducted once a year for the last three years. Farmers meet three times a month for hands-on exercises. They serve as extension workers in the barangay with their own farm as a demonstration area. Part of the BAT is exposure trips to farms of successful farmers (cross-site visits).

Commitment translated into action

Nestor "Boy" Nombreda, a progressive farmer, was enthusiastic and was willing to take the lead in community seed banking. Since then, he has served as the organization's president. The USM project coordinators and the husband-and-wife tandem of Drs. Edwin and Rose Hondrade provided the proper environment within which the CSB could operate. The LGU through the Municipal Agriculturist Office (MAO) serves as adviser and provides additional support to the USM local champions.

The mayor of Arakan, an upland rice farmer himself, is supportive of the role of the CSB in developing and raising productivity in the valley complex. As a market integrator, the local government is supporting the CSB by buying seeds and distributing these to other farmers under its dissemination program. This will help expand the area for upland rice production, which has been declining over the years.

Together with USM staff, IRRI introduced technologies related to seed health management, weed control, rice diversification, and improved varieties for crop diversification. Under the banner program of CURE, "landscape management" was adopted wherein intensive rice production could be done in valley bottoms and other crops or rice could be grown in the uplands. Diversified farming in the uplands would help increase production and reduce the hunger months.

Farmers have also learned to adopt conservation agriculture, which promotes zero tillage and other soil conservation measures. Barangay officials emphasized the two-pronged objective of the upland management program: increasing productivity and conserving the soil.

CURE staff Dr. Casiana Vera Cruz (5th from left), Dr. Digna Manzanilla (6th from left), and Isabelita Oña with USM partners Dr. Edwin Hondrade (2nd from left) and Rose Hondrade (3rd from right), Arakan agricultural technician James Dulay (exreme left), and municipal agriculturist Edgar Araña and his staff.

Expanding market demand for seeds

The popularity of the seeds from Arakan Valley has reached Cotabato and Surigao. Some farmer-buyers were even willing to pay the asking price for Dinorado, which provides additional income for upland farmers. The LGU has records of seeds distributed to other provinces such as Surigao, Sultan Kudarat, Lanao, Saranggani, and Basilan. However, the growing demand was not easy to meet because of limitations on land and capital.

The topography of Arakan limits expansion of land for rice.

Seed multiplication is done in the uplands and seed quality is improved through seed fairs conducted with CSB members. The CSB members increased the seed production of both traditional and modern varieties through seed-to-seed production. In the future, farmers hope to sell large volumes of seeds for better market integration. The ACSBO president shared that CSB members are inviting other farmers from rainfed and irrigated areas to become members of the CSB in Arakan so they can also contribute to supplying seeds requested from other places. USM partners also tried to link ACSBO members to traders who are interested in Dinorado from Arakan. Farmers were advised to make an inventory of their seeds to meet the traders' demand. If the ACSBO could strengthen its ties with the traders, they would be able to determine the demand for seeds and rice, and better plan production and the areas that they would need to cultivate.

Vision for Arakan Valley Complex

ACSBO's vision for Arakan is to be known as the "Home of Dinorado." The farmers aim to produce high-quality rice. Ultimately, their goal is to increase rice production and improve livelihoods. With the announcement from the DA secretary that the uplands will be developed to provide additional rice production, the LGU is now gearing up to further improve its upland development program.

For Cotabato, the target was to grow Dinorado on 4,000–5,000 ha of upland area in 2011 through seed production in the lowlands. The LGU was preparing a scheme on how to multiply upland rice seeds in lowland areas. This required training of lowland seed growers on proper seed production.

A Manobo farmer inspecting his Dinorado rice.

Dinorado (with average yield of 1 t/ha), which is grown through organic farming, is highly preferred by farmers and consumers. Organic rice commands a price of P 45–50/kg, while nonorganic rice's price is P 38/kg.

USM trials in Arakan showed that, when Dinorado is interplanted with UPLRi5, it gives a yield ratio of 2:4 in favor of UPLRi5. This highlights the importance of planting not only the traditional variety but also combining it with modern high-yielding varieties.

Because of the entry of multinationals operating in the fruit industry in Cotabato, existing farming systems in Arakan are expanding the area for plantation crops such as banana and rubber. However, the local executive has assured that some areas are reserved for upland rice production to avoid a rice shortage.

Lowland areas more favorable to seed production.

How the CSB developed and how it works

The development of a CSB followed at least a four-stage process: (1) preparatory/preplanning, (2) planning, (3) implementation, and (4) monitoring and evaluation (Fig. 2).

During the preparatory stage, the farming community's needs are assessed through a participatory rural appraisal (PRA) conducted by the CURE team with key informants at the village and municipal levels.

Constituting the planning stage are the presentation of the PRA results, followed by the formulation of solutions and planning of activities during consultation meetings with upland rice stakeholders. Also at this stage, the vision, goal, objectives, and specific activities are identified.

After the stakeholders have agreed on the plan, the establishment of the CSB farms via PVS prefaces the implementation stage. Informal community monitoring and field evaluations as well as sensory evaluations are conducted to determine farmers' preferences of varieties of seeds to be multiplied on their CSB farms. Formal surveys are carried out to determine the yield performance of CSB entries.

The CSB manages the use of the combination of traditional and modern varieties to encourage multivarietal cropping. Farmers have learned to grow rice not only for home consumption but also for seeds regardless of farm size. Trained farmers through the CSB have reduced the problems in seed quality and supply. The CSB members from rainfed lowlands can recruit members and engage in farmer-to-farmer extension. Farmers are interested in more training programs to gain better access to information and technologies. CSB members also undergo BAT, in which they learn to do extension work. This paves the way for farmer-volunteerism, an important factor in farmer-to-farmer sharing of knowledge.

Farmer-members of ACSBO store their seeds individually. This is what is referred to as de facto seed banking. The primary consideration here is security of good-quality seeds and grains that farmers have produced themselves. Seed quality and availability are very important to upland farmers. Those who have been trained on seed health management avoid seed exchanges with untrained co-farmers since they are not assured that the same quality of seeds will be returned to them.

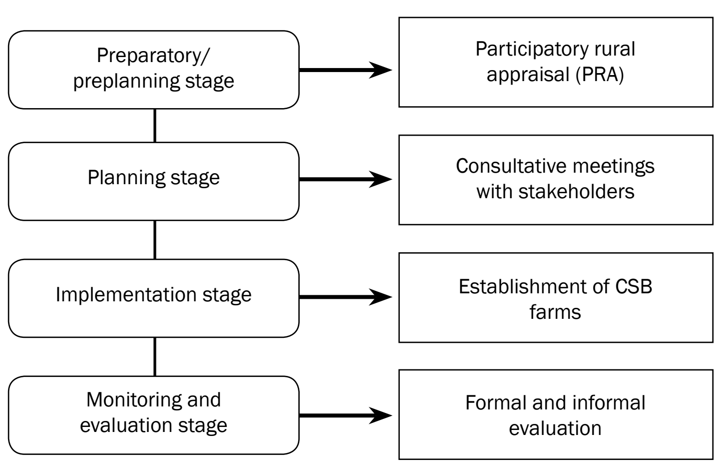

Fig. 2. Development stages of a community seed bank.

Woman farmer cleaning seeds before storing.

The LGU has maintained its own seed inspectors since 2007. Every year, these seed inspectors attend a refresher course on seed quality check. Just like the formal seed quality system, the seed inspectors certify the quality of seeds produced by each participating farmer. CSB farms are inspected prior to harvest and samples from seed stocks are evaluated in terms of cleanliness/purity, moisture content, and germination rate. On top of this established system, a well-observed community "guarantee system" pervades and ensures that the quality of seeds is safeguarded.

Women as seed-keepers

Women perform the following tasks: weeding (together with men), planting (with family), harrowing (done by some women but not common), fertilizer application, harvesting and threshing, and applying for loans from lenders. Seed cleaning, storage, and maintenance are also done by women. Men usually perform land preparation.

Other women check the field before harvest to remove off-types and also do threshing to avoid mixtures. Off-types are harvested separately from the pure varieties. Women harvest only the mature panicles. Seeds are sun-dried using a "*trapal*," where seeds are directly spread on covered concrete streets. Women also do winnowing of harvested seeds to remove unfilled grains.

Women are the ones who allocate the rice harvest whether for reserved seeds, food consumption, or other purposes. Some women, when they run short of grains for food, do not consume their seed stock because it is more expensive to pay for seed loans than to pay for rice used for home consumption. They just borrow rice grains for food and keep their seeds intact.

Women usually attend training programs when their husbands have to do other work or are unable to attend. They serve as extension workers within their family of workers. They are also usually in charge of storing their seeds. Seeds are stored in plastic containers, plastic sacks, bamboo baskets, or "*tabungos*." The variety characteristics most preferred are softness, good milling recovery, early maturity, and drought tolerance.

Outcomes and lessons learned

The involvement of the farmers in CSB activities and learning experiences benefited the farming households and the community. Farmers mentioned that, before the CSB project, they were experiencing seed scarcity, low yield, poor seed quality, and a lack of improved varieties. With new technologies and new lines or varieties of upland rice, they gained higher yields. In 2004, a baseline survey indicated an average yield of 1.58 t/ha. A follow-up focus group discussion in 2010 showed that farmers have at least doubled their average yields, with a range of 2.1–4.2 t/ha.

Seed exchanges have strengthened community relationships. Sharing of seeds with neighbors provided seed security in cases of calamities. Consequently, food security has improved. The 6–8 food-short months were reduced to two (June-July). Also, children, having enough food, did well in school (Fig. 3).

Upscaling the successful experience

The LGU serves as an upscaling link, expanding to other upland areas in the municipalities of Kabalantian and Binoongan, where the LGU conducted FFS for additional seed production areas. An international NGO, ACF (Action Against Hunger International), is now working with the LGU and buying seeds, especially Dinorado. The DA selected other upland rice production areas.

The FFSs conducted in additional villages were carried out by "*purok*" or by cluster. An FFS was held 11 times throughout the growing period. Minorities involved in Kabalantian were *Manobo tinanamon*, *Cebuano*, and *Ilongo*. The sources of seeds were the *Manobos*. Varieties grown were Hamintana, Baris, Inabana, Nay, Nato, Sinulid, and Singguyan, all indigenous materials.

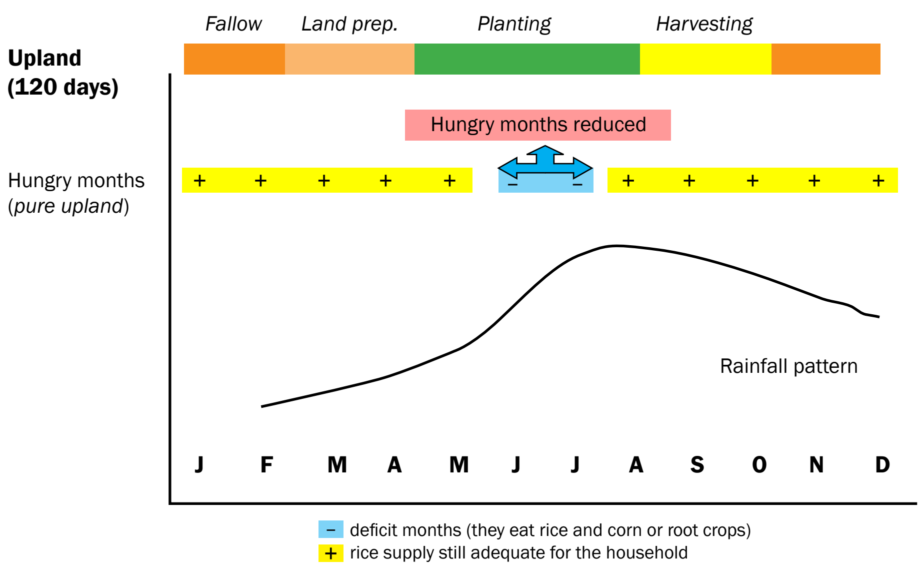

Fig. 3. Reduction in hungry months. Blue represents "hungry" months and yellow food-sufficient months. A reduction in the number of "hungry" months is an effect of increases in the yield of varieties used by the community seed bank farmers.

The Municipal Agriculturist Office indicated that the upland rice industry of Arakan is promoted through a land-use program, LUPA, or *Luwasnon kag malambuon nga Umahan kag kinaiyahan Pangabuhian para sa Arakeños*. This program is a collaboration among the LGUs, Cotabato Foundation College of Science and Technology, and Don Bosco Foundation for Sustainable Development, Incorporated. Incidentally, the Don Bosco Foundation is promoting the use of organic farming for rice production in Arakan.

Also, through this program, the LGU, as an institutional link for research in the uplands, conducts farmers' participatory research-cum-FFS on upland rice production. The LGU collects traditional varieties in the uplands and evaluates these under varying conditions. In addition, the LGU characterizes all varieties grown in Kabalantian. Its institutional program also aims to increase the production of upland rice and interplanting of rice with other crops.

The LUPA program conducts farmers' participatory research in Kabalantian and Binoongan. The program demonstrates the LGU's capability to replicate or upscale the CURE technologies introduced in the development of a CSB. This time, however, the LGU in collaboration with a partner NGO and a community college emphasizes the use of the organic method of growing upland rice as well as the conservation of traditional upland rice varieties.

Meanwhile, the USM continues its technology demonstration in Arakan as a showcase for other LGUs that want to replicate the seed banking strategy used. Upscaling is also linked through a USM-DA collaborative program dubbed "Food for the Masses" to extend the technologies to upland farmers all over Mindanao.

CASE 2. BRINGING NEW HOPE: LAMJUNG SEED PRODUCERS' GROUP IN NEPAL

Bishnu Bilas Adhikari, Digna Manzanilla, and Liza Raitzer

In Nepal, 80% of the total population derives its food security, livelihood, and income from the agricultural sector. However, Nepalese farmers have limited access to quality seeds of improved crop varieties.

The informal sector had been dominating the seed supply system and the seed replacement rate has remained unacceptably low. The lack of quality seeds during the main cropping seasons made Nepalese farmers risk their production by using either their own poor-quality seeds or grains as seed. Of the total requirements for cereal crop seeds of the Nepalese people, the formal sector contributed less than 10%.

Community seed producer groups and seed cooperatives

In 2005, IRRI implemented a project that aimed to improve food security and environmental sustainability in marginal uplands (IFAD-TAG 706). The International Fund for Agricultural Development (IFAD) in partnership with the Institute of Agriculture and Animal Science (IAAS) funded the project.

The project's participatory research program in the mid-hills (900–1,500 m) selected the Sundarbazar Village Development Committee (VDC) in Lamjung District as the key research site. Validation and development of new technologies for the poor farm families living in western mid-hill regions took center stage, focusing on upland and lowland rice, lentil, a green manure crop (*Dhaincha*), and rice-based seasonal and off-season vegetables.

The project initially formed three focal groups in the village: the upland rice group, lowland rice group, and vegetable groups with farmer-cooperators for the mother-and-baby trials for a farmer field trial, farmer acceptance test, varietal demonstration, and minikit programs mainly for planning and distribution of trial materials, and for the evaluation and selection of varieties under varying field conditions and using different management practices.

Farmers' field days organized separately at the maturity stage of upland rice, paddy, and vegetables provided farmers with the opportunity to observe the performance of promising lines and varieties that were obtained from IRRI and the National Rice Research Program. The project's mode of technology dissemination is in Figure 4.

To date, seven seed producers' groups (SPGs) and two cooperatives have been formed since 2005 in the three districts where CURE has its ongoing research activities for its project "Community-Based Program on Household Rice Seed Security and Livelihoods." The nine groups/cooperatives are located in seven villages spread out in Lamjung, Tanahun, and Gorkha districts (Table 1).

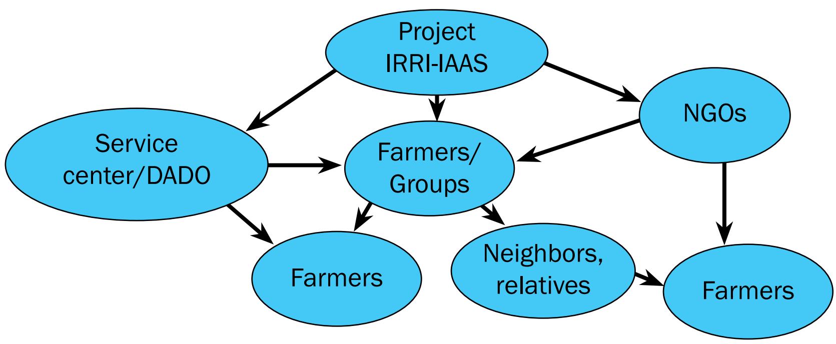

Fig. 4. The project's mode of technology dissemination.

Table 1. Seed producers' groups at CURE sites in Nepal.

Seed producers' group	Village, district	Membership (no.)	Year established
1. Sundar Seed Cooperative Ltd.	Sundarbazar, Lamjung	40	2007
2. Pragati SPG	Purkot, Tanahun	60	2008
3. Hariyali Seed Cooperative Ltd.	Purkot, Tanahun	25	2010
4. Tarku SPG	Tarku, Lamjung	36	2010
5. Majhuwa Ladies SPG	Sundarbazar, Lamjung	21	2010
6. Harrabot SPG	Tarkughat, Lamjung	34	2010
7. Jaya Buddha SPG	Banu, Tanahun	38	2010
8. Bhrikutir SPG	Palungtar, Gorkha	28	2010
9. Gaikhur SPG	Gaikhur, Gorkha	46	2010

The SPGs and cooperatives have an average of 36 members each, with an elected 11-member executive committee. The groups and cooperatives hold regular meetings, usually once a month. Once a year, a general assembly takes place at which several important issues such as membership fees and rules, expansion plans, and other matters are discussed and decided upon. Approximately half of the groups/cooperatives collect membership fees.

The members consent to produce new varieties for seed production. In return, farmers will receive regular training and technical advice and are entitled to sell their seeds at a price of about NRs2/kg higher than the grain price. Members can also obtain foundation seeds and fertilizer at subsidized prices.

Production

IAAS provides training to the groups/cooperatives at least two times a year (before planting and just before harvest). The DADO and NGOs may also provide training for farmers in the villages. Students from IAAS and members of the various groups have been trained to inspect seed plots. Farmers and students conduct moisture, germination, and purity tests, and carry out plot inspections regularly. In addition, a seed inspector from the regional seed laboratory visits the cooperatives' plots several times during the cropping season: at vegetative, flowering, and maturity stages of the crops. For an authentic and validated quality check for seed certification, all the seed groups and cooperatives send seed samples just before harvesting to the regional seed laboratory in Bhairahawa.

With funding from the CURE project, IAAS has employed a farmer in Bhanu who is a member of the Jaya Buddha Seed Producer Group to assist SPG members in Bhanu, Palungtar, and Gaikur. Trained by the Institute, the local resource person's role is to visit farmers from the groups and guide them during the whole process: from planting, roguing, field inspection, and harvest to seed storage. Also, under the current project, a graduate student of IAAS has been employed as a field assistant.

Seed variety selection and benefits

The recommended seed varieties are selected through participatory research. IAAS researchers arrange seed plot trials of modern varieties in farmers' plots. The number of varieties tested varies. In 2010, seven varieties were tested for lowland rice and six for upland conditions. The researchers and participating farmers established the crops with suitable management practices. At maturity stage, informative signs were placed in the fields. Farmers, those participating in the research, and the nonparticipants, ranked the varieties according to their preferences. Varieties with the highest ranking will be used by the SPGs/cooperatives in the following season.

The project started with four genotypes of upland rice (Radha-32, Ghaiya-2, IR55435-5, and Pakhejhinuwa) and six of lowland rice (Radha-4, Ram Dhan, Barkhe-3017, Sunaulo sugandha, Barkhe-2024, and NR-1824-21-1-1). These were validated and upscaled for dissemination during the third year of the project in six more villages with similar agro-climatic domains in Lamjung, Tanahun, and Gorkha districts. These varieties are high yielding, resistant to drought, of good cooking and eating quality, comparably tolerant of common pests and diseases in the areas, and mostly command a higher price in the market. Other varieties were introduced and tested by the farmers using the plot design and management practices introduced by the project for systematic data collection.

To solicit farmers' participation, IAAS and DADO rewarded individual group members with the best performance in seed production and for their engagement in R&D activities. As CURE continuously generates new varieties and management practices, the SPGs introduce these to the farming communities. Mother trials under the PVS approach elicited farmer-preferred varieties and served to showcase the performance of new varieties.

Rainfed varieties fast becoming popular are Radha 4, Sukha-1, Sukha-2, and Hardinath-1. Farmers also maintained their local traditional varieties such as Pakhejhinuwa and Ratothanter for their resistance to pests and diseases, resilience to changing weather conditions, and the added economic value for the farming households.

The availability of good-quality seeds means food security. Farmers noted that new varieties can improve their low and unstable production (1.5–2.0 t/ha) since they had mostly been producing traditional varieties such as Eakle, Jarnali, Madishe, Mana muri, Jhinuwa, and Mansara.

Farmers using the new varieties purchased from the SPGs noted significant increases in yield ranging from 40% to 100%, aside from providing them with many varietal options.

Farmers can now enjoy rice year-round and grow winter vegetables such as cauliflower, cabbage, potato, and onion; broadleaf mustard; and off-season summer vegetables such as sponge gourd, cucumber, bitter gourd, and bottle gourd. Straw yields, an important input for their livestock production, also increased.

Sundar Seed Cooperative—the center of the seed production community

Sundar Seed Cooperative, the first group to be formed since IRRI's initial engagement in Lamjung District in 2005, is by far the largest retailer of seeds among the groups and cooperatives participating in the project. The cooperative prioritizes buying from its own members, but also purchases seeds from farmers from other groups and cooperatives. The Sundar Seed Co-op is currently at the center of seed production and distribution of the community seed production in the three districts.

The co-op organized a quality control team that closely supervises and inspects the seed plots of its members and nonmembers from which they intend to purchase seeds. Only seeds of good quality are bought and collected. Thereafter, seeds are packed and stored at the co-op's rented storage room. This process usually takes place in December-January. In May, at the time of planting, the seeds are sold to its members and farmers in the three districts.

A revolving fund was raised to jump-start the activities. Each member was required to contribute 2,500 Nepali rupees (US$36). In their first year, the SPG produced 4 tons of seeds. The following year, 20 tons were produced with more than 1,000 farmers procuring their seeds from the cooperative. In the third year, the SPG produced 30 tons. For the coming years, they hope to attract at least 3,000 farmers from adjacent villages to procure seeds from the cooperative.

Demand for seeds is increasing as more farmers can see the performance of new varieties. The cooperative also sells the seeds at a lower price. The cooperative has estimated that it can meet only 11% of the total demand for seeds in surrounding villages of Lamjung and other neighboring districts.

Seed collection and storage

Currently, only a few of the groups can afford to rent storage space. A majority of the seeds are stored in progressive farmers' houses. In 2010, 169 tons of seeds (14 tons of upland rice and 155 tons of lowland seeds) were produced by all the seven groups and two co-ops. Of these, almost 30% were stored by the progressive farmers, 20% by the Sundar Seed Cooperative, and 40% or 65 tons were consumed as grains.

The groups'/cooperatives' lack of funds to purchase seeds, lack of storage facilities, and food insecurity account for the high consumption of grains.

Government support

The government of Nepal is encouraging the establishment of community SPGs/cooperatives via a nationwide program, "District Seed Self-Sufficiency Program (DISSPRO)." DISSPRO commenced in 2003. Its objective is to make each of the country's 75 districts self-sufficient in quality rice seeds of modern varieties. Through this program, the government provides a 25% subsidy for foundation seeds to SPGs/co-ops, a 20% subsidy for fertilizer, funds for storage facilities, small machinery, and land for storage houses. Aside from this program, groups and cooperatives can also apply for funding support from NGOs.

Although the Sundar Seed Cooperative has received grants and land for a storage building from the government seed program, its storage house that is under construction was halted due to a lack of additional funding. The lack of proper storage space makes it difficult to maintain seed quality as different varieties can easily get mixed up during the storage time.

The government provides a seed subsidy at 25% to the farmers' groups for foundation seeds, just enough to start their activities. SPGs are given priority in government programs because of the role they play in enhancing food security, especially in areas not easily reached by the government.

The DADO provides training on quality seed production, seed storage, methods to increase yield, and on control of insect pests and diseases. The DADO also provides training to farmers on seed quality control. Selected farmers become seed inspectors. They go to the field and check whether farmers follow the proper technologies. Each year, the DADO selects one farmers' cooperative that will be granted a revolving fund and machinery.

For qualifying cooperatives, the government provides free land on which they can set up their storage for each VDC under DISSPRO. The government launched this program by selecting 25 cooperatives from the 75 districts based on the total area for rice. The DADO also supports efforts to create greater awareness on the availability of seeds through radio programs and local newspapers.

The local champions

Considered a welcome development is the presence of local champions who unselfishly devote time to help facilitate the formation of small farmers' groups and empowering them to take action on their concerns. A dedicated team of scientists from IAAS, with the able leadership of Bishnu Bilas Adhikari, has dedicated its time to facilitating rural development.

Bishnu, an assistant professor at the institute and an agronomist, serves as the CURE site coordinator and a major driving force of the project. Bishnu has a multidisciplinary team composed of agricultural economist Hari Krishna Panta, horticulturist Kishor Chandra Dahal, and soil scientist Janma Jaya Gairhe. The team provides technical assistance on seed-to-seed production for good-quality seeds and vegetable production. Team members initially identify the groups of farmers and provide the critical link between the farmers and the support system provided by the government and other grass-roots organizations. Of the nine farmers' groups, four have leaders who are retired school teachers in the district who are also capable of guiding the direction of the cooperative and seed groups. The others are farmer-volunteers.

Improving livelihood: a model of success

Initially, a set of landed farmers is identified. Farmers' land is used for demonstration, PVS, and seed production trials. A designated team can also help farmers with the setting up of the trials. These farmers must be willing to be trained on seed production, seed health management, and testing the new varieties in their fields. Farmers participate in training programs on best agricultural practices and other topics based on training needs assessment.

Women are also becoming more active in farming. In two groups, as many as 40% of the members are women.

Farmers can access sources of foundation seeds, which are the DADO, projects, and/NGOs operating in the villages, so they can produce truthfully labeled seeds that are sold to other farmers. The CURE project staff and DADO provide quality assurance services. However, the whole process depends on the community guarantee system that is anchored on trust and, at times, on group pressure to ensure adherence to certain "quality standards" set by the group and the supporting entities. Incidentally, the group can take advantage of training on crop diversification, such as vegetable crops and seed production, livestock production, and other livelihood programs.

The Sundar Seed Producers, Ltd., and the Hariyali Seed Cooperative, Ltd., as the central seed procurement enterprises, have office assistants and specified land areas where seeds are produced. They then define the system for cleaning, drying, tagging, packing, pricing, and labeling. A storage house is usually rented or used for free in case a member is willing to spare space in his/her home. Members bought their own weighing scale, seed dryer, and other equipment, some of which were provided by the projects. The SPG brings its seeds in sacks to the cooperative. Members either shoulder the transportation cost or add it to their selling price.

CASE 3. BUILDING A RICE SEED NETWORK

Md. Khairul Bashar, Ahmed Salahuddin, and Paul Van Mele

Summary

Since the signing of the national seed act (Amendment) in 1997 and national seed rules in 1998, NGOs and private agencies have been able to purchase breeder seed from the Bangladesh Rice Research Institute (BRRI); they plant breeder seed to raise quality seed for farmers. Until recently, only 5% of the rice seed was supplied to farmers by a few government and private agencies. A more efficient national seed system would have to supply farmers with timely, adequate quality, modern variety seeds at affordable prices. With this in mind, BRRI developed a public-private network to ensure a continuous supply of breeder seed under the PETRRA project.

We trained and technically supported a wide range of partners to produce foundation and quality seed. Over four years, the supply of quality seed to farmers has increased from 5% to an estimated 15%, while the number of organizations involved increased from three in 1998 to 54 in 2003. Apart from a better-coordinated demand assessment, decentralized production and dissemination of seed, the network enables a quick response to sudden seed shortages due to natural disasters. As its coordinator is also head of the national rice gene bank, the network also helps partner NGOs conserve rice biodiversity by collecting and evaluating local varieties.

Actors and network

BRRI is responsible for producing breeder seed of the varieties they develop and recommend. BRRI produces and supplies breeder seed to the government's Bangladesh Agricultural Development Corporation (BADC), which multiplies the seed and distributes it nationwide.

In the old model, only BADC produced foundation seed on its farms (Fig. 17.1). Certified or truthfully labeled seed (TLS) was produced from foundation seed through their contract growers in 15 zones of the country.

Under the new model, BADC is no longer the sole producer of foundation seed. They now share their physical plant, such as processing centers and stores, with other players in the seed business, and so gradually become a service provider. The governmental Seed Certification Agency is not directly involved in the network, but plays a vital role by providing quality control services from breeder seed to foundation seed to certified seed.

By 2003, quite a few private seed producers had become involved in the seed network, mostly operating at about the same scale as the local NGOs, but selling their seed on the open market. Throughout the country, an increasing number of NGOs have embarked on agriculture and now distribute quality seed to the poor. Although it is difficult to classify the wide range of seed producers, an overview is given in Table 17.1.

Evolution of rice seed network

Before PETRRA. Until the late 1990s, the private seed sector was not interested in growing or selling rice seed. NGOs lacked the equipment and skills, resulting in questionable seed quality. Of the large volume of seed needed by farmers, BADC was able to provide only about 5% of it, suggesting that there was a nationwide scarcity of good, formal seed. After the national seed rules took effect in 1998, NGOs and private-sector agencies started approaching BRRI for breeder seed. This was on a first-come, first-served basis, and without any screening of partners as to their capacity to produce foundation and quality seed.

Phase 1. Increasing breeder seed production. In 1999, the Genetic Resources and Seed Division of BRRI launched the first phase of this PETRRA subproject to increase the supply of breeder seed and to help all categories of seed producers to improve their knowledge.

Phase 2. A network emerges. In the second phase of the project, it became clear that BRRI had to screen for the most suitable partners. A memorandum of understanding was signed between BRRI and several NGOs and private seed companies with enough technical capacity and land to grow foundation seed. This gave them a guaranteed supply of breeder seed, and a legal framework for producing foundation or quality seed under BRRI's supervision. In 2004, several other organizations were about to sign a memorandum of understanding. BADC is no longer the sole producer of foundation seed. For an overview of the major differences between the old and new seed system, see Figure 17.1 and Table 17.2.

PETRRA provided an environment for its different subprojects to regularly exchange experiences at the uptake forum and laid the groundwork for a rice seed network. All organizations that were involved in the nine seed uptake subprojects increasingly requested breeder seed from BRRI and automatically became members of the seed network.

Phase 3. Local leadership leads to regional networks. This decentralization into focal area forums should lead to fewer direct requests for breeder seed from BRRI headquarters, as the networks coordinate local demand and as BRRI regional stations produce more seed.

Table 17.1 Comparison between seed producers under the rice seed net.

	Local NGO	National NGO	Private sector (PS)	BADC	BRRI
Mandate(s)	Improve livelihood by forming groups and providing microcredit	Enterprise development for sustainability	They have no mandate to benefit poor farmers Provide service through business	To provide service to the nation by producing and distributing quality seed	-To develop modern rice varieties and sustainable rice production technologies adapted to different seasons and ecosystems -To provide breeder seed to multiple actors upon request -To maintain rice gene bank
Focus on resource-poor	Yes	Yes	No	No	Yes under PETRRA
Motivation to participate in network	Highly self-motivated and feel privileged to be part of value-based seed network	Motivated to expand their work	-Highly motivated and feel privileged to be partner of network -To become established as seed entrepreneur	-Motivated -To sell their products and service to the network partners	-Highly motivated -Leading the network is part of BRRI's mandate
Pre-1998 experience of seed production	No	No	No	Yes	Yes
Strong points	-A lot of scope to work with poor farmers locally -Work with groups -Can assess demand and distribute seed efficiently	-Have fixed, nationwide clientele groups -Push seed sales to their clients through credit support -Have skilled personnel and physical facilities	Similar to local NGO except Syngenta, but sell seed through dealers in open market	-Highly skilled personnel -Enough physical facilities and logistics throughout the country -Have own processing centers and marketing channel	-All kinds of technical support (demand-led variety development, training, monitoring, etc.) -Maintain seed network throughout the country
Competitive advantage	Enjoys the trust of the community	Have well-established nationwide customer base	Small seed producers/ sellers already know their customer base; Syngenta has good marketing network and attractive packaging	Due to government subsidies, they can sell seed at low price through a well-established marketing channel	Not applicable
Weaknesses	-Little experience with seed, less trained personnel and fewer facilities -Low market coverage	-Work with people irrespective of poverty levels -Higher price of seed than BADC -Inadequate demand assessment resulting in unsold seed being sold the following year	-Price higher than BADC -For small entrepreneurs, human resources and physical facilities are insufficient	-Sale of produce is not ensured -No control over variety and quantity selection as this is decided by Seed Promotion Committee of Ministry of Agriculture	-Limited physical facilities -Insufficient skilled personnel in breeder seed production activities

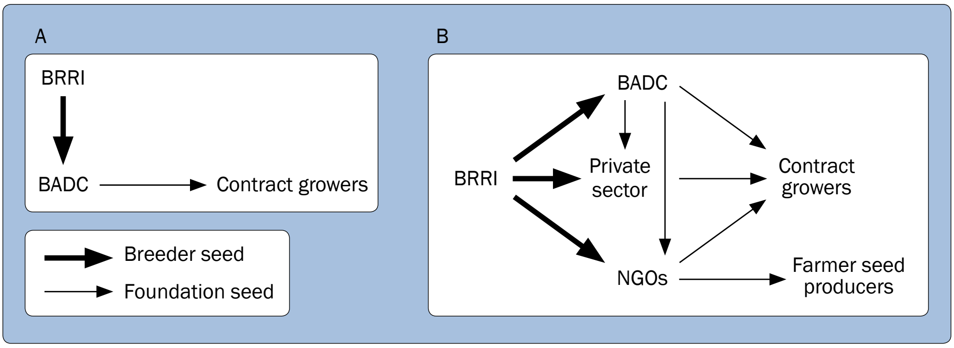

Fig. 17.1. Old (A) and new (B) seed systems in Bangladesh.

Table 17.2. Comparison of old and new seed distribution systems.

	Old system	New system
Demand		
• Planning	Narrower	Wider
• Quantity	Based on sales records of the previous season.	Seed producers within the network take stock of needs and place their demands for amounts of breeder seed directly to BRRI.
• Variety	No knowledge about farmers' preferences. Appropriate varieties demanded by farmers were not available in all locations.	Based on preference surveys, quality seed of locally requested varieties is produced and distributed easier and quicker.
Quality	Quality of seed was questionable.	Capacity of NGO and private sector is built and monitored by BRRI scientists to ensure quality of foundation seed production.
Availability	Not ensured. Only 5% of the national seed demand could be supplied.	Seed supply has increased to meet 15% of the national demand.
Dissemination	Slow. Network of dealers was weakly developed within districts.	Quicker. Farmers have timely access to quality seed.

How does the rice seed network operate?

Identify partners and establish network

BRRI established a rice seed network at the national and regional levels to get quality seed easier and faster to poor farmers. It allows for local demand to determine which varieties will be produced and how much.

At the national level, we initially chose partners based on their existing capacity and nationwide coverage, either directly or through strategic networks with local organizations. So far, BRRI has signed a memorandum of understanding with three NGOs (BRAC, GKF, and Podakhep), and one private company (Syngenta). The NGOs have their own foundation seed farms, and to some extent their own processing and storage facilities. Other NGOs such as AAS, Proshika, RDRS, and Shushilan along with some private companies such as Supreme Seed and Alpha Agro Seeds are still in the process of signing a memorandum of understanding, but they are already allowed to buy breeder seed (Fig. 17.2).

The number of partners in the network grew from three in 1998 to 54 in 2003, of which about 35 are small-scale agribusiness dealers. They easily build on their existing customer base and respond well to demand. Unlike the private companies, local NGOs have not started mass-producing rice seed, because they perceive it as risky and lack the expertise. Nevertheless, those who have started on a small scale are now expanding; because they now know they can get a fair price and easily sell all their seed.

Small seed entrepreneurs and local NGOs use breeder seed directly to produce truthfully labeled seed. Most of them use BADC processing and storage facilities, so that both genetic and physical purity is guaranteed. It is a waste to use breeder seed to produce truthfully labeled seed, but it is how the network is experimenting, learning, and developing. Over time, these seed producers will need to rely on foundation seed suppliers in their area rather than on breeder seed from BRRI.

To respond better to location-specific demands, focal area forums have been created in northwest and northeast Bangladesh, where regional BRRI stations already produced and distributed seed. Although first set up to talk about regional issues on rice and to explore ways to deliver information consistently to farmers, seed came up as issue number one in both areas. Partners were selected who have a license from the Ministry of Agriculture and who are specifically working with resource-poor farmers in that focal area. In the northwest, RDRS has taken the lead, while in the northeast, albeit a bit slower, AAS is emerging

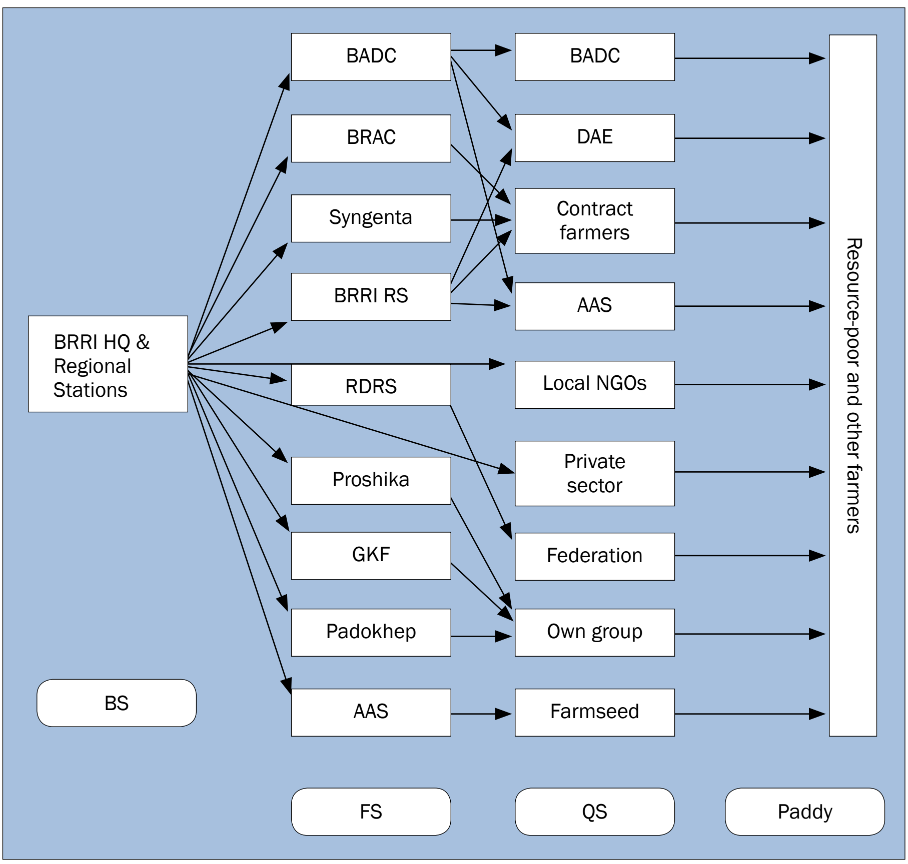

Fig. 17.2. Flows of breeder (BS), foundation (FS) and quality seed (QS) through the rice seed network, 2003.

as leader. The national and regional networks have been strengthened through formal agreements, training, regular monitoring of foundation seed production plots by BRRI, and interactions of all partners in planning workshops.

Assess quantity of breeder seed required to meet demand of specific varieties
The demand for breeder seed is gauged at the national and focal area level. At the national level, the demand analysis, planning of production and distribution, and policies are discussed by the seed promotion committee under the Ministry of Agriculture. To better assess local needs, the Adaptive Research Division of BRRI has adopted a pro-poor partnership and bottom-up approach, as described in the previous chapter.

Planning workshops for the focal area forums are organized at the BRRI regional stations, or at any of the partner organizations.

Supply breeder seed to partners
BRRI has the sole responsibility to produce and distribute breeder seed, which is supplied to network partners in 10-kg bags. Personnel of the Seed Certification Agency monitor the distribution of breeder seed and seal the bags with a tag. Apart from BRRI headquarters, now two of the nine regional BRRI stations produce breeder seed of certain varieties as well.

In 2003, demand for and production of breeder seed was double compared to the previous years, despite BRRI having raised the price per kg by 400%. Even after this price hike, some small-scale private seed producers still buy breeder seed to produce truthfully labeled seed. This waste of resources is hard to avoid at this stage of development, as mentioned earlier.

Ideally, a national strategy should be developed to decide who should produce foundation seed and where. BADC, BRRI regional stations, experienced NGOs, and large companies could cover the whole country.

Train the trainers
For years, the senior author (Bashar) was regularly invited as a speaker in training programs organized by BADC. Since PETRRA, the techniques used for maintaining purity of breeder seed are taught equally to the network partners through training, monitoring, and visiting their foundation seed production farms.

On-the-job training courses on seed production and preservation are organized by the Genetic Resources and Seed Division at BRRI. The training also helped develop an esprit de corps. Trained personnel then teach quality control to groups of smallholder seed producers. Various mechanisms to work with poor seed producers are described in the following three chapters.

Monitor seed quality regularly
Personnel from the Seed Certification Agency monitor breeder seed production at BRRI headquarters in Gazipur and the regional stations (Table 17.3). At the same time, BRRI scientists help to solve technical problems in the field.

The first monitoring takes place in the field, the second during drying and processing, and the last one during storage, when samples are taken for laboratory testing. During supervision, the Seed Certification Agency recommends several techniques to improve breeder seed production, such as leaving a one-line gap after each six lines during transplanting, drying one variety at a time on the drying floor and threshing only one variety at a time.

Table 17.3. Actors involved in quality control under rice seed network, 2004.

Seed class	Producer	Actors for quality control
Breeder seed	BRRI	Breeders and staff of Seed Certification Agency
Foundation seed	BADC, private sector, and NGOs	Producer, BRRI scientists, and staff of Seed Certification Agency
Certified and TLS seed	BADC, private sector, and NGOs	Producer (optional Seed Certification Agency and BRRI)

Per request, BRRI scientists monitor the foundation seed production plots of the partner organizations so that they can maintain the required field and seed standards set by the Seed Certification Agency. Although certifiers are limited, they also visit the foundation and certified seed plots of partner organizations to give them tags after satisfactory results. But what will happen with quality control of foundation seed after the project ends? Considering that the incentives for BRRI staff to visit every foundation seed farm upon request of a partner will diminish, policy support is needed to strengthen the Seed Certification Agency.

Conserve rice biodiversity

PETRRA has stimulated synergies between her subprojects. The head of the national rice gene bank (Bashar) and coordinator of the national seed network is also the principal investigator of another PETRRA subproject on rice biodiversity. As such, the rice seed network started to become a hub for local varieties or landraces to enter the formal system. BRRI dhan34, for instance, was the first local aromatic variety that became registered, and now the network has opened up opportunities for a broader range of local varieties to be collected, screened, registered, and become legally protected by intellectual property rights. Some NGOs are currently playing an innovative role in securing rice biodiversity. In Khulna in southwest Bangladesh, about 16 NGOs have been engaged in germplasm collection of local varieties. Through the rice seed network, we identified a few suitable NGOs who help to evaluate these local varieties with farmers in a wide range of different agroecosystems and to multiply the most important ones.

Keys for success

- Changed seed policy helps seed producers to get access to breeder seed.
- A well-equipped breeder seed unit has been established at BRRI.
- Ensured access to breeder seed motivates partners.
- Increasing demand of quality seed ensures that all seed is sold.
- Partners share information and resources.
- Partners get technical knowledge through training and monitoring.
- Quality control is emphasized.
- The rice seed network developed in a flexible, learning by doing environment provided by PETRRA.

Difficulties, risks, and assumptions

A favorable natural environment is essential for growing good seed. Natural disasters can disrupt the seed flow. Proper field selection is essential. Although it seems risky that the quality of seeds produced by smaller partners scattered throughout the country cannot be monitored by an official agency, the ultimate quality control happens by pressure of their customers. Of course, this bottom-up quality control works only when farmers have sufficient choice in seed suppliers. To meet the growing demand for breeder seed in the future, it will be necessary to invest in physical and human resources. Increasing the price of breeder seed from Tk 25 (US$0.45) per kg to Tk 100 ($1.75) reduced the misuse of seed and increased the revenue for BRRI. However, the breeder seed unit at BRRI cannot use this money for its self-sustainability and to accommodate the growing demand. Policy changes are required to make this happen. The nine regional stations of BRRI have enough land to grow more breeder seed. Also, foundation seed could be produced here, but so far BRRI is not officially recognized to do this. Revising the law with regard to BRRI's and BADC's mandate would be recommendable.

Small-scale seed producers generally lack access to bulk processing and storage facilities, which prevents quality seed from reaching poor farmers at a reasonable price. BADC, selling seed at a subsidized rate, distorts the market. To avoid this, seed should become registered as an industry.

Taking stock of existing facilities and developing a framework of who produces what seed nationwide is something the rice seed network identified as essential, but little time was actually given to bringing this into practice. Delegating responsibilities from BRRI headquarters to other players could reduce the network's management load, freeing energy to spend on further expanding the network and on producing breeder seed.

Scaling up

By establishing the network, the supply of quality rice seed to farmers has increased from 5% to about 15%. The network allows BRRI to assess the demand for its breeder seed more accurately, and so to produce the right amounts, but it also enabled partners to quickly help one another at times of acute seed shortages due to natural disasters.

As there are very few seed outlets in southwest Bangladesh, since 2003 seed production has been promoted in six villages, of which three are under the supervision of the NGO HEED Bangladesh and three are under the NGO Shushilan. In each village, nine farmers were trained to grow foundation and quality seed. They received breeder seed of BR23 and BRRI dhan40, the most popular varieties in the region. The smallholder seed producers are now keenly aware of the demand for seed by clients in the area. In 2004, another seed producer group started producing BRRI dhan28 and 29.

Some network partners such as ABCD and BRAC have since developed a memorandum of understanding with the Bangladesh Agricultural Research Institute (BARI) to get breeder seed of other crops. Smallholder seed producers have already applied their skills to other seed crops, including onions, wheat, mustard, and potatoes (see Chapters 18 and 20).

Conclusions

The network now has many partners and is capable of producing quality seed, with profitable businesses emerging. The rice seed network has improved access to quality seed at the grass-roots level, resulting in a rapidly growing demand for quality seed. Policy reform is needed to optimize breeder seed production and performance of the rice seed network.

Source:

Md. Khairul Bashar, Ahmed Salahuddin, Paul Van Mele
Building a rice seed network. Innovations in Rural Extension:
Case studies from Bangladesh
Edited by Paul Van Mele, Ahmad Salahuddin, Noel Magor. 2005
CABI Bioscience, IRRI, CABI Publishing, 307 p.

Module 2

Common Components and General Steps in Establishing a CBSS

Digna O. Manzanilla

Module objectives:

1. To understand and be guided by the common components or elements of a community-based seed system (CBSS) as observed in many models and cases.

2. To gain knowledge on how to set up or facilitate the formation of a CBSS in a selected community or village.

LESSON 1: COMMON COMPONENTS OF A CBSS

OBJECTIVES

1. To know the common components of a CBSS
2. To be able to explain the importance of each component

The community-based seed system (CBSS) can be considered a suite of technologies and services. The components mentioned here are those that worked for us in our projects and cases.

Other components were observed and noted from other models. However, depending on available resources and situations in the field, these could vary from community to community, and from project to project. The following components allow for a combination of economically important varieties and commodities, leading to income diversification (Manzanilla et al 2011):

1. Organization of farmers or identifying the target farmers' association existing in the area (formal or informal). This can include training the farmers on managing the cooperative, farmers' association, or farmers' group, or capitalizing on an existing cooperative. This will take care of seed-to-seed production. With a system of organized farmers, pooling extra production is possible to meet market demand for rice varieties—which can add to the income from sales of seeds and rice grains.

2. Capacity enhancement of farmers on seed health management. This activity is for enhancing knowledge on seed purity and quality, and ensuring seed supply at the right time with the right quantity and quality for enhanced food security through increased production and reduction of losses. This can include a farmers' field school (FFS) with a "Quality Rice Seed Production Course" or seed-to-seed production with emphasis on seed health management.

3. The introduction of appropriate management technologies. This maximizes the potential yield from the selected varieties. In crop management processes, existing good agricultural practices can be enriched.

4. The introduction of rice-crop diversification for system resilience and productivity based on cultivar × agronomic options. The introduction of other crops (cash crops and perennial crops) together with other agronomic options for crop nutrition, pest control, and diversification can be in the form of training on crop diversification to allow for other sources of food and income.

5. The conduct of participatory varietal selection (PVS) processes helps identify and introduce well-adapted and preferred rice varieties to increase total farm productivity. The provision of climate-ready rice varieties/elite lines and preferred traditional varieties is the ultimate goal of breeding programs. This increases the production of high-value traditional varieties for consumption and for selling in niche markets, thus increasing income from sale the of seeds and economically important crops.

6. Group learning and information-sharing strategies include demonstration trials, field days, farmer-volunteers, seed fairs, and farmer-to-farmer seed and information exchange. Information-sharing strategies will focus on seed selection, seed health, crop diversification, and cropping systems that conserve both rice and soil resources in marginal uplands.

7. The identification of “local champions” such as institution executives, municipal agriculturists, government and nongovernment extension agents, and farmer-leaders as change agents and sources of motivation and learning in the community. This would include farmer-volunteers who become leaders in organizing farmers, a leader in the community with a firm commitment to support the CBSS efforts, and those who serve as trainers and cooperators for demonstration trials.

8. A seed quality inspector for quality assurance for good seed. This can be the link to a formal institution (for more advanced stages of seed banking). In most cases, the CBSS is anchored in “community trust” or a “community quality guarantee” system to ensure an acceptable quality of grains to the farmers.

9. Linkage to formal research institutions for the following:
    a. Characterization of rice genetic resources.
    b. Ex situ conservation of rice genetic resources (for varieties that may not have been chosen by farmers based on their preference criteria, but that have been deemed necessary to conserve for important characteristics—this can be through formal links with institutions for research purposes (if necessary).

10. Market linkages. These are for community-based seed system that will engage in pooling of excess production to tap into available markets for seeds, as a potential source of additional income. This can also include market linkages for additional crops that may be produced from crop diversification endeavors. Market integration of the CBSS can be achieved through pooling of excess production to enable marketing of rice, rice seeds, and cash crops. Farmers’ associations can develop a system of collection and distribution.

11. Outscaling/upscaling activities such as the conduct of farmers’ field days, cross-site/farm visits, the production of information, education, and communication materials, and others.

Activity

Form into four groups to discuss the following:

1. Which components have you used before this training? What did you learn then that would help in your role in facilitating the establishment of CBSS?
2. Discuss any potential obstacles that you would encounter in your institution and target community once you start establishing a CBSS.

LESSON 2: SETTING UP A CBSS

OBJECTIVES

1. To gain knowledge on the different steps that can be undertaken to facilitate the formation of a CBSS in a selected community or village
2. To learn some tools in conducting the various steps

STEPS IN THE FORMATION OF A CBSS

A. Initial preparations in the community

1. Project site selection. In identifying the site, village, or community, the following may be used as a set of criteria or guidelines:

    - There is a problem of seed insecurity in the area due to varying climatic conditions or calamities.
    - There are no or limited sources of seeds.
    - Farmers do not work together if they find it hard to exchange or save seeds. In some cases, there can be an existing farmers' association but it is not dealing with seed exchanges.
    - Farmers are so poor that they consume their reserved seed stock for home grain consumption.
    - The community has a willingness to embrace change or is responsive to changes that can be introduced by the project.
    - The presence of support groups, support systems such as a focus on agriculture by the local government, or the presence of sources of information.
    - An area where the project can have greater impact—in terms of number of farmers that can benefit.

2. Community participation in a visioning exercise, in which there is creation of awareness on the loss of genetic resources, rapid loss of useful plant resources (see ACSBO CASE 1), and the introduction of modern and improved varieties can be discussed with the community.

To be included here is the determination of community indicators of change to ensure that CBSS components can meet farmers' needs and can contribute to genetic resource conservation, seed security, food security, and enhanced livelihoods.

- The identification of traditional knowledge and traditional varieties that are important because they can yield well also and/or can command a high price in the market and they have good quality.
- The identification of farmers' needs and aspirations.
- A community dialogue on problems, opportunities, strengths, and weaknesses—this can include stakeholder analysis to define who can be potential collaborators, alliances, and sources of information and support.

This may also include engaging the participation of the government extension arm/NGOs present in the area.

3. Conduct of a rapid rural appraisal during community meetings (Table 1 as suggested methods); this suite of methods can include the following:

    - Information gathering on plant species, ethno-botanical surveys, or participatory "seed mapping" for genetic diversity and location.
    - The use of local plants and sources of seeds.
    - Farmers' problems with seed sources and access.
    - Farmers' current practices in seed production, storage, and exchanges, among others.

The brief descriptions of some of the most important participatory rural appraisal tools and methods in Table 1 can be used for problem diagnosis. These are mainly used for the preparation of the village descriptor and baseline information.

4. Identifying a group of farmers, workers, and partners who are willing to take part in the process. The farmers could be those who are already part of a formed cooperative or farmers' association existing in the community. Or, if these are not yet present in the area, a group of farmers willing to take on the challenge can be identified. They need to agree to be trained on seed health management.

5. Identification of local champions. These are the LGU, researchers, and development workers working on related programs who can help facilitate the formation and growth of the CBSS. This also includes progressive farmers, farmer-volunteers, or farmer leaders who can share knowledge, and be an "agent of change" in the community. These farmers must have the dedication to help others and have the vision that is shared by the community.

6. Assessing seeds, validating technologies, and selecting preferred varieties. These are traditional rice varieties, new or improved modern varieties that can be introduced. This can be done using the protocol for PVS. Through on-farm trials, farmers select their most preferred varieties, and test the seeds introduced; they can have a combination of FVs and MVs selected through participatory approaches. Trials can show the differences in performance of varieties: traditional vs. commercial varieties, tolerant vs. nontolerant, different crop management practices, and others.

    PVS involves the selection by farmers of nonsegregating characterized products from plant breeding programs. Such materials include released cultivars, varieties in advanced testing, and advanced nonsegregating lines. PVS is a simple way for breeders, agronomists, and social scientists to learn which varieties perform well on-station and on-farm (Paris et al 2011).

    It is important that the farmers have access to foundation seeds, provided by the project, the government program, or some other source, to start their own seed production system.

7. Conduct of group training on "seed-to-seed" production of good-quality seeds, seed health management and crop diversification, and other relevant topics identified based on training needs assessment. The schedule and the type of training/learning would depend on the available resources. For instance, if the project has enough resources, a season-long training can be conducted. Otherwise, a series of short courses can be conducted.

Table 1. Different tools in rapid rural appraisal that can help in CBSS formation.

Objectives	Specific tools	Rationale/use	Output
1. To characterize the biophysical and socioeconomic conditions at the site	a. Village transect/ transect walk	To collect information on the biophysical and social conditions of the farming communities and how these factors could support or constrain the formation of seed banks, and the adoption of technologies	A transect that shows the land types, irrigation facilities, and areas affected by submergence, drought, and biotic stresses.
	b. Resource and social mapping	Resource and social maps of a village that can help identify the key players in the community, such as local seed sources, supplies of inputs, credit, farmers as leaders, potential support for extension, and others.	
2. Define the cropping pattern and determine the characteristics of biotic and abiotic stress problems	a. Seasonal calendar (climate, cropping pattern, and period when rice is sufficient and scarce	To understand the importance of the production of rice grains and seeds and how this is affected by other stresses	A monthly calendar showing the cropping patterns and nature, timing, depth, intensity, and days when stresses occur; a monthly calendar showing the months when rice grains and the seed supply are sufficient or scarce.
	b. Trend analysis		A trend diagram showing the incidence of stresses and the changes in the community for the last 5 years.
3.Analyze the biotic and abiotic problems in the farming community, their primary and secondary causes, as well as their effect on rice yields	Problem tree analysis cause-and-effect link approach	To understand the farmers' perception of the problem, its causes, and the effect (extent of loss) on rice yields	A diagram showing biophysical, socioeconomic, and institutional causes of the stresses, as well as the effects of such stresses on the farming situation and the various aspects of life in the community. The resulting chart will serve as a basis for identifying intervention points for facilitating the formation of seed banks, as well as for research and extension.
4. Identify resources, social capital, communication, and the seed delivery system (including the flow of information)	a. Venn diagrams showing the relative importance and roles of each actor. The relative importance can be shown by the size of the Venn diagrams.	To understand the relative importance of each actor in the extension and communication delivery system, in general, and for the seed system in the community in particular.	Schematic and Venn diagrams showing the linkages between actors involved in the extension and communication delivery systems
	b. Schematic diagram of seed delivery system, including flow of information	To define the inputs, information, technologies, and other requirements in the seed delivery system	Schematic diagram showing the flow of seed delivery and identify room for improvement

Source: Adapted from Paris T, et al 2011.

In many cases, food security involves the introduction of a rice variety or crop diversification for system sustainability and productivity. Selected crops follow the socioeconomic conditions in the community.

B. Formation of the CBSS

Identifying the CBSS components should be based on available resources and according to the needs in the community. The following are key steps in the selection of type of community seed banking, from the simplest form of de facto system or the more complicated and geographically extensive seed network:

1. Starting from the very basic CBSS de facto type, the trained farmers can start with their own collection of preferred seeds, cuttings, tubers, and other planting materials. Based on the case models of CURE, the following are the criteria for selection (Arakan brochure on CSB):

    - Adaptability to local climatic conditions
    - Duration or maturity
    - Resistance to pests and diseases prevailing in the area
    - Resistance to drought and other abiotic stresses
    - Resistance to lodging
    - Farmers', traders', and consumers' preference based on social and economic situation

2. Selecting the site for the seed-to-seed production. Farmers will select the most fertile part of their rice field for the seed production plot. The size of this plot will depend on the amount of seed expected to be produced in terms of both farmers' needs for the next growing season and whether there will be other purposes such as selling and exchanges or gifts to relatives, friends, and neighbors.

3. Application of the learning on seed-to-seed production and seed health management (refer to the other modules in this manual). These steps would include, among others, field preparation, removing off-types, harvesting and threshing, cleaning and drying seeds, storing seeds, planting, and restocking seed supplies, among others.

C. Foundation for sustained growth

1. Transformation into a more organized farmers' group. In order to attain sustainability of efforts, the group of farmers initially trained can be facilitated (or they can do this on their own, or there could be an existing cooperative already) to formally organize themselves. Countries have their own government procedures and requirements for the formation of rural workers, a farmers' association, or a cooperative.

    This would entail the identification of an initial set of officers as the founding members. The rest of the operations can be provided by the concerned government institution or by the project.

    Eventually, the farmers may develop into a more organized group such as the other types of CBSS such as the "seed exchanges" and "SeedNet or seed network." These are formalized and registered groups with a relevant government farmers' association accreditation agency (if any). The government agency relevant to this formal group setup may require specific structures, documentation, systems, and other details:

    - Set of officers
    - Constitution and by-laws

- Production system
- Seed collection system
- Seed distribution/market system
- Distribution of profits
- Farm production record-keeping system and farmers' association chosen system of community seed banking
- Other services and requirements

The success of the CBSS would greatly depend on the careful assessment of the needs of the farming community, assessment of the resources available to the project and to the community, and the identification or matching of components and services of the CBSS based on available resources and according to the needs of the farmers.

2. Seed quality assurance and links to formal institutions. Many CBSS rely on seed inspectors who are trained by projects and government institutions for extension but mainly operate on "trust" and a "community guarantee system." Called informal systems, these are not yet classified as producing "certified seeds" from formal sources. However, the informal systems can be elevated into commercial seed growers once provided with proper training and accreditation by the government.

3. In this case, the CBSS will have their own internal control system based on a set of practical approaches of testing seed quality attributes such as moisture content, physical purity, and germination for quality assurance of seeds produced under the informal seed system that approximates the standards of the formal system. In many cases, this necessitates the participation of the key actors of the farmers' association in government-sponsored training programs on seed quality certification or a guarantee system to formalize their seed growers' status in the community.

   Seed certification is a system of seed production geared toward maintaining genetic identity, varietal purity, and standards of quality seeds of superior crop varieties to maintain genetic ident ity and purity and make available to farmers high-quality seeds of superior varieties.

   For seed quality inspection and genetic resources conservation, the Bureau of Plant Industry through the National Seed Quality Control Services (BPI-NSQCS) is mandated by the Seed Industry Act of 1992 (Republic Act 7308) to support the major thrusts of the Department of Agriculture in the provision of quality assurance and control services for seed and planting material production, processing, storage, and distribution, and training in seed quality control toward sustainable agriculture and environmental protection (Torio 2011).

   The BPI-NSQCS is the seed-certifying agency in the country that implements quality control procedures in certification for both seed stock production of government seed farms/institutions and private seed growers. Seed inspectors of seed testing laboratories conduct field inspection, seed sampling, and tagging of bags passing certification. Only crop varieties, classes, cultivars, and hybrids approved by the Philippine Seed Board/National Seed Industry Council will be eligible for certification.

4. Scaling-out and scaling-up activities. These are conducted to promote the gains from CBSS. Scaling up is the vertical movement of experience, knowledge, technologies, impacts, and effects along the ladder or levels of organization of a society. This involves other stakeholders' groups, expanding to other layers in the system (Paris et al 2011).

Examples are a policy forum to involve LGUs at the municipal, provincial or regional, and national levels.

Scaling out is the spread horizontally within a particular layer or level, for instance, farmer-to-farmer, community-to-community, and others. Examples are cross-farm visits/site visits and demonstration trials, among others. Refer to Module 3 for other examples.

Activity

In your group, discuss the following:

1. Which component of the CBSS do you think would be most difficult and why?
2. How can you address this difficulty?
3. Who are the actors in your target community that you think would be able to help and contribute to the formation of seed banks?

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Module 3

Support Systems, Strategies, and Socioeconomic Considerations in CBSS Development

Digna O. Manzanilla and Thelma R. Paris

Module objective:

This module provides some guidelines on the support systems that the target communities and development workers can access in establishing a community-based seed system. The key players in the sector are also indicated, emphasizing on the importance of building alliances. Participatory approaches and the gender dimension are discussed to make for an inclusive growth approach to seed sector development in unfavorable rainfed areas.

LESSON 1: COMMUNITY-BASED SEED SYSTEM SUPPORT

OBJECTIVES

1. To know some support systems that can help establish the activities of the community-based seed system (CBSS)
2. To identify some key support systems that can contribute to the sustainability of the CBSS

The end goal of establishing a CBSS is to help farmers gain access to good-quality seeds, given the scope and extent of a country's seed distribution system. To realize this, certain factors can help establish, enhance the operations of, and sustain the existence of this informal seed system. These can generally be referred to as "support systems."

1. **Integration into current activities and programs.** Some government programs can help establish and maintain the growth of an informal seed system. A development facilitator can tap these programs and link the activities of the CBSS. In the Philippines, the Department of Agriculture (DA) released Memorandum Order No. 20 Series of 2011 signed by DA Secretary Proceso J. Alcala on 15 September 2011—Subject: Guidelines on the implementation of community seed banks (CSBs). The Department issued this memorandum order to ensure food sufficiency and farmers' access to quality seeds through the establishment of CSBs.

   In Nepal, the nationwide District Seed Self-Sufficiency Program aims to make each of the country's 75 districts self-sufficient in quality rice seeds of modern varieties. Through this program, the government provides a 25% subsidy for foundation seeds to seed producer groups or cooperatives, a 20% subsidy for fertilizer, funds for storage facilities and small machinery, and land for storage houses.

2. **The extension system in the village through the local government unit (LGU).** It would be wise to check whether there are extension workers assigned in the area. Linking up with them would help facilitate the formation of the CBSS and in the diffusion of technologies and information. If there are NGOs working in the village, they can also be considered allies in bringing about change there. They are sources of knowledge, inputs, and other forms of support.

3. **Market linkages.** To enhance the benefits derived from the CBSS, the farmers' group can engage in a more systematic production schedule based on demand for seeds in the target area and establish a system of collection of produce that is intended for selling. However, certain factors have to be considered such as distance between the farmers and the collection center and potential market.

4. **Crafting a business plan**. For a better market orientation, business plans can be developed to provide details on how to run the CBSS (for models that go beyond mere exchanges and de facto type of seed exchanges between farmers) as a business enterprise. Depending on their capacity and willingness, the farmers can aspire to operate community-based seed production as a business enterprise. The plan will include the business concept that describes the business, its product, and the market it will serve. The business plan can provide the market assessment, production schedules to meet the target production/supply of seeds and other agricultural products,

operational plans, and financing details, among other important aspects. It should point out exactly what will be sold, to whom, and how the business can keep a competitive advantage.

5. **Institutional linkage for the "seed guarantee system."** Many CBSS rely on government and nongovernment programs' established procedures for seed quality assurance. A trained project staff, government staff, or trained farmers can serve as the "seed inspectors" at the community level. These individuals can guarantee that the seeds produced have followed certain standards. In many cases also, community trust in farmer-to-farmer seed exchanges works as an internal mechanism that would ensure that certain standards have been followed in producing the seeds.

6. **Credit facility and sources of production inputs.** Farmers need cash for their crop production. When formal credit facilities are not available and not accessible, they rely on informal sources of credit or what is referred to as "loan sharks" that impose exorbitant interest rates. There are cases also in which the traders of agricultural inputs also serve as credit sources in the community. This can be tackled if cooperative formation is part of the plan of farmers' groups.

LESSON 2: KEY PLAYERS IN CBSS FORMATION

OBJECTIVES

1. To identify key players and stakeholders in the community who can support the establishment and growth of the CBSS

1. Program implementers/development facilitators

- These are the program leaders, regional or provincial executives, and other local executives who can lend support to the formation of seed banks, production and distribution of seeds, and information and technology sharing.
- Involvement of local executives and LGUs for technical and financial support, most especially in areas where the development agenda includes rice farming productivity, is one of the priorities.

2. Farmers' associations and existing programs

Many countries have programs that build local capacity through the formation of farmers' associations. It would be advantageous for the CBSS if it could build on any existing community organizations, for both organizational capacity and availability of resources that can serve as the starting platform for the seed bank.

3. Local extension agents from the government

- The seed bank can also be tied up with government programs in the target communities. There is a need to get their active participation in the development of seed banks and other development agenda items.
- Tapping the support of the community NGOs. These have a development agenda that is parallel to the objectives of enhanced rice production and dissemination programs.

4. **Farmer-leaders and farmer-volunteers from farmers' associations**

   These are farmers that have been or can be trained and have become champions of the cause of rice-farming community development and equitable spread of benefits from improved varieties and technologies (Paris et al 2011). These include

   - Farmer-leaders existing in the community that are potent partners in technology diffusion.
   - Farmer-volunteers who are progressive farmers in the community and value the concept of information sharing and learning at the same time. They manage to provide time to tend to their own farms and at the same time share the model of "learning-by-doing" with co-farmers.

5. **Local champions from universities and institutions of learning**

   Universities and research institutions are potent sources of local champions who can deliver rural development services. Many successful rural development programs have identified these local champions who can provide the following support: (a) as facilitators at the start of the program, (b) as sources of technical know-how based on their expertise and research agenda, and (c) as actors who can support the "ripple effect" necessary to reach a greater number of technology and information users in the community. Both the CBSS models in Arakan Valley in the Philippines and in Lamjung, Nepal, have been driven by the commitment of professors and researchers from the universities and institutions.

   A local champion could be any progressive, dedicated, and experienced person—a farmer, a farm manager, an entrepreneur, or even a rich and progressive farmer—with the conviction of helping others and making a difference in the lives of co-farmers in the farming communities. These people can provide resources, leadership, facilitation skills, and other capacities that can have far-reaching impacts in the communities.

LESSON 3: SCALING-UP AND SCALING-OUT ACTIVITIES

OBJECTIVES

1. Differentiate between scaling-up and scaling-out strategies in disseminating varieties and other technologies through a CBSS
2. Understand and identify practical strategies for widescale promotion of seeds and technologies in rice-farming communities

Scaling-up strategies

The concept of "scaling up" refers to a vertical expansion in reach of products of development activities, from one group of "next users" or intermediaries and "final users" or users of generated technological innovation. It is considered a hierarchical expansion, from target adopters at the grass-roots level to policy-making entities of varying levels (village, municipality, province, region, etc.), donors, and development institutions along the continuum of partnership. This concept brings to the fore the expansion of the sphere of influence of technology users to the higher plane of authority to gain support in technology dissemination (Paris et al 2011).

Scaling up also connotes a vertical movement of experience, knowledge, impacts, and effects, and moving up the levels of organization of a sector or society. This implies involving more stakeholder groups up the ladder from farmers to extension agents and NGO workers to local officials, to researchers, to policymakers/ministers, and to donors (IIRR 1999, in Paris et al 2011).

Scaling-up strategies include, but are not limited to, the following:

1. Policy forum, national consultation, policy dialogue
2. Participation of LGUs in project design, implementation, monitoring, and evaluation
3. Link to municipal, district, provincial (and the like) programs in agricultural development, particularly in rice production and crop diversification
4. Participation of other government organizations and NGOs
5. Production of information, education, and communication (IEC) materials for policymakers and allies at different levels or groups of stakeholders to include policy briefs, brochures, fact sheets, and other briefing materials

Scaling-out strategies

On the other hand, "scaling out" is the spread of a project output (i.e., a new technology, a new strategy, etc.) from farmer to farmer, community to community, or within the same level or group of stakeholders. This is horizontal expansion within the same level or sector (Paris et al 2011). A CBSS formed in one village that has expanded to other villages would be an example of a scaling-out activity. Activities that are aimed at spreading new varieties and management practices also fall under scaling-out strategies.

This section provides a list of strategies and mechanisms for scaling out technologies and information for CBSS services. The key considerations in choosing the most appropriate combination are availability of resources (both human and financial), the capacity of the community and other users to absorb and adopt the strategies, and the results of the assessment of the problems at hand.

1. Project-to-farmer cooperators—distribution of farmer-preferred varieties to active male and female farmers in many villages representing the target environment. For example, participatory varietal selection (PVS) activities define farmers' involvement in demonstration trials. This is to scale out the results of researcher-managed and farmer-managed trials to farmers and communities by distributing preferred varieties to other farmers in different communities.

2. Field days and field demonstrations, including both men and women farmers, to disseminate more varieties and to encourage spread through farmer-to-farmer exchange. This will allow farmers, researchers, extension workers, academe, and others to observe/evaluate the field performance of PVS varieties as well as gather information on perceptions on varietal preferences, and operationalizing the expression "to see is to believe" in technology dissemination.

3. Dissemination of a basket of technologies. Farmer-preferred varieties can be disseminated with other technologies, such as soil fertility management practices, especially in areas with low soil fertility.

4. IEC materials that can address both scaling-out and scaling-up objectives. Print and nonprint materials are leaflets, flyers, technology series, training manuals, technical

bulletins, videos of selected appropriate technology, knowledge banks, interactive e-learning modules, and distance education or school-on-the-air.

5. Farmers' field school (FFS). The FFS is a participatory approach used in many programs that anchor on farmers' participation not only as users of technologies but also as partners for dissemination to other farmers. This makes use of the actual application of adult learning, similar to experiential learning techniques and participatory training methods. The concept of an FFS can be used in any topic in CBSS, seed health management, and crop production, including plant breeding. In this practice, farmers become experts and facilitators and are strengthened in their informed decision-making skills with newly acquired knowledge, experience, and skills.

6. Seed fair. This is a common approach in on-farm conservation of seed biodiversity, specifically in increasing community awareness of locally adaptable genetic resources and landraces. Seed fairs expose farmers to the diversity of available on-farm genetic resources and how local capacity can conserve them. In this event, a variety of activities can be included such as exchanges of seeds, distribution of new varieties in mini-kits or small packets, demonstration of some farm practices, and information sharing.

7. Farm walk. This is a fast-rising strategy in sharing farm practices and schemes to solve farm problems. It may include a tour of the farm, taking note of its components, products, resources, and marketing strategies. This farmer-to-farmer learning experience allows time for questions and answers in the field, and provides an opportunity for farmers to share their practices and strategies and the concepts and principles behind them. In some cases, this is a completely open farm space with a unique mission to engage the community at varying levels (Paris et al 2011).

LESSON 4: SOCIOECONOMIC CONSIDERATIONS

OBJECTIVES

1. To discuss the importance of considering the socioeconomic dimension in establishing CBSS, particularly gender-responsiveness and the incorporation of participatory approaches in activities

The socioeconomic dimension incorporates into the concerns and activities of CBSS some related issues on the social, economic, institutional, political, environmental, and demographic patterns and their linkages, which make up the context of development in the uplands and rainfed lowland environments.

Gender and community seed systems

Gender in rainfed area development is about the relationships of men and women (as in this case, in the seed system in rainfed communities). It takes into account the uniqueness in social relationships and different mind-sets and orientation of men and women and examines how these differences can enhance rather than limit relationships so that interaction becomes productive and beneficial to all.

In broad analytical terms, incorporating gender concerns in upland development through community seed systems refers not only to men or only to women but to the relationships between them and the way these are socially constructed. Gender is how the society (we) constructs or interprets what is expected or allowed from a woman or man. This varies across situations and locations. It is highly influenced by culture but changes over time since culture is dynamic. Gender is best defined in terms of how men and women relate to each other as influenced by culture and society.

Gender is also defined as a useful socioeconomic variable to analyze roles, access to and control of resources, decisions, responsibilities, constraints, opportunities, benefits, and incentives of people involved in agriculture and natural resource management.

Why is it important to incorporate gender concerns?

In terms of development efforts and program focus:

1. The contributions of women farmers to the household economy and the national economy continue to be undocumented, undervalued, and considered irrelevant in most national statistics in agricultural development, rural development policies, and programs.
2. This leads to a lack of effective technology transfer programs, further impoverishment of poor rural women, and disregard of the potential of women as key agents of food production.
3. More and more development programs, including the International Fund for Agricultural Development, now aim to formalize their existing strategies on gender in the project cycle and increase consistency, transparency, and accountability in decisions concerning the gender dimensions of their operations.

In terms of role in the organizational aspects of CBSS:

1. Men and women are both beneficiaries and key players in the overall setup and organization of CBSS.
2. There is increasing interest among women to take up key roles in rural group formation.
3. There are differences in terms of their condition and position in the household, organization, and the community.
4. Men and women have different roles, knowledge, and needs. Women also have accumulated knowledge and skills over the years in farming.
5. Research on the status of program beneficiaries (extent of the impact of the program on the beneficiaries).
6. Need to document gender-based success stories (strengths and areas for improvement) that can be shared and source of learning for other farming communities.

Strategies for engaging participation of women in upland agriculture and CBSS

1. Document and recognize their roles in rice farming that can be shared with the rest of the community.
2. Enhance skills and knowledge of men and women farmers on all aspects of seed-to-seed rice production, seed health management and other technologies, and information introduced in the community.
3. Include at least 30% of women in community-visioning exercises, field days, PVS, training and extension activities, meetings, and others.
4. Encourage and strengthen their role in CBSS formation in terms of role in farming, as officers of the association, and even in scaling-up and scaling-out activities.
5. Monitor, evaluate, and document the participation of women in many rice-farming activities.

6. Include the women as trainers in programs and consider their knowledge that can be shared with the rest of the community.
7. Consider women's role in communicating new developments in rural transformation, and in the dissemination of technologies and outcome and impact assessment:

   a. Include women's impact as key agents of change in technology dissemination (scaling out), for instance, in women-led extension strategies.
   b. Social and economic impact assessment such as changes in gender roles, changes in work burden, empowerment, improved family welfare, increased food-provisioning ability, more educated girls and boys, etc.

Participatory approaches in CBSS

The CBSS models introduced and developed through the CURE programs have been anchored on participatory approaches, from the definition of problems to the identification of sites, seed system services, and target areas, down to the monitoring and evaluation and assessment of outcomes and benefits. Horne and Stur (2003) described their approach to rural development as "participatory" with the farmers and development workers working together to solve complex problems and where the farmers are the main decision makers. This approach has helped them combine the local knowledge of farmers from their long years of farming and the ideas, information, and technologies that the development workers could offer.

Three dimensions are useful with respect to the quality of participation: stage of participation, degree of participation, and actors' roles in participation. These can be seen in the following aspects that have worked for the CURE models:

- Farmers' participation in the seed system should be at all stages of design, implementation, and monitoring and evaluation.
- As the participation of farmers at the initial stages is strengthened, the more they become actively involved in the other details of the seed system.
- The degree of participation of farmers or other users who are involved in the seed system may influence or affect the processes at any given stage. These people can decide on the services and the extent of activities related to seed production and distribution.
- Participation can also take place at the problem diagnosis stage. This can be realized through the use of participatory approaches in defining the village characteristics where the new rice lines or varieties would be tested. Participatory rural appraisal tools and methods can be used to characterize the village and the farming systems.

Activity

1. In your target community, discuss the possible partners and stakeholders that can support the credit and production input requirements of the farmers.
2. Identify any support available in your target community necessary to establish a good community quality assurance service for good-quality seed production.
3. Identify up-scaling and out-scaling strategies that you can introduce in your project activities in support of the formation and wide-scale promotion of CBSS technologies, information services, and products.

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Module 4

In Situ Conservation of Traditional Rice Varieties

Renato A. Reaño

Module objectives:

1. To provide an overview of the concept of community-based seed systems (CBSS), some basic definitions, and why they are important in securing food and enhancing livelihoods in unfavorable rice environments, particularly in marginal uplands

2. To provide different types and examples of CBSS to guide their establishment in many upland areas and for better appreciation of these systems

LESSON 1: CONCEPTS, PRACTICES, AND CHALLENGES OF *IN SITU* OR ON-FARM CONSERVATION OF TRADITIONAL RICE VARIETIES

OBJECTIVES

1. To understand the basic concepts and characteristics of *in situ* or on-farm conservation of traditional varieties
2. To discuss the common practices and indigenous knowledge being practiced on-farm and the challenges of the system
3. To present some mitigating strategies and genebank principles that can be applied on-farm to improve the community-based conservation and seed system

Conventional conservation strategies

Conservation is one way to prevent varietal or species loss and preserve biodiversity. Conservation will help stop the continuous loss of species and genetic diversity due to the increasing human population and encroachment on natural habitats of rice.

In situ and *ex situ* conservation are two prevalent methods to conserve plant diversity.

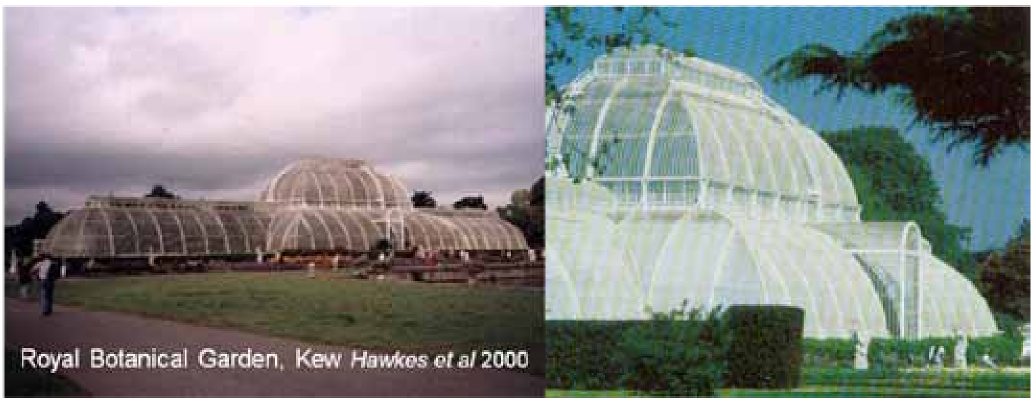
- In *ex situ* conservation, the genetic resources are conserved outside their natural habitat in identified genebanks.

  These genebanks can be
  - □ Storage of seed (orthodox seeds) at +5 to –20 °C
    - ○ The easiest
    - ○ The most cost-effective
  - □ In vitro storage of plantlets (4—25 °C)
  - □ Cryopreservation or storage of propagules at ultra-low temperature using liquid nitrogen (–150 to –196 °C)
  - □ Field genebanks
    - ○ For vegetatively propagated species
    - ○ Fruit trees with recalcitrant seeds

- Below are examples of genebanks for *ex situ* conservation.

Base collection in IRRI's genebank.

Active collection in IRRI's genebank.



Royal Botanical Garden, Kew.

Field genebank of yam at the International Institute for Tropical Agriculture.

Yam conserved in vitro in the genebank at the International Institute for Tropical Agriculture.

- *In situ* conservation is defined as
  - □ "The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where the species developed their distinctive properties" (Reid et al 1993:305).
  - □ "*In situ* conservation of agricultural biodiversity is the maintenance of the diversity present in and among populations of the many species used directly in agriculture, or used as sources of genes, in the habitats where such diversity arose and continues to grow" (Brown 2000).
  - □ "*In situ* conservation specifically refers to the maintenance of variable populations in their natural or farming environment, within the community of which they form a part, allowing the natural processes of evolution to take place" (Qualset et al 1997).
  - □ "*In situ* conservation refers to the maintenance of genetic resources in natural settings. For crop resources, this means the continued cultivation of crop genetic resources in the farming systems where they have evolved, primarily in Vavilov Centres of crop origin and diversity" (Brush 1991).
  - □ "*In situ* conservation means preserving in their original agroecosystem, varieties cultivated by farmers using their own selection methods and criteria" (FAO 1989, Bommer 1991, Keystone Centre 1991, in Louette and Smale 1996).

Oryza rufipogon **population preserved** ***in situ*** **in Lao PDR.**

Oryza nivara **population in Thailand.**

On-farm conservation

- This is an approach to *in situ* conservation of genetic resources, focusing on conserving cultivated plant species in farmers' fields as part of existing agroecosystems and it differs from other types of *in situ* conservation that are concerned with wild plant populations growing in their original habitats (genetic reserves).
- It is "the sustainable management of genetic diversity of locally developed traditional crop varieties with associated wild and weedy species or forms by farmers within traditional agricultural, horticultural, or agri-silvicultural cultivation systems" (Maxted et al 1997).

Farmers grow and conserve several varieties in Irian Jaya.

Farmers' preserved varieties in Cagayan Valley, Philippines.

Upland farmers showing panicles of conserved varieties of four morphological types.

Objectives of *in situ* conservation

Why *in situ* conservation? Advantages of preserving traditional varieties on-site

- To conserve and allow the process of evolution and the natural adaptation of crop species to take place in their environment
- To allow and promote conservation of diversity at different levels and in different ecosystems, between species and within species
- To promote the integration and involvement of farmers in the National Plant Genetic Resources System
- To preserve the ecosystem services for Earth's life support system, and ecological balance
- To maintain or increase farmers' control of or access to crop genetic resources
- To provide farmers with access to the formal seed system

Characteristics of on-farm conservation

- Maintenance and recovery of viable populations of species in the surroundings where they developed distinctive traits
- Managed by farmers, their family members, tribes, ethnic groups, or the community
- Application of indigenous knowledge in seed production, postharvest, and storage practices
- Varieties of interest are mostly traditional ones and landraces and part of their culture, traditions, rituals, and festivities, and were selected using their own criteria
- Provides a natural laboratory for the evolution of crop species to continue
- Helps with the gradual buildup of traits to adapt to specific eco-geographic regions matching the requirements of a local tribe or community
- New and more adapted types evolved; thus, diversity within species and the ecosystem is augmented
- Favors variations within cultivars and/or within species

An upland farmer growing the best variety available suited for his farm.

New and more adapted types evolved and this allows variations within cultivars.

Wild and weedy rice commonly invade farmers' fields, where outcrossing may occur.

In situ conservation provides a natural laboratory for evolution. Here, an upland ecosystem.

This system represents a natural laboratory for evolution. Here, a wetland ecosystem.

Photo 16. Varieties of interest are mostly traditional ones and landraces.

On-farm conservation involves not only the farmers but also members of their family. Shown are (A) field activities and (B) a postharvest activity.

Cultivars for on-farm conservation

Factors influencing farmers' choice of varieties

- Adaptability of the variety in the ecosystem being a product of natural evolution on-site
- Special traits or characteristics of the variety of commercial or cultural importance
- Farmers' capability in maintaining a certain number of varieties
- Agricultural intensification or technical changes such as high-yielding varieties (HYVs) and other production technologies
- Agroecology, for example, heterogeneous highlands prefer traditional varieties; irrigated lowlands prefer modern varieties
- Market infrastructure; integration of market for seeds and crop output
- Ethnicity—social and cultural preference associated with distinct traditions, cultures, and rituals

Example: Agricultural intensification and variety choice
Bellon et al's (1998) comparison of rice farming systems in the Philippines reveals differences in farmers' use of landraces versus modern varieties based on agroecological conditions and levels of agricultural intensification. In upland and rainfed lowland (less intensive) ecosystems, landraces persist in farmers' fields, whereas, in the irrigated (more intensive) ecosystem, modern varieties have completely supplanted landraces. The opportunity cost of maintaining landraces thus increased with an agroecosystem's potential for intensification.

Example: Wealth status and maintenance of selected varieties in Nepal
Research from the Nepal component of the IPGRI *in situ* conservation on-farm project revealed wealth as an important socioeconomic factor affecting the rice varieties maintained by households in three ecosites in Nepal. While resource-poor households cultivate more coarse-grained, drought-tolerant varieties, resource-rich households grow high-quality varieties for premium market prices and special food preparations.

A variety conserved by farmers in Luang Prabang because of its long panicles.

Varieties are preserved because of their special traits of economic or cultural importance.

Types that evolved in the area and are well adapted to the ecosystem.

Modern technology and rice intensification.

Common practices and indigenous knowledge practiced in on-farm conservation

- Conserving/preserving the existence of varieties by continuously planting them every cropping season
- Similar field practices for seed and ordinary rice production
- Postharvest processing such as manual harvesting and threshing using an available thresher, for example, by foot, pounding, machine, sun drying, winnowing, etc.
- Use of locally available storage containers or packaging made of indigenous materials such as grains in sacks, and big baskets for storage in a barn, hut, or any available storage place
- Sharing and exchanging seeds among farmers in the community to promote diversity on the farm, and maintain varieties through sharing

Harvesting by cutting peduncle using blades.

Harvesting by stripping grains.

Harvesting using a sickle.

Threshing and winnowing; cleaning threshed grains.

Sun-drying grains and nonthreshed panicles using mats or on concrete pavement.

Seeds are packed and stored in many ways, for example, as a haystack.

Varieties of interest are preserved by continuously planting them every cropping season.

Challenges of on-farm conservation

- Genetic erosion due to unforeseen forces, for example, war, natural disaster
- Loss of genetic integrity
  - Contamination from another variety
  - Effect of changing environment
  - Informal and undocumented seed system and nomenclature
  - Genetic drift or genetic shift
  - Natural outcrossing from adjacent fields, dropped seeds, or volunteer plants
- Socioeconomic changes may either foster or hinder biodiversity conservation over time
- Loss of diversity due to poor management practices and mishandling
  - Loss of viability because of environmental factors
  - Inappropriate packaging for storage conditions
  - Improper postharvest handling
  - Unsuccessful seed production because of pest and disease outbreaks
- Reduced use and value in breeding and research due to difficulty in identifying and accessing this germplasm
- Use of reserved seeds for other purposes
- Replacement by modern varieties or HYVs

Loss of integrity because of contamination by other varieties from several sources.

Loss of seed quality due to improper handling and maintenance.

Measures to mitigate challenges

- Complementing on-farm (*in situ*) conservation with *ex situ* conservation strategies
  - Application of conservation principles on-farm to prolong storage life of seeds
  - Active and base collection principle
  - Harvest at right time
  - Use of locally available airtight containers for better storage
  - Slow drying process immediately after harvest
  - Maintaining purity and genetic integrity of the conserved varieties through genebank seed production strategies
  - Keeping short notes/records about the variety to be conserved
  - Duplicating on-farm collection in genebanks as backup
  - Educating farmers about the importance of genetic erosion, genetic integrity, purity, and genetic changes, and the principles of seed drying and storage
  - Proper programs on on-farm conservation and maintenance with farmers and the community as key partners

Application of genebank principles on-farm

(A) Maintaining varietal purity, (B) harvesting by panicle if necessary.

(A) Hand threshing and (B) drying using mats to avoid damage by too hot temperature on concrete pavement.

(A) Packing in locally available and moisture-proof containers with desiccant and (B) storing in a cool dry place in the farmhouse.

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Module 5

Seed Health Improvement for Crop and Pest Management

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Module objective:

To enable participants/trainees to understand the importance of using healthy seeds in relation to pest and disease management for good yield

Every planting season, farmers face the same problem—where to obtain good-quality seeds. They usually have the following options: use seeds from their own stock, buy them from or exchange them with other farmers, or buy them from agricultural stores.

Studies conducted by Hossain et al (2008) showed that 81.6% of the farmers used their own seed stock, whether traditional or modern varieties. However, this can create some real concerns among smallholder farmers. Seeds harbor microorganisms such as fungi, bacteria, viruses, or nematodes. These microorganisms infect the crop during its active growth in the field and cause seed conditions that lower seed quality. Furthermore, these microorganisms can stay in the seeds for considerable periods of time; thus, these microorganisms can be transmitted from one place to another or from one season to another.

In addition, seedlots (an identifiable amount of seeds used for planting, exchange, or distribution), if not properly processed, can include many seed contaminants that can also affect crop productivity. These seed conditions and seed contaminants affect the health of seeds, which in turn affects crop health and eventually crop yield.

LESSON 1: SEED QUALITY ASSESSMENT

OBJECTIVES

1. To understand the meaning of seed health and its importance to pest and disease management to achieve good yield
2. To understand what is a healthy seedlot/good-quality seedlot
3. To understand what makes a seedlot unhealthy/bad

Questions

1. What is seed health and its importance to pest and disease management to achieve good yield?
2. What is a healthy/good seedlot?
3. What makes a seedlot unhealthy/bad?

Seed health ("Kalusugan ng binhi") refers to the presence or absence of (1) seed conditions ("kalagayan ng bawa't buto") brought about by disease causing microorganisms, referred to as "pathogens" and (2) seed contaminants ("bagay nanakalahok o nakahalo") that result in poor quality or poor seed health status of a seedlot for planting (Fig. 1).

A good-quality/healthy seedlot is pure/clean (without undesirable seed contaminants and seed conditions), viable (with acceptable germination rate), and with appropriate moisture content. Maintaining the health of a seedlot means preserving its genetic and physical purity. This module will focus on the preservation of physical purity of a seedlot.

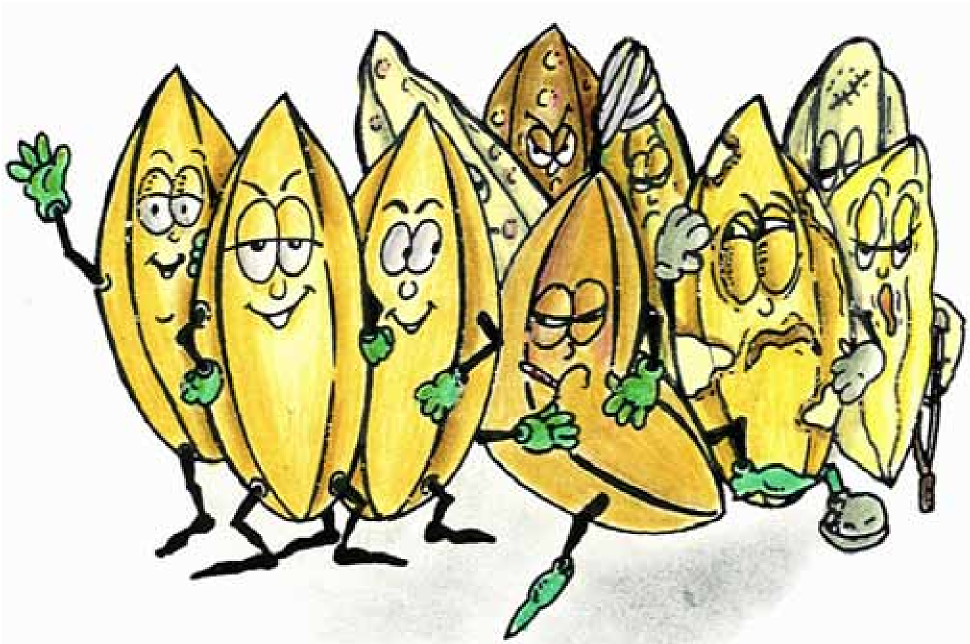

Fig. 1. The seed health/quality affects crop yield.

Aside from visual characteristics that can be determined through careful inspection, the presence of microorganisms (cannot be seen by the naked eye) can also affect the quality/ health of seeds. Seeds that may seemingly look healthy may also harbor microorganisms that can cause diseases (Fig.2). These microorganisms can be fungi, bacteria, viruses, or nematodes and the primary inoculum of these microorganisms can be disseminated by air (airborne), seed (seedborne), or soil/water (soil-/waterborne) (Fig. 3). The diseases caused by these microorganisms are oftentimes manifested through discoloration, deformities, half-filled or unfilled grains and the presence of spores (spore balls). This training module will tackle only those that are seedborne or carried by seeds. Seedborne diseases can start in the field when crops are actively growing (photo 1). This means that field activities to eliminate potential sources of inoculum of seedborne microorganisms should start at these early stages to avoid damage to seed health. Seed contaminants should be removed also because they can also harbor microorganisms.

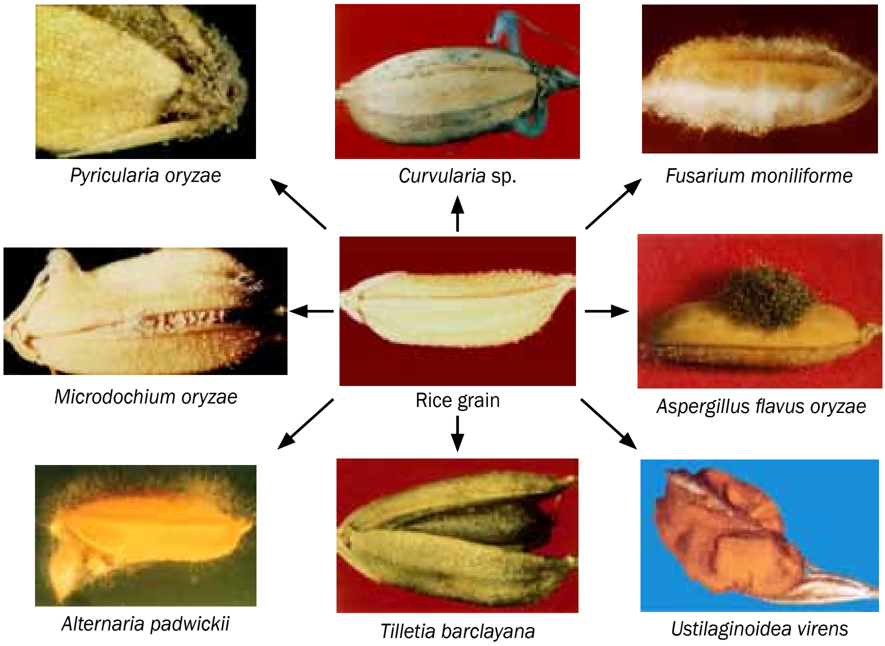

Fig. 2. Seedborne fungi associated with rice seeds.

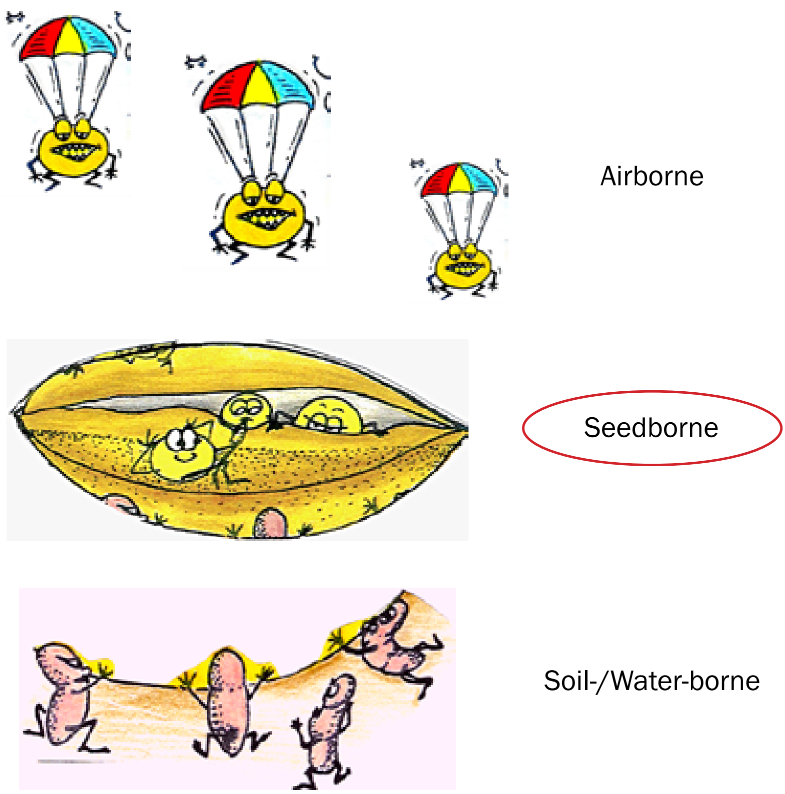

Fig. 3. Modes of dissemination of microorganisms.

Photo 1. Diseased plants with discolored/unfilled/moldy seeds brought about by seedborne microorganisms.

The importance of seed health management

One of the major issues in good crop production is the availability of good-quality or healthy seeds. A study conducted in the Philippines by Hossain et al (2008) noted that farmers rely heavily on own farm-saved seeds (Table 1). Almost 82% of the farmers were getting seeds from their harvests. Other sources of seeds are exchanges with neighbors and co-farmers (3.5%), buying from neighbors (6.5%), and getting support from the government (5%). A very limited amount is sourced from commercial sources (3.2%). Farmers using their own seed stocks, even if starting with good-quality seed, run the risk of reduced seed vigor and seed quality over time.

Table 1. Sources of seeds planted by farmers, 1999.

Source	Modern varieties	Traditional varieties (%)	All varieties
Own stock	79.8	86.7	81.6
Exchange with neighbors	3.6	3.2	3.5
Purchased from neighbors	7.0	5.2	6.5
Private seed traders	2.6	4.8	3.2
Government institutions	6.6	0.0	5.0
NGOs	0.3	0.0	0.3

Source: Hossain et al (2008).

Seed health affects crop health, which in turn affects crop yield (Fig. 4). Using good-quality seeds can improve yield by 5–20% (IRRI Rice Knowledge Bank, Quality Rice Seed, www.knoweldgebank.irri.org /qualityseedcourse). Using low-quality or unhealthy seeds results in a poor crop stand and/or crops that are weak and susceptible to pests and diseases. Yield, in turn, is also low, with low-quality or unhealthy seeds.

On the other hand, several methods or processes can be used to improve the health or quality of seeds such as sorting, winnowing, and flotation. A seedlot with many seed contaminants and poor seed conditions will require more input in terms of seed processing. Thus, the use of good-quality or healthy seeds can reduce farmers' production costs.

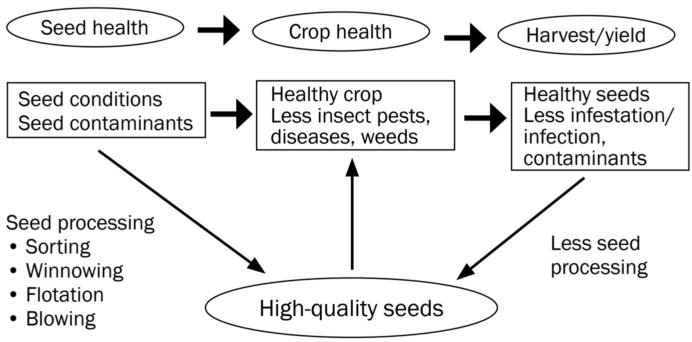

Fig. 4. Farmers' seed health practices for crop production and pest management (Mew 2008).

What makes a seedlot bad/unhealthy?

The presence of seed contaminants and poor seed conditions can make a seedlot unhealthy. The following illustrations show the different types of seed contaminants. These are components that are unwanted because they lower the quality of the seedlot and may harbor microorganisms.

Kinds of seed contaminants

Photo 2. (A) Storage insects, (B) weed seeds.

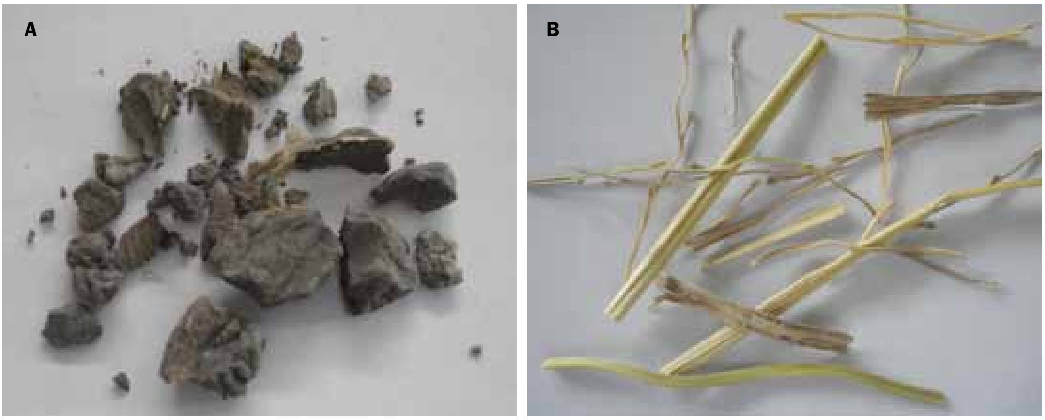

Photo 3. (A) Soil particles, (B) other plant parts.

Photo 4. (A) Sclerotia, (B) gravel/sand

Photo 5. (A) Varietal mixture, (B) seeds of other crops.

Seed conditions are characteristics or status of seeds that lower the quality of the seedlot. The following photos show examples:

Photo 6. (A) Unfilled/partially filled seeds, (B) deformed seeds.

Photo 7. (A) Insect-damaged seeds, (B) broken grains/seeds.

Photo 8. (A) Smutted seeds (Kernel smut), (B) seeds with soil particles.

Photo 9. (A) Germinated seeds, (B) smutted seeds (False smut).

LESSON 2: WAYS OF IMPROVING SEED HEALTH

OBJECTIVES:

1. To understand the different ways of improving the health of a seedlot at various stages of crop establishment and crop production

How can we improve the health of a bad seedlot?

Improvement of seed health can be done when the crop is still in its active growth in the field or with the harvested seeds.

Photo 10. Improving seed health (A) at the field or (B) with the harvested seeds.

In fields

Seed health can be improved in fields when the crop is already actively growing. Farmers can select a particular parcel or part of their ricefield where they intend to get their seeds as planting material for the next cropping. This is where they can invest more time and labor to maintain the cleanliness and/or purity. The following are ways to maintain good seed quality:

Roguing. This is the removal of off-types, diseased plants, and weeds (as shown in the pictures). This is mainly done to avoid cross-pollination or variety mixtures that can lower the quality of the seeds produced . This should be done throughout the active growing stage of the crop.

Photo 11. Removing weeds.

Photo 12. Removing varietal mixtures or "off-types." These "off-types" flower early or mature ahead of the rest of the crop or can be taller or shorter (depending on the expected height of the variety being grown or any other characteristics based on crop morphology (refer to module on in situ conservation of traditional rice varieties). These are plants with heterogeneous characters in seed production plots.

Photo 13. Removing diseased plants called "Bakanae."

"Bakanae" is a fungal disease caused by *Fusarium moniliforme.* Infected or diseased plants are taller but thinner, and pale green in color and eventually die. If they ever produce panicles, the grains are sterile or unfilled.

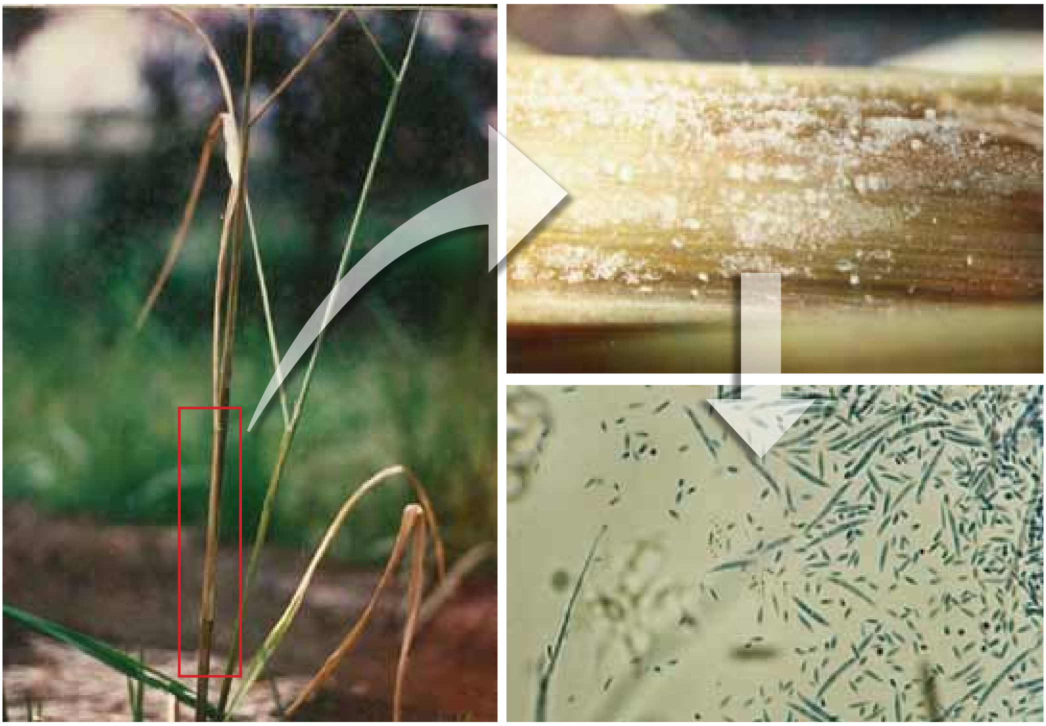

Photo 14. Tiller infected by Fusarium moniliforme manifested by a powdery substance, which is spores of the fungi, and these will infect seeds of nearby plants.

The following are disease assessment parameters used as tools in crop health inspection:

Incidence—the number of plant units infected expressed as a percentage of the total units assessed.

$$\text{Incidence} = \frac{\text{Tiller count with infection}}{\text{Total number of tillers observed}} \times 100$$

Severity—the area of the plant tissue affected by the disease expressed as a percentage of the total plant area.

$$\text{Severity} = \frac{\text{Sum of average \% leaf area of affected tillers}}{\text{Total number of tillers}} \times 100$$

where

$$\text{\% Leaf area of affected tiller} = \frac{\text{Readings in leaf 1 + leaf 2 + ...+ } n^{th} \text{ leaf}}{\text{Total number of leaves on the tiller}}$$

Harvested seeds

(1) Flotation ("Pagpapalutang") is a method of removing seed contaminants and poor seed conditions in a seedlot (Photo 15). The seeds are placed in a water-filled container. The "floaters" are those that are unfilled, partially filled, with insect damage, weed seeds that are lighter in weight, and other particles. These floaters should be discarded. The "sinkers" are heavier in weight and are normally good seeds. The disadvantage of this method is that varietal mixtures (such as corn seeds and others that are also heavy in weight) will not be discarded. The flotation method should be used just before a wet-seeding type of crop establishment or when the field is ready for seed sowing.

Photo 15. Flotation ("pagpapalutang").

(2) Winnowing ("Pagpapahangin"). This method uses the wind to eliminate or remove seed with poor condition and seed contaminants by using the wind (Photo 16). The disadvantage of this method is that varietal mixtures are not eliminated since they are of the same weight as the *palay*. The efficiency of this method also depends on the skills of the person controlling the flow of the seeds from the container, and the strength of the wind.

(3) Sorting ("Pagpipili"). This is hand-picking or manual separation of undesirable objects in the seedlot (Photo 17). This method makes use of the knowledge of the types of contaminants and seed conditions that should be eliminated. People also find this process time-consuming, but very effective in eliminating unwanted particles and elements from a seedlot.

Photo 16. Winnowing ("pagpapahangin").

Photo 17. Sorting ("pagpipili"). Farmers removing seeds with poor condition and seed contaminants.

LESSON 3: USING GOOD/HEALTHY SEEDS FOR BETTER YIELD

OBJECTIVES:

1. To learn about the advantages and benefits of using good-quality seeds.
2. To give some examples of studies that can provide evidence of the impact of using good-quality seeds for better yield.

Improving the quality of seeds is a major concern among farmers. A study conducted in Infanta, Quezon, in the Philippines showed that most farmers adopt flotation as a seed-cleaning practice (54%), followed by winnowing (17%) (Fig. 5). However, some farmers do not clean their seedlot, indicating the importance of training them on seed health management. In this same study, results show that farmers who adopted winnowing and flotation had the highest yields of rice. Using the technologies and methods described in this module can provide farmers with seed with quality that is on a par with the certified seeds (Table 1).

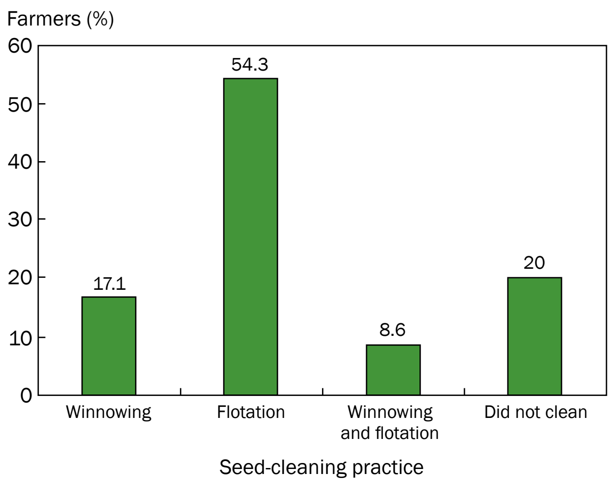

Fig. 5. Seed-cleaning practices of farmers in Infanta, Quezon (Mew et al 2001).

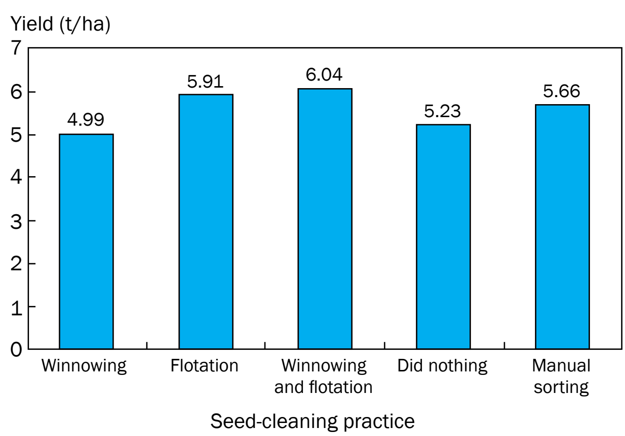

Fig 6. Yield of experimental plots of farmers in Infanta, Quezon (Mew et al 2001).

Table 1. Seed standards for certified (F1) and parental seeds (AO No. 20 series of 2005, NSIC).

Factors	Breeder		Foundation		Registered		Certified (F1)
	A	B/R	A	B/R	A	B/R	
Pure seed (min.) %	99	99	99	99	98	98	98
Weed and other crop seed (max.) %	0	0	0	0	0.5	0.5	0.5
Inert matter (max.) %	1	1	1	1	1.5	1.5	1.5
Red rice no. of grains*	0	0	1	1	2	2	3
Other varieties*	1	1	3	3	5	5	5
Germination (min.) %	85	85	85	85	85	85	85
MC (max.) %	14	14	14	14	14	14	14

Result of cleaning

The effect of grain discoloration to percent germination and intensity of seedborne organisms (Table 2) shows that, the cleaner the visual condition of seeds, the higher the percentage of germination and the lower the intensity of seedborne infection.

Table 2. Percent germination and infection level of Sarocladium oryzae and Bipolares oryzae at different intensity of grain discoloration.

Scale	Description	Intensity (%)	Diagnosis	Germination (%)	S. oryzae (%)	B. oryzae (%)
1	Clean	0	Clean seeds; no discoloration	92	13	6
2	Light	1–5	Pinhead spots at one point of the seed	95	17	17
3	Intermediate	6–25	Few pinhead and sesame-sized spots	92	17	17
4	High	26–50	Large spots single or scattered	88	20	28
5	Severe	51–100	Heavily discolored	76	33	32

Yield advantage of farmers from seed cleaning

The following shows yield performance per hectare using healthy rice seeds in selected rice-growing countries.

a. **Bangladesh** (YI = 700 kg). For harvest, Bangladeshi farmers whose yields had previously amounted to 5.1 t/ha were reaping about 5.8 t/ha using healthy seeds. Across the entire 560 farms, yields from sorted seeds were, on average, 9% higher. Applied to the entire Bangladeshi rice crop, this would mean an increase of 2 million tons of grain (Taher Mia 2001).

b. **India** (YI = 560−760 kg). In West Bengal, India, the use of high-quality seeds alone can ensure a yield advantage of 5.6−7.6 quintals per hectare (1 quintal = 100 kg) in bunded transplanted fields on red and lateritic soils. The yield advantages in direct-seeded unbunded fields ranged from 3.25 to 4.20 q/ha in various districts (Chatterjee 2000).

c. **Philippines** (YI = 7−20%). The farmers in Central Luzon, Philippines, obtained 7% higher yield than farmer-kept seeds at sites where yield is already high. At sites where yield is low, the yield difference was 20% (Diaz et al 1998).

So using goood quality or healthy seeds will result to a healthy crop which in turn will produce good yield with less or no seed conditions and contaminants.

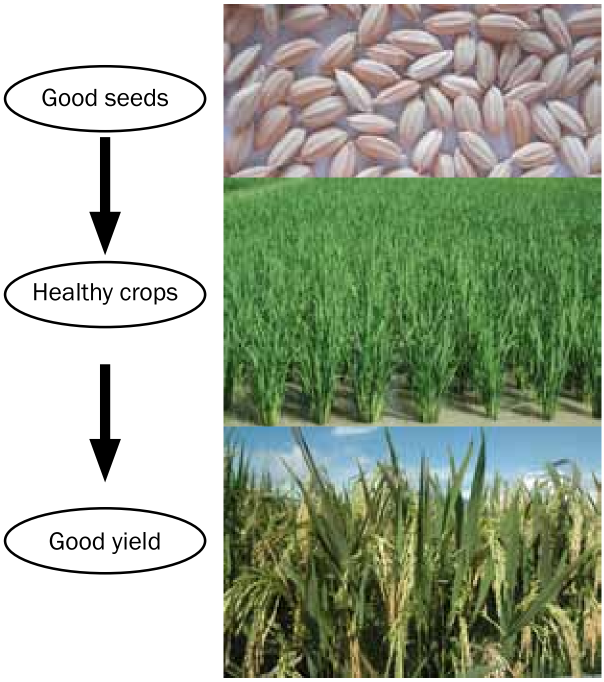

Fig. 7.

HANDS-ON EXERCISES

Activity 1: Identification of a healthy seedlot

Seeds are sometimes categorized as “good” or “bad,” depending on the observed characteristics. This exercise should be done at the start of the session. The seed packets are labeled and represent three seed categories. However, the seed categories should not be disclosed to the participants; only the resource person must know this information.

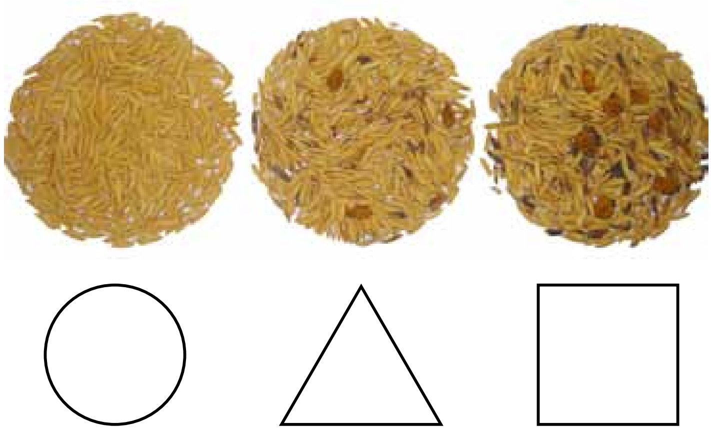

Fig. 8.

Directions

1. Divide participants into groups.
2. Provide each group with one set of materials.
3. Request participants to pour each seedlot into corresponding container ("bilao").
4. Request/allow participants to examine each of the three seedlots (Fig. 7) (the members of the group should compare the contents of each packet).
5. Participants are asked which among the three seedlots they will recommend as planting material. Why?
6. Can the other two seedlots be used as planting material? How?

Materials

One set composed of three seedlots with the following seed categories (good, moderate, bad) placed separately in labeled packets.

Discuss the following:

- Definition of seed health
- Importance of seed health in relation to pest and disease management

Activity 2: Identification of seed conditions and seed contaminants

Materials

One set composed of 17 specimen boxes containing different seed conditions and seed contaminants, and labels.

1. Divide participants into groups.
2. Provide each group with a set of materials.
3. Request participants to bring out the specimen boxes and labels.
4. Put/match corresponding labels to identify the different seed conditions and seed contaminants (i.e., discolored seeds, weed seeds).
5. Identify whether the specimen is a seed condition or seed contaminant.

Discuss the following:

- Different seed conditions and seed contaminants resulting in a bad/unhealthy seedlot
- Difference between a seed condition and a seed contaminant
- Effects of the presence of these different seed conditions and seed contaminants in a seedlot used as planting material

Answers to activity 2

Specimen

1. Other plant parts
2. Weed seeds
3. Sand/pebbles
4. Broken grains/seeds
5. Varietal mixture
6. Kernel smut
7. Sclerotia
8. False smut
9. Insect-damaged seeds
10. Moldy seeds
11. Seeds with soil particles
12. Other seeds
13. Discolored seeds
14. Deformed seeds
15. Storage insects
16. Germinated seeds
17. Unfilled/partially filled seeds

Directions

1. Identify some components of a seedlot
2. Differentiate between seed contaminants and seed conditions

3. Cite some reasons for cleaning rice seeds
4. Conduct some basic farmers' practices to obtain clean seeds/quality seeds
5. Define the two disease assessment tools

Components of a seedlot: see the lectures/lesson notes

Photo 18. Good-quality seeds.

Instruction:

- Match the name tag and the object that can be observed during the dry seed inspection/visual examination of a seedlot.

Identify seed conditions and seed contaminants.

Instruction:
Group the labeled objects into two:

- ○ Seed condition
- ○ Seed contaminant

Activity 3: Farmers' practices to improve health of a seedlot

Materials
Three seedlots, 100 g of one variety, bad/unhealthy, with many seed contaminants and poor seed conditions: one for physical sorting, one for flotation, and one for winnowing.

Directions

1. Divide participants into groups.
2. Provide each group with a seedlot.
3. Assign one farmer's practice to a group.
4. Allow the participants to process the seeds (time the whole process; identify what was removed (in terms of seed conditions and seed contaminants).
5. Make the groups present their findings.

Discuss the following:

- Different farmer practices in improving the health of a seedlot (physical sorting, flotation, winnowing)
- Advantage and disadvantages of each practice

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Module 6

Rainfed Rice Varieties and Technologies

Modesto M. Amante

Module objectives:

1. This module illustrates the different traits of rainfed varieties intended for upland or aerobic cultivation. It includes both traditional and improves released varieties available either at the International Rice research Institute in Los Baños, Laguna (Plant Breeding, Genetics and Biotechnology and Genetic Resources Center) or at Philippine Rice Research Institute (PhilRice) in Muñoz, Nueva Ecija.

2. The module provides some of the basic information regarding salient features of rainfed upland varieties and its adaptability to both favorable and unfavorable environments such as drought areas.

OBJECTIVES

1. To differentiate and characterize upland varieties vis-à-vis lowland varieties

2. To enable upland farmers and other stakeholders to gain access to locally available traditional and improved upland varieties and sustain increases in productivity and profitability

Rationale

Upland rice varieties are varieties that are grown in an aerobic type of soil that is well drained, not flooded, and prepared, and varieties are seeded in dry soil that depends on rainfall for moisture. Upland rice is grown without flooding, usually on hillsides in more mountainous regions. Farmers in the upland tend to grow any available rice seeds, which may not be well adapted to the conditions existing in upland rainfed areas. In most cases, the varieties that many farmers are using are the ones that have been bred for irrigated lowland but, when stress comes, yield is sacrificed and farm productivity declines. Many upland farmers plant local or traditional cultivars that do not respond well to improved management and the addition of more inputs.

Differences between lowland and upland rice varieties

1. Traditional upland rice varieties
   a. Height: a tall traditional upland variety has a height of 120–180 cm
   b. Maturity: 120 days (average)
   c. Usually have 2–4 productive tillers
   d. Large panicles with many grains (150–300) per panicle
   e. Well adapted to poor or unfavorable environments
   f. Low to medium grain yield (1–3 t/ha)
   g. May lodge under good management if high inputs are applied

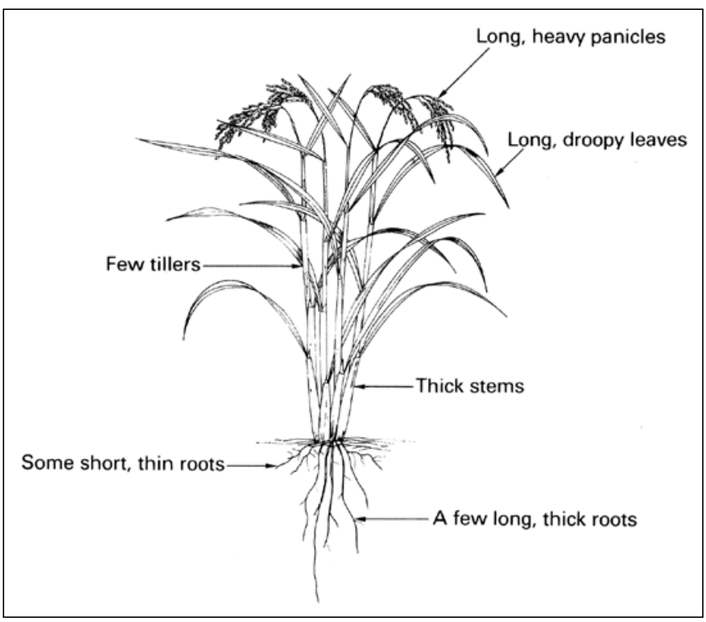

Fig. 1. Basic illustration of a traditional upland rice variety.

Upland rice varieties

a. **Drought tolerance.** This trait is highly interactive with crop phenology, plant growth prior to stress, and the time, duration, and intensity of drought stress. Being drought-sensitive takes at least 2 rainless weeks to cause any marked differences in reaction at the vegetative stage and at least 7 rainless days at the reproductive stage to cause injury. Normally, leaf rolling at the beginning is noticed, followed by leaf drying as drought progresses.

Photo 1. Comparison between an improved drought tolerant upland against a susceptible variety.

b. **Tall in height.**

c. **Weed-competitive.** The rice plant is taller than the weeds; it grows faster than the weeds at the early stage of rice growth; early vegetative vigor within the first month is high.

Photo 2. A weed competitive variety.

d. **Not input-responsive.** An increase in fertilizer inputs can lead to early lodging.
e. **Low yielding (1–2 t/ha).**
f. **Tillering is low, not more than 6, average of 2–4 tillers per plant.**

Lowland rice varieties

Lowland rice is grown in fields that can be flooded, either rainfed or irrigated. Their common traits are as follows:

a. Drought-sensitive
b. Short in height
c. Not weed-competitive
d. Input-responsive
e. High yield potential (6–8 t/ha)
f. Short to medium growth duration, below 100 days (early), 100–120 days (medium), above 120 days (late-maturing)
g. High tillering ability. Usually have 10–15 productive tillers.
h. Well adapted to favorable environment

Key characteristics of improved upland rice varieties (aerobic rice)

a. Adapted to aerobic soil
b. Drought-tolerant
c. Short to medium height
d. Weed-competitive
e. Input-responsive under good management or application of higher inputs
f. High-yielding (4–7 t/ha)
g. Can be planted in upland and lowland ecosystems

Photo 3. Example of aerobic rice—PSB Rc9 (Apo variety).

Available local or traditional and National Seed Industry–released upland varieties

1. Some locally available traditional upland varieties are in the seed bank of the Genetic Resources Center of IRRI (Source: Data Management, GRC-IRRI).
2. Some traditional rice available in Region XI.

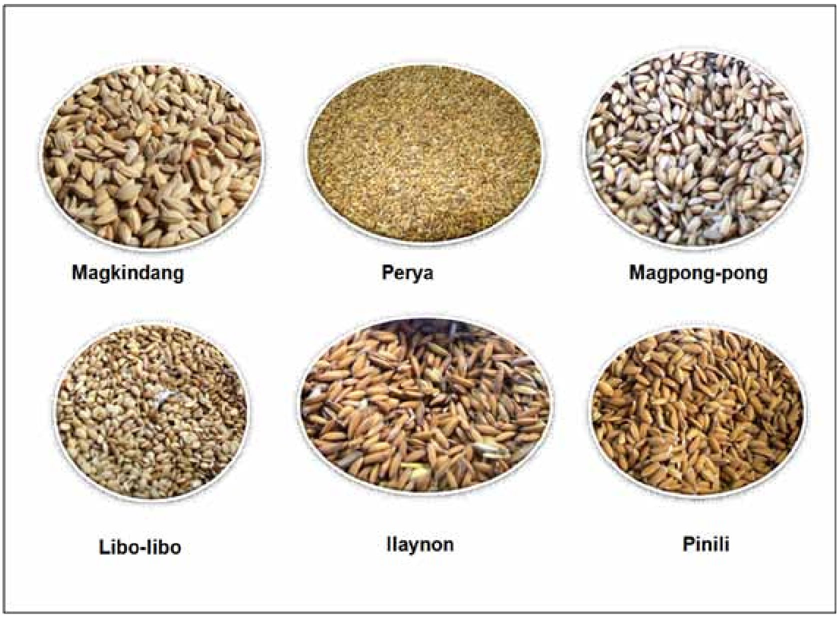

Photo 4. Some of the traditional rice available in Region XI (Davao region).

3. Popular rice seed board varieties released since 1972 that are adapted to both upland and rainfed areas in the Philippines (Table 1).
4. Some upland and traditional varieties released by the Philippine Seed Board or National Seed Industry Council (NSIC) (Table 2).
5. Some of the released varieties in the Philippines that are adapted to drought-prone environments.
6. Released in 2009: Sahod-ulan varieties are rainfed dry-seeded rice and also recommended for upland conditions.
7. An upland variety released by NSIC in 2011 (Table 3).
8. New Sahod-ulan varieties released for rainfed lowland and favorable and drought-prone areas in the Philippines (Tables 4–7).

Table 1. Philippine rice varieties for upland and rainfed conditions.

Variety/ecosystem	Year approved	Breeding institution
Upland		
C22	1972	UPLB
IR43	1978	IRRI
IR45	1978	IRRI
UPL R1-3	1979	UPLB
BPI R1-6	1979	PhilRice
UPL R1-5	1980	UPLB
UPL R1-7	1981	UPLB
PSB Rc1 (Makiling)	1990	IRRI
PSB Rc3 (Giniling Puti)	1997	Trad. variety
PSB Rc5 (Arayat)	1997	IRRI
PSB Rc7 (Banahaw)	2001	PhilRice
NSIC Rc9 (Apo)	2001	IRRI
NSIC Rc11 (Canlaon)	2001	PhilRice
Dual-role variety		
NSIC Rc222 (Tubigan 18)	2010	IRRI
Rainfed dry seeded		
PSB Rc16 (Ennano)	1993	Trad. variety
PSB Rc24 (Cagayan)	1994	PhilRice
PSB Rc42 (Baliwag)	1995	PhilRice
PSB Rc60 (Tugatog)	1997	IRRI
PSB Rc62 (Naguilian)	1997	PhilRice
PSB Rc68 (Sacobia)	1997	IRRI
PSB Rc70 (Bamban)	1997	IRRI
NSIC Rc192 (Sahod ulan 1)	2009	IRRI
NSIC Rc222 (Tubigan 18)	2010	IRRI
Rainfed		
C168	1973	UPLB
IR46	1978	IRRI
UPL R1-2	1978	UPLB
IR52	1980	IRRI
Rainfed lowland transplanted		
PSB Rc12 (Caliraya)	1992	UPLB
PSB Rc14 (Rio Grande)	1992	UPLB
PSB Rc36 (Ma–Ayon)	1995	Trad. variety
PSB Rc38 (Rinara)	1995	Trad. variety
PSB Rc40 (Chayong)	1995	Trad. variety
PSB Rc98 (Lian)	2001	UPLB
PSB Rc100 (Santiago)	2001	PhilRice
PSB Rc102 (Mamburao)	2001	IRRI

Table 2. Some traditional Philippine upland varieties (as of 20 Sept 2011, N = 948).

IRGC acc. no.	Variety name	Donor code	Species name
5997	Apostol	FAO GS 1067	*O. sativa*
328	Azucena	FAO GS 1205	*O. sativa*
44295	Balibod		*O. sativa*
44297	Ballatinao		*O. sativa*
53132	Bangkoro		*O. sativa*
44311	Benerhin		*O. sativa*
4021	Binicol	PI 223555	*O. sativa*
5991	Binundok	FAO GS 1069	*O. sativa*
19396	Camoros	01-069	*O. sativa*
3827	Denorado	CI3233	*O. sativa*
337	Dinalaga	FAO GS 1208	*O. sativa*
67431	Dinolores		*O. sativa*
30333	Dinorado		*O. sativa*
5193	Elon Elon	MALIGAYA NO. 78	*O. sativa*
23364	Kinadang Patong		*O. sativa*
733	Kinadang Pula		*O. sativa*
4016	Kinadang Puti	PI 220421	*O. sativa*
44549	Lobang (Red)		*O. sativa*
353	Palawan	FAO GS 1212	*O. sativa*
16925	Pirurutong		*O. sativa*
53072	Wagwag Pino		*O. sativa*

Photo 5. UP Los Baños developed varieties for upland areas released by the Philippine government in 1980 and 1981, respectively.

Photo 6. An IRRI developed upland variety locally knoown as 'Makiling' released by Philippine Seed Board. The variety is well adapted to an acid upland condition.

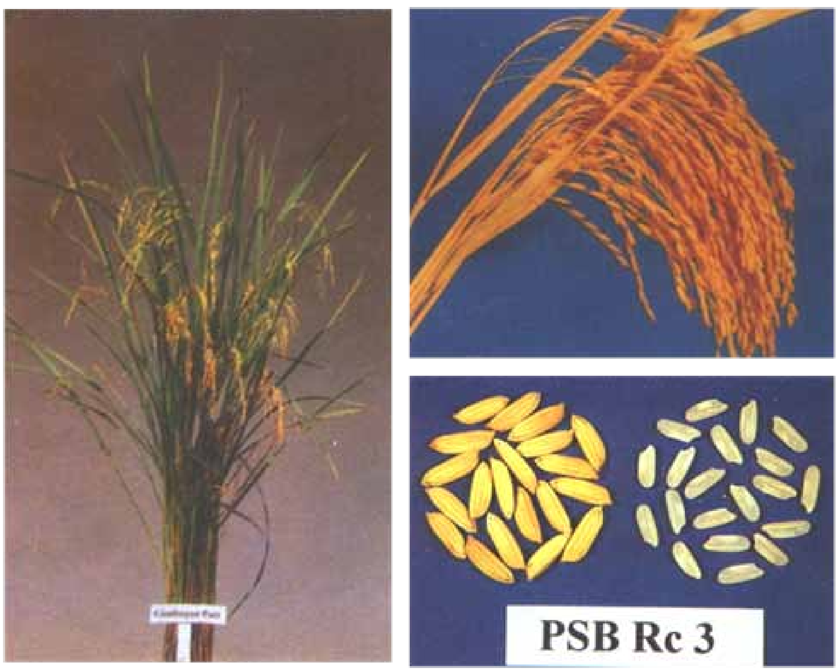

Photo 7. A traditional upland variety locally known as 'Ginilingan Puti' released in 1997.

Photo 8. An IRRI developed upland variety released in 1997 and locally known as 'Arayat'.

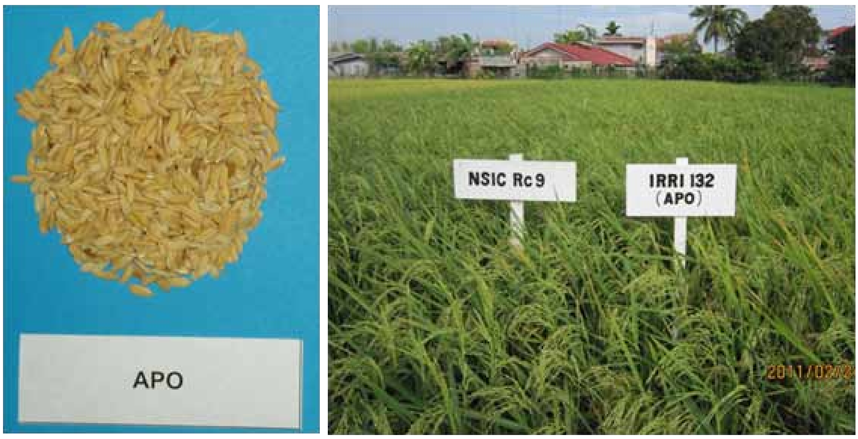

Photo 9. Most popular and widely cultivated IRRI developed upland variety released in 2001.

Photo 10. NSIC Rc 192 is adapted to both transplanted lowland and direct seeded upland conditions.

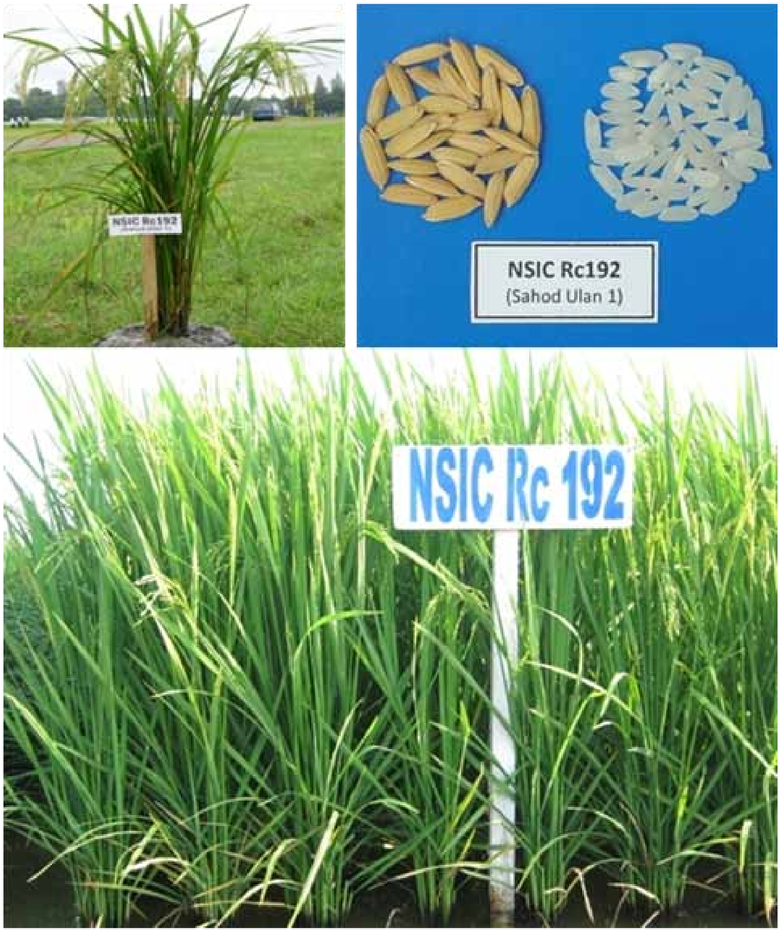

Photo 11. The variety is released as Sahod Ulan 1 (Philippines) and Sukha Dhan 2 (Nepal).

Table 3. NSIC 2011 Rc23.

Designation	Commercial name	Agronomic characteristics					Remarks	Recommendation
		Ave. yield (kg/ha)	Max. yield (kg/ha)	Maturity (DAS)	Plant ht. (cm)	Tillers (no.)		
IR79913-B-176-B-4	Katihan 1	2,993	7,613	108	108	64	• With an average yield of 2.9 t/ha and yield advantage of 6.9% over the check variety, UPL Ri7. • Very early maturing at 108 days. • Strong resistance to blast and whiteheads (WSE & YSB at majority of test sites). • Intermediate amylase content. • Good milling and head-rice recovery.	National, upland areas, dry seeding culture

Table 4. NSIC 2011 Rc274.

Designation	Commercial name	Agronomic characteristics					Remarks	Recommendation
		Ave. yield (kg/ha)	Max. yield (kg/ha)	Maturity (DAS)	Plant ht. (cm)	Tillers (no.)		
IR81412-B-B-82-1	Sahod Ulan 3	2,977	6,664	116	92	69	• High yield advantage of 28.5% over the check variety, PSB Rc14. • Medium maturing at 116 days. • Resistant to blast in CVIARC, and intermediate to VSU. • Resistant to intermediate reaction to whiteheads (YSB) at all sites and moderately resistant to green leafhopper across seasons. • Long and slender grain with high milling recovery.	Rainfed lowland, favorable and drought prone

Table 5. NSIC 2011 Rc278.

Designation	Commercial name	Agronomic characteristics					Remarks	Recommendation
		Ave. yield (kg/ha)	Max. yield (kg/ha)	Maturity (DAS)	Plant ht. (cm)	Tillers (no.)		
IR81023-B-116-12	Sahod Ulan 5	2,421	5,314	110	122	86	• Average yield of 2.4 t/ha and yield advantage of 4.5% over the check variety, PSB Rc14. • Early maturing at 110 days. • Resistant to intermediate reaction to blast at VSU, CVIARC, PhilRice CES, and PhilRice Midsayap and intermediate to sheath blight at UPLB • Resistant to moderately resistant to whiteheads (WSB & YSB) at six test sites and moderately resistant to green leafhopper across seasons. • Intermediate amylase content; long and intermediate grain. High milling recovery and highly acceptable grain quality	Rainfed lowland, favorable and drought prone

Table 6. NSIC 2011 Rc280.

Designation	Commercial name	Agronomic characteristics					Remarks	Recommendation
		Ave. yield (kg/ha)	Max. yield (kg/ha)	Maturity (DAS)	Plant ht. (cm)	Tillers (no.)		
IR72667-16-1-B-B-3	Sahod Ulan 6	2,516	5,573	123	104	81	• With positive yield advantage of 8.6% over the check variety, PSB Rc14. • Resistant to blast in CVIARC, resistant to moderately resistant to blast and bacterial leaf blight at PhilRice-Isabela • Intermediate to bacterial leaf blight at PhilRice-Midsayap, bacterial leaf blight and sheath blight at WESVIARC. • Resistant to intermediate to whiteheads (WSB & YSB) at majority of test sites, moderately resistant to intermediate reaction to green leafhopper. • Intermediate amylase content with extra long and slender grain; Grade 1 milling recovery • Aromatic with high percentage acceptability and comparable to IR64, also slightly aromatic in raw form	Rainfed lowland, favorable and drought prone

Table 7. NSIC 2011 Rc284.

Designation	Commercial name	Agronomic characteristics					Remarks	Recommendation
		Ave. yield (kg/ha)	Max. yield (kg/ha)	Maturity (DAS)	Plant ht. (cm)	Tillers (no.)		
IR72667-16-1-B-B-3	Sahod Ulan 8	3,733	5,720	114	98	91	• Average yield of 3,733 kg/ha and yield advantage of 10.2% over the check variety, PSB Rc14. • Early maturing at 114 days. • Resistant to intermediate reaction to blast at PhilRice CES, UPLB, BIARC, & CVIARC. BLB at BIARC, RTV at PhilRice CES & PhilRice-Isabela; intermediate to SHB at WESVIARC • Resistant to moderately resistant to WSB & YSB at PhilRice-Agusan, VSU, BIARC, and CVIARC and to GLH • Intermediate amylase content with extra long and slender grain. • High milling recovery with acceptable head rice and physical attributes. • Highly preferred in raw form compared with two check varieties, IR64 and PSB Rc14.	Rainfed lowland, favorable and drought prone

Differences in naming of released varieties

Between 1960 and 1989, Philippine rice varieties were coded as to the institution or breeding center that developed them. For example, IR64 was developed by IRRI, BPI Ri 10 by the Bureau of Plant Industry (BPI), and UPL Ri 7 and C22 by UPLB.

From 1990 to 2001, the varieties were coded "PSB Rc" by the Philippine Seed Board, in which Rc stands for rice. According to the numbers, an even number means the variety is best for lowland areas and an odd number is best for upland areas. Local names may also be attached; if the variety is named as a river or lake, this name is for lowland varieties; names of mountains are used for upland rice.

After 2002 to now, the name "NSIC Rc" stands for the National Seed Industry Council for rice. The odd number and even number rule still applies but the following popular names are used: lowland varieties—Tubigan (inbred); Mestiso (hybrid); upland varieties—Katihan; rainfed—Sahod ulan; cool elevated—Cordillera; saline—Salinas; glutinous—Malagkit; aromatic—Mabango.

Activity

At the end of this module, you should be able to

1. Define what upland rice is.
2. Differentiate lowland rice, upland traditional rice, and improved upland rice (aerobic rice).
3. Know how the different rice varieties are named.

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Module 7

Production of Quality Seeds

Joel D. Janiya

LESSON 1: CHOOSE GOOD-QUALITY SEED OF A SUITABLE VARIETY

OBJECTIVE

To explain why quality seed is important in rice production

It is important to use quality seed in rice production. Using quality seed can increase yield between 5% and 20%. On the other hand, using seed of lesser quality will introduce more weeds and off-types into your crop, make your crop more susceptible to disease, and produce weaker plants.

The following are benefits of high-quality seeds:

- Help you save your money as you need less seed—quality seed means a higher percentage of seed emergence
- Minimize replanting
- Produce vigorous seedlings
- Produce uniform plant stands
- Hasten plant growth
- Enhance resistance to stress and diseases
- Result in uniform ripening, which means more uniformity in the harvested grain. There will be less mixture and that can mean a higher market price.

Using quality seeds means saving money on the inputs to production. With higher yields, farmers get more income or more food for the family.

LESSON 2: CHARACTERISTICS OF QUALITY SEED

OBJECTIVES

1. To understand the characteristics of quality seed
2. To understand the importance of varietal purity and be able to measure the purity of a sample
3. To understand the characteristics of clean seed and to determine how clean your seed is
4. To understand the importance of viability—high germination percentage and seed vigor

Questions

1. How can I know that the seed I am producing or using is quality seed?
2. What is quality seed?
3. Can I do some simple tests to know whether my seed is of high quality?

In this lesson, you will learn about the characteristics of quality seed. You will learn why these characteristics are important. In subsequent lessons, you will learn simple tests to determine whether the seed you are growing or using is quality seed.

A rice seed is a live grain. It can germinate and grow into a full plant and produce more seeds, whereas a grain can be alive or dead. It can germinate if it has a germ cell (embryo portion of a grain) or it cannot germinate because it has no embryo or germ cells.

The following are characteristics of quality seed:

1. The seed is **pure**—there is only one variety; it is not a mix.
2. The seed is **clean**—it does not contain weed seeds, stones, or litter, and the grains are not discolored by disease.
3. The seeds are **viable**—they have high germination and the seedlings are vigorous.

Quality seed is pure—it has varietal purity.

Varietal purity is the genetic or cultivar purity and it can be described by physical, chemical, and crop attributes.

Photo 1. Quality seed.

LESSON 3: LAND SELECTION, LAND PREPARATION, AND SOWING OF SEEDS

OBJECTIVE

To be able to select appropriate land, prepare it appropriately, and correctly sow seed.

In an upland ecosystem, rice seed is directly sown in the main field. Adequately fertile clay-loam soil having good water-holding capacity is preferred for rice seed production. Land used to grow the same variety in previous years is good for seed production.

1. Selection criteria for seed-producing land

a. Select a fertile field.
b. The field should be in a location that is readily accessible for inspection. The farm needs to be visited frequently for management to avoid damage by cattle or birds.
c. The field should not have been planted to rice. If the field is planted to rice, the variety previously planted should not be the same variety being produced.

2. Preparation of land for rice seed production

Good land preparation is important to allow homogeneous development of plants. Plants will develop evenly when they all receive equal amounts of nutrients and water. Further, this is important for early growth of rice. It ensures vigorous growth and the correct number of plants per unit area. The soil should have uniform particles and be fine in texture. Good land preparation also encourages strong seedlings, and good and uniform plant growth.

Photo 2. Land preparation (A). Emerged rice seedlings in a well prepared soil (B).

Rather than burning it, all plant debris should be plowed into the ground to provide organic matter.

As soon as the early rains set in, the land should be thoroughly plowed 4–5 times, followed by harrowing to create a uniform field for seeding. If the field has been planted to rice in the previous season, remove volunteer rice seedlings. This can be done by allowing rice seeds from the previous crop to germinate and emerge, and then killing seedlings by cultivation. This can be done 2–3 times to avoid mixture. The field should be free from volunteer rice seeds before planting.

Photo 3. Drop seeds after harvest (A). Volunteer rice seedlings (B).

3. Method of seeding

Sowing crops in rows is recommended. Row seeding facilitates weeding and the application of other inputs (i.e., fertilizers and pesticides), and promotes a good stand and higher yield. The choice of method of seeding will depend on cost and availability of labor.

In rolling or hilly areas where cultivation is not suitable, a dibbling method can be used. Dry seeds are dibbled into a 2–3-cm deep hole using either a sharp stick or any pointed object. The depth of sowing is important in creating a good stand of plants.

Photo 4. Hand sowing in rows in hills (A). Rice seedlings hill-sown in rows (B).

Photo 5. Sowing by dibbling.

Seeds will emerge from greater depth in sandy soil but from shallow depth in clay soils. Sowing in dry soil should be deeper than in moist soil to ensure that seeds are in contact with moisture. In areas where weather conditions cause crusting or baking of the soil surface after heavy rains, crops should be planted just deep enough to be well covered and the soil on top of them left loose.

4. **Seed rate**

   A proper seed rate is necessary to get an appropriate number of plants with homogeneous and healthy growth. A seed rate of 40–60 kg/ha, depending on seed size, can be used with standard spacing of 20–30 cm between rows.

5. **Sowing time**

   Time of sowing differs according to the agroecology and the availability of moisture. Before sowing seeds, rains make the seeds well established. Thus, after a good rain, seeds should be sown into moist soil.

LESSON 4: ISOLATION IN RICE SEED PRODUCTION

OBJECTIVE

To understand the importance of maintaining isolation in seed production

Isolation means the separation of a crop from all possible sources of contamination during the growing period. It is one of the main methods used to maintain varietal purity and is primarily achieved by maintaining separation from other rice crops.

Isolation distance is needed when different varieties are being grown for seed production. The isolation distance between varieties must be wide enough (at least 3–5 m) to prevent cross-pollination.

Although rice is a self-pollinated crop, cross-pollination does occur. This is mainly due to wind pollination as rice pollen is light and dry and can be carried by the wind a considerable distance. Cross-pollination occurs more when the crop experiences some stress (e.g., drought). The larger the seed plot, the less is the danger of outcrossing.

The objective of maintaining isolation is to minimize outcrossing in plants intended for seed production. If pollen from another variety fertilizes plants in a seed crop, varietal purity will decline.

Incidentally, isolation distance is compulsory for seed producers to get their multiplied seeds certified by an appropriate authority.

LESSON 5: ROGUING FOR RICE SEED PRODUCTION

OBJECTIVE

To understand the importance of roguing to maintain genetic purity

Roguing is the removal of off-types or mixtures. Plants with heterogeneous characters in seed production plots are called off-types. Roguing in a seed production plot is extremely important as pollen from off-type plants can cause irreparable damage through cross-pollination.

The following are sources of off-types:

- Volunteer plants from a previous crop
- Natural outcrossing
- Minor genetic variation
- Developmental variation
- Mechanical mixtures of seeds during postharvest
- Natural mutation

Off-types can be identified by the following characteristics of plants:

Photo 6. Plant height: Plants are either taller or shorter than most of the population in the field.

Photo 7. Plants have a different color of leaves, sheaths, and straws.

Photo 8. Presence or absence of awns: If a majority of the plants have awns, then those without awns are off-types and vice versa.

Photo 9. Panicle exsertion: Plants with earlier or later panicle emergence are to be considered as off-types (only those with a flowering range of 2–3 days should be kept).

Photo 10. Angle of flag leaf: If an erect flag leaf is dominant, then horizontal and droopy leaves are off-types.

Photo 11. Size, shape, and color of grains: If most of the panicles have long grains, then those with medium grains are off-types. If slender grains are dominant, then bold grains are off-types, etc.

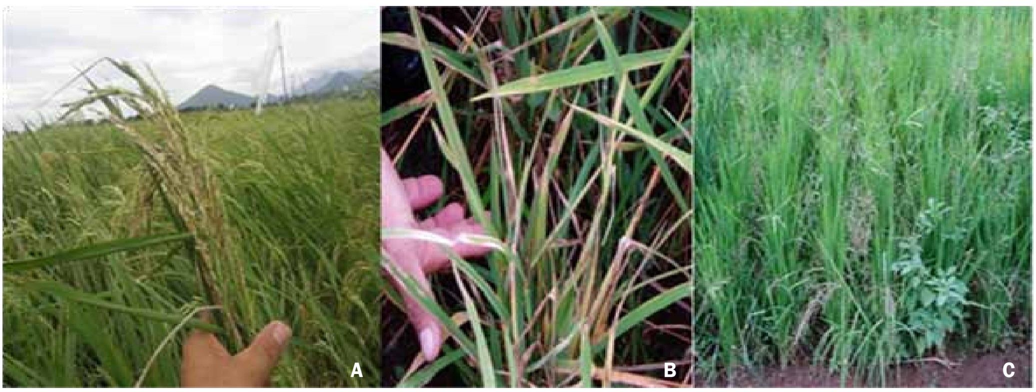

Photo 12. Diseased or insect-damaged plant. (A.) Insect (B) disease (C) weeds.

Photo 13. Apiculus color.

Photo 14. Glabrous or pubescent.

Photo 15. Different heading and maturity dates, for example, extra early or late plants.

Photo 16. Different plant types and panicle types, for example, open or closed tillering; open or closed panicle.

Roguing should be done continuously over the whole growing season (as one notices off-types), with a special emphasis during the period of panicle emergence to early seed development. Usually, roguing is done during the following stages: vegetative growth, flowering, postflowering, and preharvest.

Module 8

Soil and Nutrient Management

Joel D. Janiya

Module objectives:

1. To know ways of managing upland soils to prevent erosion
2. To understand the effect of fertilizer on seed production and how to apply it properly
3. To be able to calculate fertilizer doses

Introduction

Two major rice ecosystems are the upland and rainfed lowland ecosystems. Rice grown in rainfed, naturally well-drained soils, without surface water accumulation, and not bunded is called upland or aerobic rice. Rice grown in bunded fields with surface water accumulation and without irrigation facilities is called rainfed lowland rice. The characteristics of these ecosystems are described in Table 1.

Improper management of soils in uplands and rainfed lowlands can lead to degradation of the soil, resulting in poor yields. Nutrient management strategies and practices should be attuned to the conditions in each ecosystem.

Table 1. Comparison of upland and rainfed lowland rice systems.

Upland	Lowland
Cultivated on undulating or steep slopes or leveled and well-drained soils	Cultivated on leveled, bunded flooded soils. May also be located in highlands in valley bottoms and on bunded or terraced slopes.
Water supply through rainfall	Water supply through rainfall or with water from catchment of small water-impounding basins
Oxidized root zone during crop growth	Reduced root zone during major part of crop growth
Crop establishment by dry direct-seeding	Crop establishment by dry direct-seeding, wet direct-seeding, or transplanting
Varieties commonly traditional	Varieties can be traditional or improved
Environmental conditions are unstable and variable	Environmental conditions are quite stable and uniform
Weeds are a serious problem	Weeds are a less serious problem
Inputs low	Inputs high
Low cost of production	High cost of production
Unstable and low yield	Stable and higher yield

Fertility and land productivity decline for several reasons (Singh and Singh 2000):

- Continuous cropping without replenishing nutrients through external sources.
- Imbalance in application of plant nutrients to the soil.
- Indiscriminate use of fertilizers and inappropriate methods of cultivation.
- Lack of or inadequate application of organic manure to the soil.
- Improper land, soil, and water management practices.
- Use of inappropriate cropping patterns.
- Erosion of fertile surface soils.
- Improper tillage practices.
- Improper crop management practices.
- Waterlogging and/or occurrence of drought.

How to reduce or prevent soil erosion and nutrient loss in the uplands.

Upland fields are vulnerable to erosion and nutrient loss, particularly on steep slopes and even in slightly undulating fields.

Land management

- Where the field is flat, the land should be leveled properly before sowing to avoid erosion and runoff.
- In sloping fields, contour plowing or cultivation and planting of hedge rows should be adopted to conserve soil and water.
- Cover crops should be used to reduce erosion and for control of perennial weeds.

Contour plowing and contour hedges in Arakan, Cotabato, Philippines.

***Mucuna pruriens* (L.) Dc. as fallow cover crop to control *Imperata cylindrica* in Luang Prabang, Laos.**

Improving fertility

- Integrated use of organic and inorganic fertilizers. Apply as much organic fertilizer (manure, compost, or farmyard manure) as is available (up to 10 t/ha). Mix this thoroughly in the soil 2–3 weeks before sowing. Apply inorganic fertilizer to complete the requirement of the rice crop. Application of organic fertilizers will help improve soil fertility and water-holding capacity.
- Green manuring. Grow green manure crops (*Sesbania* spp.) or green manure trees (*Gliricidia* spp. or *Leucaena* spp.) as contour hedge-rows to help prevent erosion. Use the leaves of the trees as green manure.
- Inclusion of legumes in rice-cropping systems.

Peanut intercropped with rice in Arakan, Cotabato, Philippines.

LESSON 2: WHY APPLY FERTILIZER?

OBJECTIVE

To understand the effect of fertilizer on seed production and how to apply it properly

Soil stores all plant nutrients. Rice roots absorb nutrients from the soil for growth, dissolved in the soil solution. A sufficient supply of nutrients from a fertile soil supports healthy growth of the crop, resulting in good yield. Poor soils usually contain low amounts of nutrients, hampering crop growth and thus reducing yield. Nutrient requirements of rice for proper growth vary depending on soil and environmental conditions. Therefore, to increase crop yields, some nutrient elements have to be applied as fertilizer. The most common limiting nutrients for rice are nitrogen (N), phosphorus (P), and potassium (K).

Balanced fertilization

Crops need nutrients for their proper growth and productivity. For rice planted in upland or rainfed lowland conditions, balanced fertilization is essential. Nutrients can be sourced from either organic or inorganic sources. Sources of organic material can be compost, manure (poultry, piggery, or farmyard manure), crop wastes or residues, and vermicompost. Commercial organic fertilizers should be used with care, as they are usually expensive and increase yields only a little. Green manure can also be used as appropriate. Inorganic sources are commercially available fertilizers.

Principles of fertilizer application

Variety: Varieties have different growth duration. Proper timing of fertilizer application based on crop growth stage is important.
Soil: Light soil needs split application of N and K compared with heavy soil.

Farmers should strive to obtain a fertilizer recommendation based on analysis of soil samples. When a soil test is not possible, general recommendations can be a good guide to applying fertilizer based on local recommendations. Nutrient needs of the crops can also be analyzed using the omission plot technique.

P and K fertilizer application: The best is as basal application (final harrowing just before seeding).
N fertilizer application: Nitrogen is the most limiting factor in rice production. However, in seed production, judicious application of N fertilizer is important since excess N facilitates vigorous plant growth that increases disease and insect infestation and delays fruiting, resulting in poor-quality seed:

- Use a judicious amount of N (recommended in your area).
- Apply in 2–3 splits.
- Apply the first topdressing at the onset of tillering (21 days after seeding) and just after the first weeding for upland rice and at 10–15 days after transplanting.
- Apply a second topdressing at about panicle initiation.
- Broadcast uniformly over the soil surface.
- Don’t apply more than 30–35 kg N per ha in a single split to minimize loss.
- Use basal N only when it is necessary.

LESSON 3. FERTILIZER COMPUTATION

To compute the equivalent amount of fertilizer necessary to supply the corresponding amounts of nutrients, use the following formula:

$$\text{Amount of fertilizer} = \frac{\text{Recommended rate (kg nutrient per ha)} \times \text{area (ha)}}{\text{\% nutrient in commercial fertilizer}} \times 100$$

Example of fertilizer calculation:

In calculating the amount of nutrients to be applied, take the following into account:

1. Fertilizer materials available
2. Kind of nutrients present in a fertilizer material or product
3. Percent nutrient content of the fertilizer products

Examples of fertilizer products:

1. Urea—46% nitrogen
2. Complete fertilizer—may contain different percentages of N, P, and K in different countries (% NPK content may be 14-14-14 or 15-15-15)
3. 16-20-0—16% N, 20% P, and 0 K
4. 18-46-0—18% N, 46% P, and 0 K
5. 0-18-0—0 N, 18% P, and 0 K
6. 0-0-60—0 N, 0 P, and 60%K

Example: Your field is 0.5 ha in size, the available fertilizer is urea (46-0-0 NPK) and mixed fertilizer (14-14-14 NPK), and the recommended fertilizer rate is 60-30-30 kg NPK/ha.

Solution:

Step 1. Determine the amount of mixed fertilizer to be used

$$\text{Amount of mixed fertilizer} = \frac{30 \text{ kg/ha} \times 0.5 \text{ ha}}{14} \times 100$$

= 107 kg of 14-14-14 to provide 30 kg N, 30 kg, P, and 30 kg K for a 0.5-ha field.

Step 2. Calculate the amount of material needed to provide the remaining amount of N.

Since 14-14-14 already provided 30 kg N, secure a fertilizer source that contains nitrogen only. The recommended amount of N is 60 kg/ha. So, with 60 kg minus 30 kg from 14-14-14, we need 30 kg more of N.

Remaining N: use urea (46-0-0 kg N) as a source of N

$$\text{Amount of fertilizer N} = \frac{30 \times 0.5}{46} \times 100$$

= 32 kg of urea is needed to supply the remaining 30 kg N.

Note: When using fertilizers containing more than one element (i.e., 14-14-14, 15-15-15, 16-20-0, and 18-46-0), calculate first the smallest amount (percentage) of element in the fertilizer material and then calculate the remaining amount for the element with the highest amount.

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9

Disease and Pest Management

Casiana M. Vera Cruz and Isabelita P. Oña

Module objective:

To illustrate the different diseases commonly observed in upland rice production areas, and diseases that are rarely observed depending on environmental conditions.

What is a diseased plant?

Disease is an abnormal condition or interruption of the normal structure or function of the plant organ or system, as manifested by a characteristic set of symptoms and signs.

The microorganisms that cause diseases on plants are known as **plant pathogens**. Plant pathogens include many species of bacteria, fungi, nematodes, viruses, and mycoplasma-like organisms. Signs are structures of the pathogens observed to be present in the diseased part of the plants.

Disease occurs when plants are susceptible: presence of a high population of the virulent pathogen, and a favorable environment for plant and pathogen interaction.

Diseases are readily recognized by their symptoms—associated visible changes from the normal functions of the plant—at certain growth stages of the plant. Symptoms can be observed on the leaves, tillers, and/or panicles of rice plants. Disease symptoms are browning, drying, leaf spots, and blighting. Affected panicles can be discolored, empty, and deformed.

LESSON 1: COMMON DISEASES OF RICE

OBJECTIVE

To be able to identify and manage the common diseases of rice in upland and rainfed ecosystems

In this section, you will learn about the characteristic symptoms of different rice diseases and the strategies to manage them. Some of these diseases can be transmitted through contaminated seeds. You need to be able to recognize these diseases in your field. When a disease is present, you can rogue or discard the infected plants if the disease is too severe.

Common diseases of rice

Fungal origin

- Blast
- Brown spot
- Sheath blight
- Sheath rot
- Leaf scald
- False smut

Bacterial origin

- Bacterial blight
- Bacterial leaf streak
- Bacterial sheath brown rot

BLAST

What causes rice blast?
Pathogen:
Pyricularia grisea (Cooke) Saccardo (anamorph)
P. oryzae Cavara (anamorph)
Magnaporthe grisea (T.T. Hebert) Yaegashi & Udagawa (teleomorph)
Magnaporthe oryzae B. Couch

The disease is air-borne through fungal conidia that may be hosted by other grasses. Infected seeds and infected plant debris may also cause secondary spread of the disease. After spore germination, infection pegs are formed that later penetrate through the cuticle and epidermis of the plant. Blast lesions could be produced on all aboveground parts of a rice plant at different growth stages (Photo 1). During severe cases of infection, the crop produces a blasted or burned appearance; hence, the name "blast."

What are the symptoms of blast?

a. Leaf spot: gray at the center with a dark border, and diamond-shaped. Lesions usually start as pin-prick spots and look similar to brown-spot lesions. Several spots may coalesce to form big irregular patches.
b. Collar blast: reddish brown to brown collar lesions that kill the entire attached leaf.
c. Node blast: the node turns dark brown to black and breaks easily.
d. Neck blast: lesions appear as a brown girdle around the node of the panicles, causing the panicles to fall over. Unlike with stem borer injury ("whiteheads") where the entire stem can be pulled out readily, with neck blast, the stem is not pulled out easily.

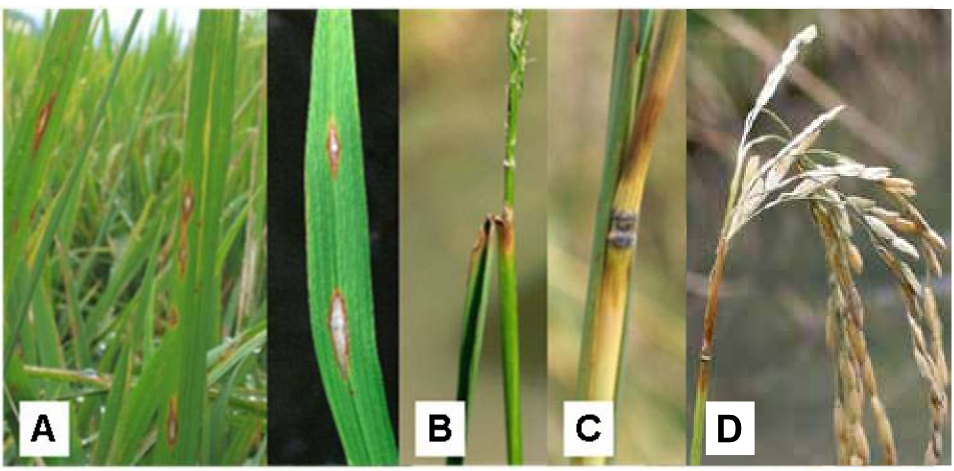


Photo 1. (A) Leaf blast, (B) collar blast, (C) node blast, and (D) neck blast under field conditions.

What factors favor blast development?

- Cool temperature at night (17–23 °C)
- High relative humidity (>90%)
- Frequent and prolonged dew periods (>10 hours)
- Long duration of leaf wetness
- Intermittent rain showers and overcast skies
- Aerobic soil (upland and rainfed environments)
- High nitrogen fertilizer
- Presence of collateral host: other grass/weeds

How do you manage rice blast?

- Host resistance: use resistant and moderately resistant varieties (quantitative trait loci or QTLs), deploying resistance genes in mixed plant populations.
- Use split application of nitrogen fertilizer.
- Use proper irrigation.
- Use healthy seeds.
- Remove weed host.
- Use fungicides when necessary.

BROWN SPOT

What causes brown spot?
Pathogen:
Bipolaris oryzae (Breda de Haan) Shoemaker (anamorph)
Drechslera oryzae (Breda de Haan) Subramanian & P. C. Jain (synonym)
Helminthosporium oryzae Breda de Haan (synonym)
Cochliobolus miyabeanus (Ito & Kuribayashi) Drechsler ex Dastur (teleomorph)

This disease is seed-borne and can be manifested as seedling blight or foliar and glume disease of mature plants. It can occur at all crop development stages. The pathogen infects the coleoptile, leaves, leaf sheath, panicle branches, glumes, spikelets, and even the roots. Infection starts at the formation of appressoria. followed by the hyphae attacking the middle lamella and penetrating the cells. The middle lamella starts to separate and causes the formation of yellowish granules.

In some cases, spores germinate by germ tubes where an appressorium is formed. The fungus directly penetrates the epidermis by the infection peg formed under the appressorium. The germ tubes also penetrate the leaf through the stomata without producing any appressorium.

What are the symptoms of brown spot?

- Seedling blight: small, circular, yellow-brown or brown lesions that may girdle the coleoptile and distort primary and secondary leaves.
- Leaf spot at tillering to mature stage: small and circular foliar lesions that are initially dark brown to purple-brown. Lesions are circular to oval with a light brown to gray center and reddish brown margin (Photo 2). Lesions are often surrounded by a brown or yellow-brown halo, which is the toxin produced by the pathogen.
- Lesions on leaf sheaths are similar to those on the leaves.
- Infected glumes and panicle branches have dark brown to black oval spots or discoloration on the entire surface.

- Spikelets can also be infected and could lead to incomplete or disrupted grain filling and a reduction in grain quality.
- Spotting and discoloration of grains: “pecky rice” (Photo 2).
- Black discoloration of roots.

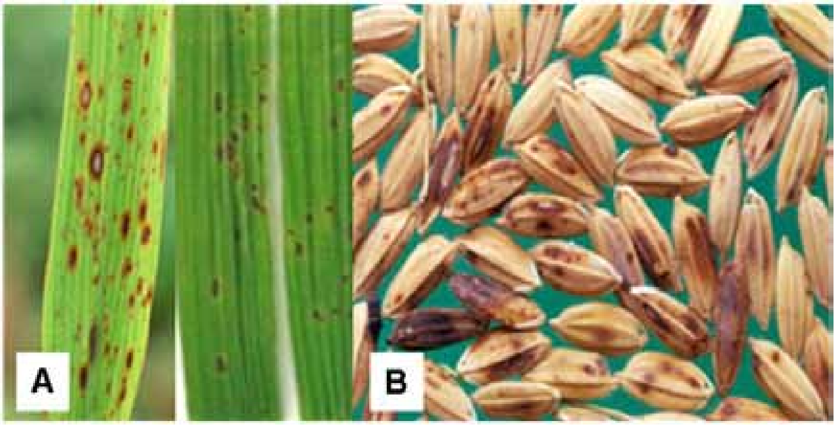


Photo 2. (A) Brown-spot lesions on leaves, and (B) discoloration and spotting of grains.

What factors favor brown spot development?

- Temperature range of 16–36 °C (optimum temperature under which fungal conidia germinate is 25–30 °C)
- ≥86% relative humidity
- Nutrient-deficient and poorly drained soil (low in potassium, magnesium, silica, iron, and calcium)
- Water stress
- Presence of alternate hosts: rice straw, stubbles, weeds

How do you manage brown spot?

- Use varieties with partial resistance and QTLs.
- Improve soil fertility.
- Use proper irrigation.
- Use healthy seeds.
- Do hot-water treatment of seeds (53–54 ºC for 10–12 min).
- Use fungicide as foliar spray.

SHEATH BLIGHT

What causes sheath blight?
Pathogen:
Rhizoctonia solani Kuhn (anamorph)
Thanatephorus cucumeris (Frank) Donk (teleomorph)

The fungal sclerotia germinate and penetrate through the cuticle or the stomatal slit of the plant. The mycelium grows from the outer surface of the sheath going through the sheath edge and finally through the inner surface. Primary lesions are formed while the mycelium grows rapidly on the surface and inside of the plant tissue. Secondary lesions are eventually formed. The disease is usually observed from tillering to milk stage in a rice crop.

What are the symptoms of sheath blight?

- Oval or irregular-shaped, greenish gray lesions, usually 1–3 cm long, on the leaf sheath, initially just above the soil or water level. Under favorable conditions, these initial lesions multiply and expand to the upper part of the sheaths, and the leaves, and then spread to neighboring tillers belonging to different hills (transplanted rice) or plants (direct-seeded rice) (Photo 3).
- Lesions on the leaves are usually irregular in shape, often with gray-white centers and brown margins.
- Infected leaves senesce and die more rapidly. Young tillers can also be destroyed.

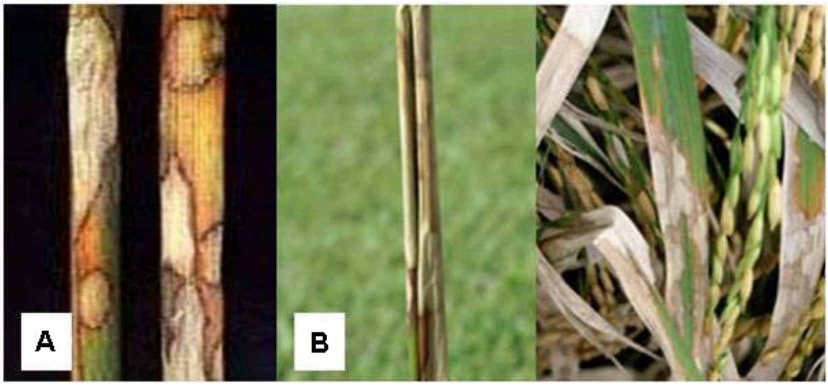


Photo 3. Sheath blight lesions on (A) rice tillers and (B) on leaves.

What factors favor sheath blight development?

- Temperature of 28–32 °C
- High relative humidity (≥85%)
- Long duration of leaf wetness
- High nitrogen fertilizer
- High seeding rate or close plant spacing
- Dense canopy
- Presence of weeds as alternate host plants

How do you manage sheath blight?

- Use varieties with erect plant morphology.
- Use proper nitrogen fertilization.
- Avoid dense planting.
- Control weeds in the paddy and on bunds.
- Use fungicides when necessary.

SHEATH ROT

What causes sheath rot?
Pathogen:
Sarocladium oryzae (Sawada) W. Gams & D. Hawksworth
Acrocylindrium oryzae Sawada (synonym)

The disease usually starts at the booting stage when brown lesions become visible in the upper part of the rice tiller where panicles are about to emerge. The disease is most often associated with the presence of stem borers and other forms of injury such as viral diseases or insect damage to the flag-leaf sheath. In some cases, the fungus infects the sheath in combination with bacterial pathogens that attack the sheath and cause grain discoloration (e.g., *Pseudomonas fuscovaginae*).

What are the symptoms of sheath rot?

- Rotting occurs on the leaf sheath that encloses the young panicles.
- The lesions start as oblong or somewhat irregular spots, 0.5–1.5 cm long, with gray to light brown centers surrounded by distinct dark reddish brown margins.
- As the disease progresses, the lesions enlarge and coalesce and may cover most of the leaf sheath.
- Lesions may also consist of diffuse reddish brown discolorations in the sheath (Photo 4).
- A powdery white growth consisting of spores and hyphae of the pathogen is usually observed on the inside of affected leaves.
- With early or severe infection, the panicle may fail to emerge completely or not at all; the young panicles remain within the sheath or only partially emerge.
- Panicles that have not emerged tend to rot and florets turn red-brown to dark brown. Most grains are sterile, shriveled, partially filled or unfilled, and discolored (Photo 4).

Photo 4. (A) Sheath rot–infected plants in the field, (B) brown discoloration of the sheath, and (C) unfilled grains due to rotting of the sheath.

What factors favor sheath rot development?

- Cool temperature (20–28 °C)
- High humidity
- Dew
- Low nitrogen
- Damage to the sheath that may be due to insects and/or infection by other pathogens
- Dense planting

How do you manage sheath rot?

- Use resistant varieties.
- Control the presence of insects and other pathogens.
- Use fungicide when necessary.

LEAF SCALD

What causes leaf scald?

Pathogen:

Microdochium oryzae (Hashioka & Yokogi) Samuels & I.C.
Gerlachia oryzae (Hashioka & Yokogi) W. Gams (synonym)
Rynchosporium oryzae Hashioka & Yokogi (synonym)
Monographella albescens (Thumen) Parkinson, Silvanesan & Booth (teleomorph)
Metasphaeria albescens Thumen (synonym)

The fungal spores, conidia, germinate and produce appressorium-like structures upon contact with stomata. The fungus enters through the stomatal slits, causing swelling of the stomata cavities. Days after, short-branched conidiophores grow out from the stomata and produce spore masses.

What are the symptoms of leaf scald?

- Zonate lesions starting from the leaf tips or edges, oblong with light brown halo. Zonation of lesions fades as lesions become old and affected areas dry out, giving the leaf a scalded appearance (Photo 5).
- Blighting of the leaf blade due to continuous enlargement and coalescence of lesions. Small reddish brown spots on the leaves and patches of brown lesions on the leaves.

Photo 5. Symptoms of leaf scald in the field—zonate lesions on mature leaves, which eventually cause drying of leaves.

What factors favor leaf scald development?

- Wet weather conditions
- High nitrogen
- Close plant spacing
- Early planting
- Weeds as alternate host
- Mechanical damage (wounds) to leaves

How do you manage leaf scald?

- Use resistant varieties.
- Apply nitrogen fertilizer only as needed.
- Optimize plant spacing.
- Use clean seeds as the disease is seed-transmitted.
- Chemical control: Treat infection with edifenphos or validamycin. Use benomyl as foliar spray when necessary.

FALSE SMUT

What causes false smut?
Pathogen:
Ustilaginoidea virens (Cooke) Takah (anamorph)
Claviceps oryzae-sativae Hashioka (teleomorph)

In one type of infection, which occurs at flowering stage, the ovary is destroyed but the style, stigmas, and anther lobes remain intact but are buried in the spore mass. The second infection occurs when the grain is already mature. The spores accumulate in the glumes, and absorb moisture, swell, and force the lemma and palea to open. The fungus contacts the endosperm and grows, replacing the whole grain with a mass of spores.

Unlike false smut, true smut (*Neovossia horrida* (Takah.) Padwick and A. Khan) may replace all or part of a kernel with a mass of black spores.

What are the symptoms of false smut?

- Smut balls are formed on spikelets, causing unfilled panicles; floret, seeds, and roots can also be infected.
- Velvety smut balls (clusters of sporangia—structures containing the fungal spores) are initially orange and then turn green to greenish black with age (Photo 6).

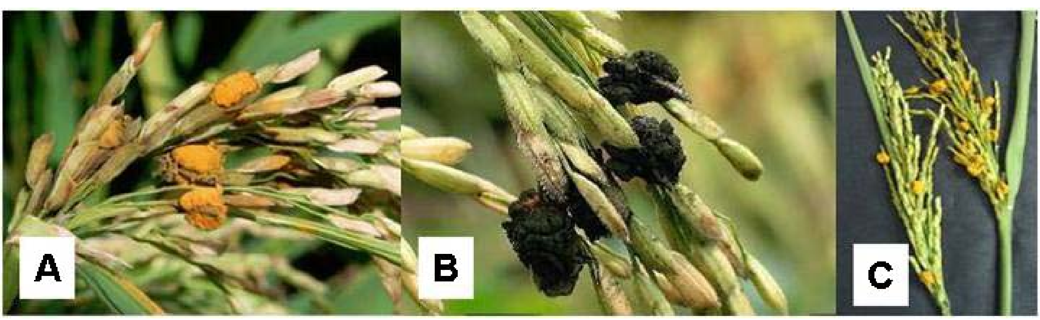


Photo 6. Smut balls on panicles in the field: (A) young spores and (B) mature spores on panicles. (C) Hybrid rice heavily infected with false smut.

What factors favor false smut development?

- High relative humidity (>90%) and low temperature (25 ºC)
- High nitrogen fertilization
- Moderate rainfall with intermittent clear and drizzling weather at flowering stage
- Weeds as alternate hosts

How do you manage false smut?

- Keep the field clean.
- Use healthy seeds.
- Use resistant varieties.
- Use the correct amount of N.
- Use hot-water treatment of seeds at 52 °C for 10 min.
- Remove and destroy diseased panicles in the field.
- Use seed treatment with carbendazim at 2 g/kg of seeds.
- Treat fields with propiconazole fungicide during the booting stage of rice.

BACTERIAL BLIGHT

What causes bacterial blight?
Pathogen:
Xanthomonas oryzae pv. oryzae (Ishiyama) Swings et al.

This disease is observed on both seedlings and older plants. The pathogen enters the leaf tissues through natural openings (water pores on hydathodes or stomata on the leaf blade, growth cracks, and leaf or root wounds). Once the bacterium enters, it multiplies in the epitheme, into which the vessel opens. When bacterial multiplication is sufficient, some bacteria invade the vascular system and some ooze out from the water pore.

What are the symptoms of bacterial blight (BB)?

- On seedlings, infected leaves turn grayish green and roll up. As disease progresses, leaves turn yellow to straw-colored and wilt ("kresek" symptom).
- On older plants, lesions usually develop as water-soaked to yellow-orange stripes on leaf blades or leaf tips or on mechanically injured parts of leaves (Photo 7).
- Lesions have a wavy margin and progress toward the leaf base.
- On young lesions, bacterial ooze resembling a milky dew drop can be observed early in the morning.
- Old lesions turn yellow to grayish white with black dots because of the growth of various saprophytic fungi.
- On severely infected leaves, lesions may extend to the leaf sheath.
- Panicles are sterile and unfilled but not stunted under severe conditions.

Photo 7. (A) Young lesions on the rice leaf; (B, C) field with severe bacterial blight infection.

How do you quickly diagnose BB in the field?

Cut across a young lesion and place it in a transparent glass container with clear water. After a few minutes, hold the container against the light and look for a turbid liquid exuding from the cut end of the leaf. The turbid exudates consist of infectious bacteria emitted from the cut end of the infected leaf.

To distinguish kresek symptoms from stem borer damage, squeeze between fingers the lower end of the infected seedling. Yellowish bacterial ooze coming out of the cut ends is typical of kresek symptoms.

What factors favor BB development?
- Warm temperature (25–30 °C)
- High humidity
- Strong winds and continuous heavy rains
- High nitrogen fertilization
- Flooded fields
- Presence of alternate hosts such as weeds, infected stubbles, and ratoons
- Presence of the bacteria in rice paddy and irrigation canal

How do you manage BB?
- Use resistant varieties.
- Use balanced amounts of plant nutrients, especially nitrogen.
- Ensure good drainage of fields (in conventionally flooded crops) and nurseries.
- Keep fields clean—remove weed hosts and plow under rice stubble, straw, ratoon crops, and volunteer seedlings.
- Fallow fields to dry them.
- Treat seeds with bleaching powder (100 μg/mL) and zinc sulfate (2%).

BACTERIAL LEAF STREAK

What causes bacterial leaf streak?
Pathogen:
Xanthomonas oryzae pv. *oryzicola* (Fang et al.) Swings et al.

The bacterium penetrates the leaf through natural openings (stomata and hydathodes), leaf injuries, or artificial wounds. After entry, the bacterium multiplies in the substomatal cavity and progresses intercellularly in the parenchyma. Soon after lesions develop, bacterial exudates form on the surface of the lesions under moist conditions during the night. Under dry conditions, these exudates become small yellow beads that eventually fall into the irrigation water. When the leaves are wet from dew or rain, with the aid of wind, the bacteria are carried from field to field by irrigation water.

What are the symptoms of bacterial leaf streak?
- Narrow, dark green, and water-soaked interveinal streaks, usually from tillering to booting.
- As the disease progresses, the streaks turn yellowish gray and, unlike with bacterial leaf blight, become translucent, with numerous milky to yellow beads of bacterial exudates formed on the surface of the lesions (Photo 8).
- When the disease becomes severe, lesions enlarge and coalesce, eventually turning brown to grayish white and drying up.

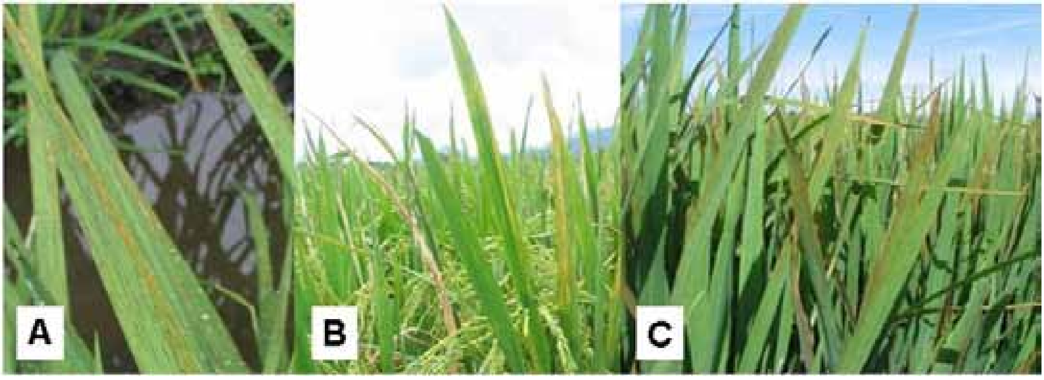


Photo 8. Symptoms of bacterial leaf streak in the field: (A) typical orange-brown and water-soaked streaks on rice leaf; (B) streaks are translucent when viewed against the light; and (C) a field with severe bacterial leaf streak infection.

What factors favor bacterial leaf streak development?

- High temperature (28–30 ºC)
- High humidity
- Rainy weather

How do you manage bacterial leaf streak?

- Use resistant varieties.
- Use balanced fertilization.
- Reduce seedling damage, particularly during transplanting.
- Maintain shallow water in seedbeds.
- Provide good drainage during flooding.
- Keep fields clean. Destroy ratoons, straws, and volunteer seedlings left after harvest.
- Dry the fields.
- Treat seeds with hot water.

BACTERIAL SHEATH BROWN ROT

What causes bacterial sheath brown rot?

Pathogen:

Pseudomonas fuscovaginae Tanii, Miyajima, & Akita

This disease is manifested as sheath and grain rot of mature plants as well as seedling rot. The pathogen exists as epiphytes and epiphytic populations of *P. fuscovaginae* peak at the booting stage.

What are the symptoms of sheath brown rot?

- On seedlings, systemic discoloration of the sheath extending toward the midrib or veins of the leaves is observed.
- On mature plants, symptoms are observed on the flag-leaf sheath from booting to heading stage and on the panicles (Photo 9).
- Oblong to irregular dark green, water-soaked lesions surrounded by a dark brown margin on the sheath.
- With severe infection, the entire leaf sheath may become necrotic and dry out, and the panicle withers.
- Grains of infected panicles are discolored, deformed, or empty.

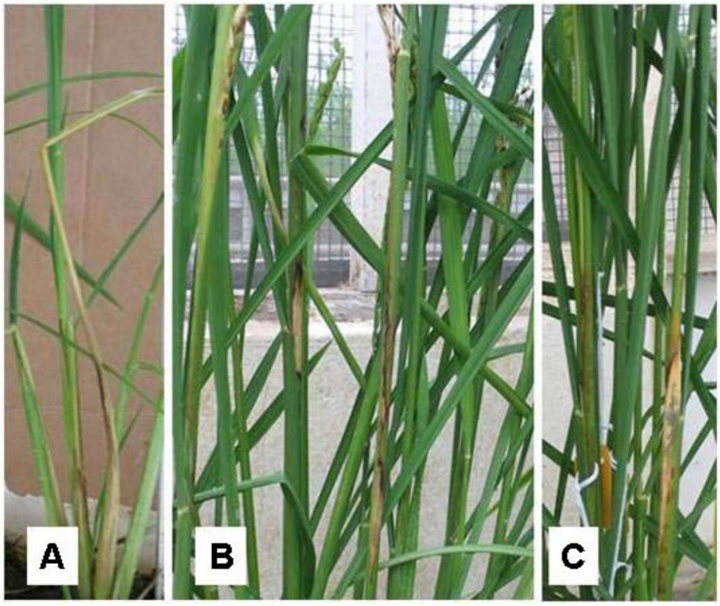


Photo 9. Sheath brown rot at (A) seedling stage and (B and C) booting stage.

What factors favor sheath brown rot development?

- Cool daytime temperatures (17–23 °C)
- High humidity
- Frequent rains
- High altitude

How do you manage sheath brown rot?

- Use healthy seeds.
- Use dry heat treatment (65 °C) of seeds.

LESSON 2: INSECT PESTS OF RICE

OBJECTIVE

To identify and manage the common insect pests of rice in the uplands

In this section, you will learn about the different insect pests of rice and the strategies to manage them. Some of these insects are transmitted through contaminated seed. You need to be able to recognize these insects in your field.

Common insect pests of rice

ARMYWORM

Other common names:

At least three species attack rice in Asia:

- Rice swarming caterpillar (*Spodoptera mauritia* (Boisduval))
- Common cutworm (*Spodoptera litura* (F.))
- Rice ear-cutting caterpillar (*Mythimna separata* (Walker))

Armyworms are caterpillars that attack rice. The caterpillars feed on rice leaves and can also cut off young seedlings at the plant or panicle base. They feed in the upper portion of the rice canopy on cloudy days or at night. A single armyworm egg mass contains hundreds of eggs. Each female lays 800–1,000 eggs during its lifetime of about 1 week.

What are the symptoms of armyworm infestation?

- Fed-upon leaf tips or along leaf margins
- Fed-upon whole leaves, leaving only midribs
- Removal of whole leaves and plants
- Cut on stem or plant base (Photo 10)
- Cutting off rice panicles from base (Photo 10)

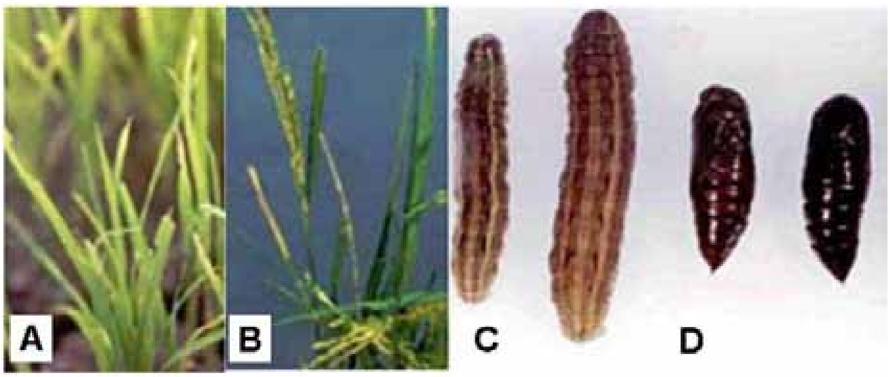


Photo 10. (A) Leaf blades and (B) panicles cut off by armyworm. (C) Larvae and (D) pupae of armyworm.

What factors favor armyworm infestation?

- Presence of many alternate hosts
- Periods of drought followed by heavy rains
- Dryland and wetland fields

How do you manage armyworm?

- Flooding reduces the caterpillar population as they cannot survive under water.
- Establish seedbeds far from large areas of weeds.
- Remove weeds outside and inside the field, and plow fallow land.
- Avoid killing natural enemies (e.g., wasps and spiders) of armyworms.
- Do not use any insecticide.
- Digging pits or trenches covered with leaves gives caterpillars a place to take shelter from the sunlight. The larvae can be easily collected from the pits.
- Ash-filled trenches may also serve as a barrier to keep armyworms out of seedbeds during an outbreak. Placing branches around fields also gives the armyworms a place to congregate where they are easily collected by hand.
- Chemical control: Insecticides should be the last resort for armyworm control. The choice of insecticide depends on factors such as the application equipment available, cost of the insecticide, the presence of fish, or a need to preserve natural enemies. Indiscriminate insecticide use can disrupt existing biological control, resulting in pest resurgence or outbreaks. Before using a pesticide, contact a crop protection specialist for suggestions, guidance, and warnings specific to your situation.

LEAFFOLDER

Other common names:

Rice leaf roller

Grass leaf roller

The adult rice leaffolder (*Cnaphalocrocis medinalis*) is a yellow-brown moth. Each female lays about 300 eggs at night during its lifetime of 3–10 days. The larva forms a protective feeding chamber by folding a leaf blade together and glues it with silk strands and feeds on leaf tissues. Longitudinal white and transparent streaks on leaf blades are created. Leaffolder caterpillars roll the rice leaf to enclose themselves and attach the leaf margins together with silk strands. While inside the folded leaf, the caterpillar feeds by scraping off the leaf surface tissue. Each female lays about 300 eggs at night during its lifetime of 3–10 days.

What are the symptoms of leaffolder infestation?

- Longitudinal and transparent whitish streaks on damaged leaves
- Tubular folded leaves (Photo 11)
- Leaf tips sometimes fastened to the basal part of the leaf
- Heavily infested fields appear scorched with many folded leaves

What factors favor rice leaffolder infestation?

- Heavily fertilized fields
- High humidity and shady areas
- Presence of grassy weeds from rice fields and surrounding borders
- Expanded rice areas with irrigation systems and multiple rice cropping

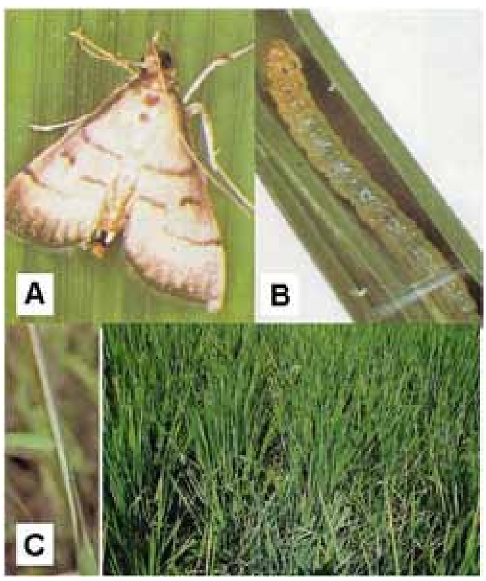


Photo 11. (A) Adult leaffolder and (B) caterpillar on rice leaf. (C) Rolled leaves caused by leaffolder under field conditions.

How do you manage rice leaffolder?

- Sometimes dead larvae turning black and hanging from leaves are found. These caterpillars are infected with a virus. Such dead caterpillars can be collected, crushed in a small amount of water, and sprayed on the crop to spread the virus to other caterpillars.

- Rotate rice with a different crop or have a fallow period.
- Avoid ratooning.
- Flood and plow the field after harvesting if possible.
- Remove grassy weeds from fields and borders.
- Reduce planting density.
- Use balanced fertilizer rates.
- Carefully break the silk strands that hold the edges of folded leaves and remove the caterpillars inside. Do not drop live caterpillars into the paddy water; they may find their way back onto rice plants.
- Caterpillars can be fed to chickens or ducks, or made into compost. Dry and crush the caterpillars to make fish food.
- Biological control: Parasitic wasps, predatory beetles, spiders, and predatory crickets (*Anaxipha* sp.) can attack leaffolders.

STEM BORER

Other common names:

Yellow stem borer (*Scirpophaga incertulas* (Walker))
White stem borer (*Scirpophaga innotata* (Walker))
Striped stem borer (*Chilo suppressalis* (Walker))
Dark-headed stem borer (*Chilo polychysus* (Meyrick))
Pink stem borer (*Sesamia inferens* (Walker))

Stem borers are caterpillars that live in rice stems and cause damage to rice plants from seedling to maturity. They eventually turn into yellow or brown moths; usually one larva occurs per tiller. Moths are active at night. A female can lay up to three egg masses during her 7–10-day life as an adult. Egg masses of yellow stem borers are disc-shaped and covered by a light brown mat of hair from the female abdomen. Each egg mass contains about 100 eggs. Photo 12 shows the different stem borers infesting rice.

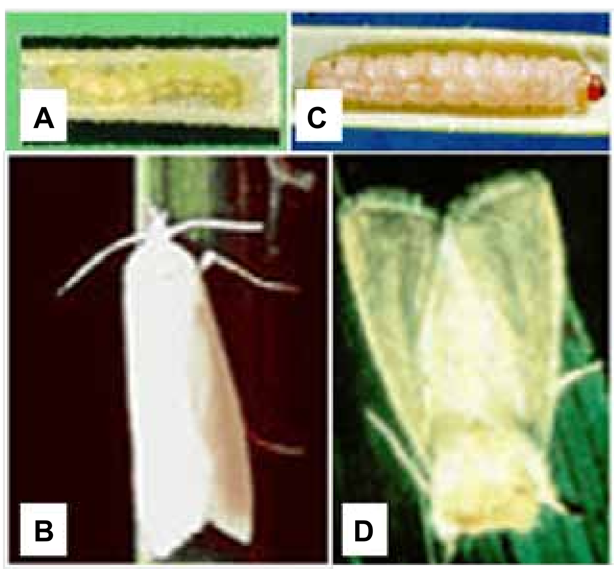


Photo 12. (A) White stem borer larvae and (B) adult. (C) Pink stem borer larvae and (D) adult.

What are the symptoms of stem borer infestation?

- At the young stage, the center leaves of the damaged tillers turn brown and die. This condition is called deadheart (Photo 13).
- If the damage occurs after the spikelets are formed, then the panicles turn white—a condition known as whitehead. Although damage often looks very bad, control is often not economical.

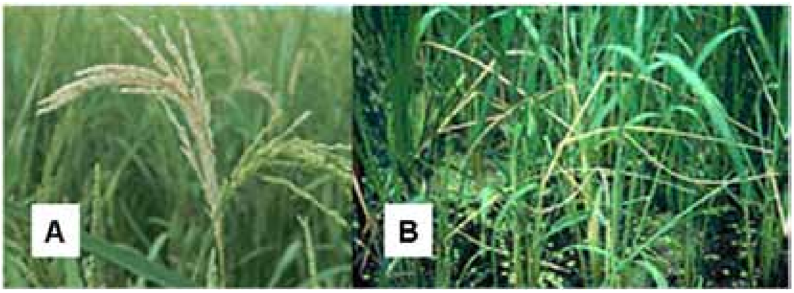


Photo 13. (A) Whitehead or dead panicle at reproductive stage and (B) drying of center tiller or "deadheart" at early vegetative stage.

What factors favor stem borer infestation?

- Ratoon crop and stubble

How do you manage stem borer?

- To conserve natural enemies, do not apply broad-spectrum insecticides (e.g., methyl parathion).
- Clip the leaf tip of seedlings before transplanting, which reduces the transfer of eggs from the seedbed to the field.
- Use stem borer–resistant varieties: IR36, IR32, IR66, and IR77 have varying degrees of resistance to some stem borer species.
- Use synchronous planting.
- Spread straw in the sun to kill resident stem borer larvae.
- Skim stem borer larvae on floating leaves off of the water with a net.
- Plow and flood the field after harvest.
- Chemical control is generally not recommended as stem borers are quite difficult to control with insecticides.

RICE BUG

Other common name: Rice seed bug

The genus *Leptocorisa* has several species of rice bugs. The most common species are

- *Leptocorisa oratorius* (F.)
- *Leptocorisa acuta* (Thunberg)

Both adults and nymphs insert their needle-like mouthparts between the lemma and palea of the rice hull to suck the endosperm of rice grain (Photo 14). In order to feed, they secrete a liquid to form a stylet sheath that hardens around the point of feeding and holds the mouthparts in place. An infested field can be recognized by the rice bugs' offensive odor. Adults are active in the late afternoon and early morning, resting in shaded areas. Each female lays hundreds of eggs during a lifetime of 2–5 months.

What are the symptoms of rice bug infestation?

- Small or shriveled grains
- Deformed or spotty grains (Photo 14)
- Empty grains
- Erect panicles

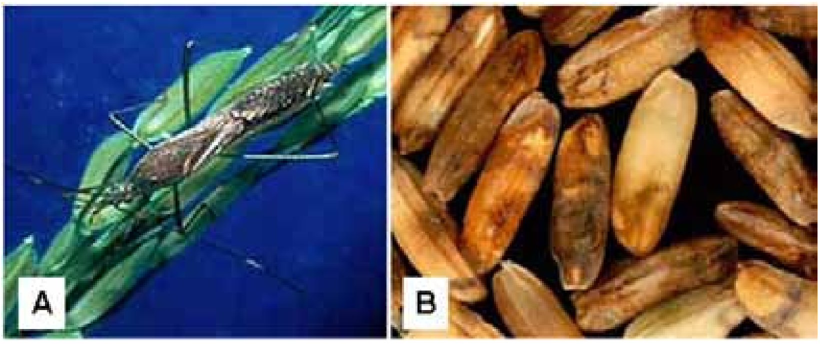


Photo 14. (A) Adult rice bug attacking the spikelets and (B) damaged grains caused by rice bug.

What factors favor rice bugs?

- Staggered rice planting
- Woodlands and extensive weedy areas near rice fields
- Wild grasses near canals
- Warm weather, overcast skies, and frequent drizzles
- Rainfed and wetland or upland rice
- Flowering to milky stages of the rice plant

How do you manage rice bugs?

- Field sanitation: Remove weeds from fields and surrounding areas to prevent the multiplication of rice bugs during fallow periods.
- Synchronous planting: Level fields with even applications of fertilizer and water to encourage rice to grow and develop at the same rate.
- Mechanical measures: When the population is low, capturing rice bugs, in the early morning or late afternoon, by a net can be effective, though labor-intensive.
- Biological control: Some wasps, grasshoppers, and spiders attack rice bugs or rice bug eggs. Indiscriminate insecticide use disrupts biological control, resulting in pest resurgence. Both the adults and nymphs are preys to spiders, coccinellid beetles, and dragonflies. A fungus infects both nymphs and adults.
- Chemical control: Begin scouting the field at preflowering and continue daily until the hard dough stage. Count rice bugs in the early morning or late afternoon from 20 hills while walking diagonally across a transplanted field. Direct control may be required if there are more than 10 rice bugs per 20 hills. The choice of insecticide depends on many factors such as the application equipment available, cost of the insecticide, experience of the applicator, or presence of fish. Before using a pesticide, contact a crop protection specialist for suggestions, guidance, and warnings specific to your situation.

GREEN LEAFHOPPERS (GLH)
Species:
Nephotettix virescens (Distant)
N. nigropictus (Stål)
N. malayanus (Ishihara et Kawase)
N. cincticeps (Uhler)

Green leafhoppers (GLH) have their effects primarily during seedling to panicle initiation stages of crop growth. Both nymphs and adults feed by extracting plant sap with their needle-shaped mouthparts.

GLH can transmit viruses and mycoplasma-like diseases of rice such as tungro and yellow dwarf. Only two species (*Nephotettix malayanus* and *N. virescens*) are important in the spread of tungro (Photo 15). If tungro is not a problem, then control may not be required as rice crops can often tolerate even high numbers of GLH.

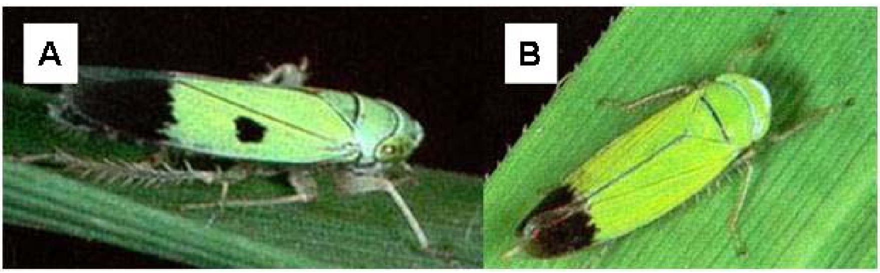


Photo 15. Two species of GLH are important in the spread of tungro: (A) *Nephotettix malayanus* and (B) *N. virescens.*

What are the symptoms of GLH infestation?
- Transmits virus diseases such as tungro, yellow dwarf, yellow-orange leaf, and transitory yellowing
- Plant is stunted and has reduced vigor
- The number of productive tillers is lower
- Withering or complete plant drying

What factors favor GLH infestation?
- Grasses near irrigation canals and levees
- Rice ratoons
- A lot of sunshine, low rainfall, and high temperature
- Rainfed and irrigated wetland environments
- Excessive use of nitrogen

How do you manage GLH?
- Use GLH-resistant and tungro-resistant varieties.
- Reducing the number of rice crops to two per year and synchronized crop establishment across farms reduce leafhoppers and other insect vectors.
- Transplanting older seedlings (>3 weeks) reduces viral disease susceptibility transmitted by leafhoppers.
- Early planting within a given planting period, particularly in the dry season, reduces the risk of insect-vector disease.

- Avoid planting during the peak of GLH activity (shown by historical records) to avoid infestation. Light traps can be used to show GLH numbers.
- Apply nitrogen as needed (based on the leaf color chart).
- Good weed control in the field and on bunds removes the preferred grassy hosts of GLH and promotes crop vigor.
- Crop rotation with a nonrice crop during the dry season decreases alternate hosts for diseases.
- Upland rice intercropped with soybean reduces the incidence of leafhoppers on rice compared with rice alone.
- Biological control: Various parasitoids attack GLH eggs, while predators and pathogens can also control GLH.
- Chemical control: In general, reducing pesticide use increases the populations of beneficiaries and helps keep GLH numbers low. Insecticide may be required if there are more than five GLH per hill, although, if tungro is present, even two GLH per hill can seriously damage a crop. The benefits of using an insecticide must be weighed against the risks to health and the environment.

BROWN PLANTHOPPER (BPH)
Nilaparvata lugens (Stål)

Planthoppers are tiny brown-gray insects (0.1–0.4 cm long) that cause hopperburn (Photo 16). Long-winged forms of BPH can disperse for hundreds of kilometers. Both the nymphs and adults of the brown planthopper insert their sucking mouthparts into the plant tissue to remove plant sap from phloem cells. During feeding, BPH secretes feeding sheaths into the plant tissue to form a feeding tube. The removal of plant sap and the blockage of vessels by the feeding tube sheaths cause the tillers to dry and turn brown, a condition called hopperburn. BPH can also transmit plant viruses, that is, rice ragged stunt virus (RRSV) and rice grassy stunt virus (RGSV).

Outbreaks result when pesticides destroy natural enemies (BPH eggs hatch unchecked, and surviving BPH quickly build up populations to damaging levels) or when long-winged planthoppers are carried in by the wind.

What are the symptoms of BPH infestation?
- Hopperburn or yellowing, browning and drying of plant (Photo 16)
- Ovipositional marks exposing the plant to fungal and bacterial infections
- Presence of honeydew and sooty molds in the bases of areas infected
- Diseased plant with ragged stunt or grassy stunt virus

What factors favor BPH infestation?
- Rainfed and irrigated wetland environments
- Continuous submerged conditions in the field
- Reproductive phase of the rice plant
- High shade and humidity
- Closed canopy of rice plants
- Densely seeded crops
- Excessive use of nitrogen
- Early-season insecticide spraying

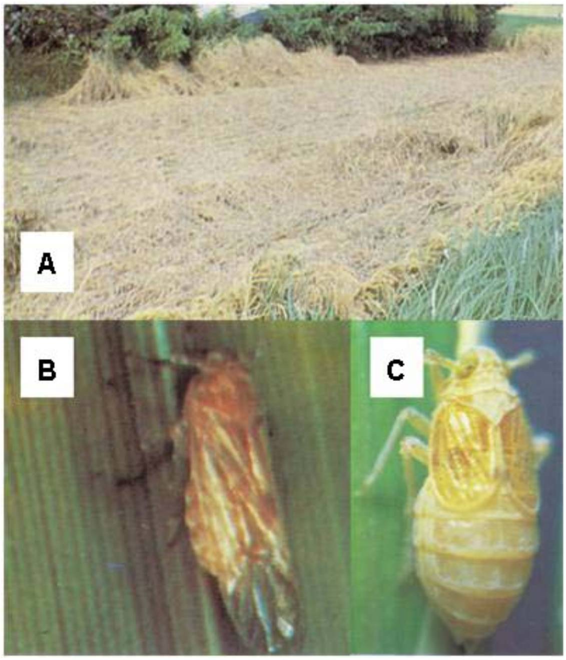


Photo 16. (A) Rice field damaged by hoppers causing hopperburn. (B) Long-winged adult of *N. lugens* lays eggs on the leaf sheath or midrib. (C) Short-winged adult of *N. lugens*, which is predominant before flowering stage.

How do you manage BPH?

- Remove weeds from the field and surrounding areas.
- Avoid indiscriminate insecticide use, which destroys natural enemies.
- Use a resistant variety.
- Critical numbers: At a density of 1 BPH/stem or less, there is still time to act in case the numbers increase.
- Look for BPH daily in the seedbed, or weekly in the field, on stems and the water surface. For older rice plants, grasp the plant, bend it over slightly, and gently tap it near the base to see if planthoppers fall onto the water surface. For transplanted rice, look at the bases of 10–20 hills as you cross the field diagonally. There is no need to scout for BPH or whitebacked planthopper (WBPH) beyond the milk stage.
- Use light traps (e.g., an electric bulb or kerosene lamp near a light-colored wall or over a pan of water) at night when rice is prone to planthopper attack. Do not place lights near seedbeds or fields. If farmers monitor on a daily basis, a light trap is unnecessary.
- Flood the seedbed, for a day, so that only the tips of seedlings are exposed.
- Sweep small seedbeds with a net to remove some BPH (but not eggs), particularly from dry seedbeds. At high BPH densities, sweeping will not remove sufficient numbers of BPH from the base of the plant.
- Biological control: Natural enemies of BPH include water striders, mirid bugs, spiders, and various egg parasitoids.
- Chemical control: Apply an insecticide to the seedbed for BPH only if all of these conditions are met:
    - An average of more than one planthopper per stem,
    - more planthoppers than natural enemies, and
    - flooding the seedbed is not an option.

EXERCISE

Materials:

- Plastic bags
- Insect nets
- Marking pens or labels

Activities:

A. Identification of diseases

1. Divide the participants into smaller groups.
2. Visit farmers' fields where diseases and insects are observed.
3. Collect any parts of the rice plants that are suspected to have diseases and place them in plastic bags. Place the plastic bags in a cool container.
4. In the laboratory, examine the diseased parts of the plant and describe the symptoms. Compare the symptoms with the pictures in this module.

B. Identification of insect pests

1. With the use of insect nets, sweep the net right and left at the canopy level of the rice plants.
2. After 10 sweeps along different directions in the field, roll the opening lightly to close the net.
3. Bring the net with the collected insects into the laboratory.
3. Carefully put the insects in alcohol for proper observation and identification.
4. Compare the freshly collected insects with the pictures of insect pests in this module.

References:

IRRI Rice Knowledge Bank
IRRI Fact Sheets
Field Problems of Tropical Rice

Module 10

Upland Rice Weeds and Their Management

Joel D. Janiya

Module objectives:

To learn weed management options in upland rice and be able to carry out effective weed control for quality seed production

Weeds are so common in rice fields and often it looks alright to have a few of them growing with your rice crop. However, when weeds become abundant and are left uncontrolled, they can substantially reduce rice yield and affect the quality of harvested grains.

Controlling weeds in a seed production plot is crucial because weeds have a negative impact on rice seed, resulting in a loss of yield and quality.

What is a weed?

Any plant that affects the beneficial use of the environment by humans falls under the category of a weed. A plant is a weed only because of human attitude. Thus, a weed is defined as

1. A plant out of place
2. A plant not sown whose undesirable features outweigh its desirable features
3. A plant or part of a plant interfering with the objectives of humans
4. A plant growing where it is not wanted

Effects of weeds

Weeds do the following:

- Reduce yield by competing with a crop for light, water, and nutrient
- Increase production costs because of the high cost of removing weeds
- Reduce crop quality by contaminating seed
- Serve as alternate hosts of pests: insects, diseases, nematodes, birds, and rodents

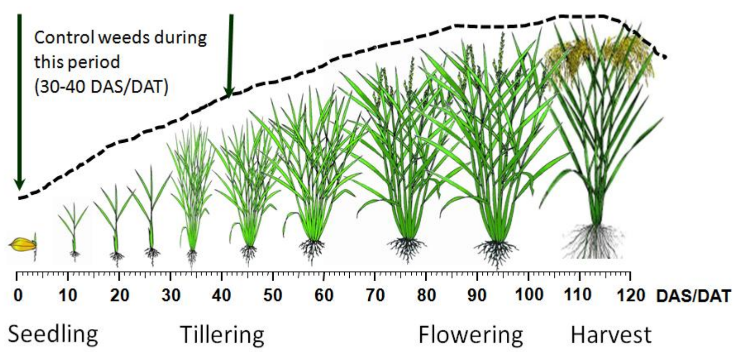
LESSON 1: GUIDING PRINCIPLES

OBJECTIVE

To learn the importance of the proper time for controlling weeds to reduce weed competition

When is weed competition greatest?

A seed production plot is normally weeded as many times as necessary to reduce the weed population. Weeds should be removed at the proper time to avoid yield losses due to weed competition. As a general principle, weeds should be controlled in the first 30% of the life cycle of the crop. The critical period falls in the first 30–40 days after seeding (DAS) of rice depending on the growth duration of the variety. Weeds that germinate after 40 days will not affect the yield of rice. When growing rice for seed production purposes, weeds growing after 40 days should be rogued of mixtures and inflorescence.



LESSON 2: CLASSIFICATION OF WEEDS

OBJECTIVE
To know the different types of weeds and their distinguishing characteristics

Weed identification is essential to weed management
Weeds are so diverse that they are difficult to place in one category. Weeds can be classified based on life span, habitat, and gross morphology. These classifications are important in choosing and designing weed control options as different types of weeds have different responses to environmental conditions and control methods.

Life span
- Annuals. Annual weeds complete their life cycle in 1 year or less. Most reproduce only by seeds. Some may produce adventitious roots on prostrate stems. If stems are cut or damaged, they may root and form new plants. Most common field weeds are annuals.
- Perennials. Perennial weeds are weeds that live more than 2 years. Perennials reproduce from seeds and vegetative parts of the plant, such as creeping roots, rhizomes, bulbs, tubers (below-ground root-like stems), or stolons (above-ground stems that produce roots).

Habitat
- Aquatic. Weeds that can emerge and grow in very wet or submerged soils.
- Semiaquatic. Dry-land plants that have some tolerance of submergence.
- Terrestrial. Plants that grow on dry land.

Types of weeds based on gross morphology
- **Grasses.** Grass seedlings have only one seed-leaf (monocotyledons). Their leaves are generally long and narrow with parallel veins. Leaves arise alternately from the nodes and have two parts: a lower portion called the sheath and an upper portion called the blade. The sheath is wrapped around the culm. At the junction of the blade and the sheath is usually a papery membrane called the ligule. Note that not all grasses have ligules. They have stems or culms that have nodes and internodes. Nodes are well-defined solid swellings at regular intervals on the stem, from which leaves arise. The internodes, portions of the culm between nodes, are usually hollow. Most grasses have fibrous root systems.
- **Sedges.** Their stems are usually solid and triangular. They have a three-ranked leaf arrangement. Each leaf arises one-third of the way around the stem from the one below. The basal portion of each leaf is fused to form a tube around the stem and there are no distinct sheath-blade divisions.
- **Broadleaf weeds.** This group can be distinguished from grasses and sedges by the presence of expanded leaf blades. Venation of the leaves may be parallel as in monocots or netted as in dicots.

Why do weeds persist?
- Crops and weeds have the same requirements for growth and development.
- Some agricultural practices create a favorable environment for their proliferation.
- They set seed before the crop ripens, in large quantities, and those seeds survive in the soil for a long period.
- They reproduce vegetatively.
- They mimic the crop.

LESSON 3: CONTROL METHODS

OBJECTIVES

1. To learn the different options for controlling weeds in rice
2. To learn the advantages and disadvantages of weed control methods

Preventive measures

Preventive measures are those taken to avoid the introduction or spread of specific weed species in an area. It is easier to check the entry of weeds rather than remove them when they are already established.

How can you avoid introducing weeds in an area?

- Use weed-free seeds.
- Employ proper management of farm implements and livestock.
- Keep bunds (levees) and irrigation canals free of weeds.
- Prevent seeding of weeds in the field and the spread of perennial weeds that reproduce vegetatively.

Manual methods

- Hand-weeding and the use of hand tools (examples are hoes and sickles)
- Advantages of manual weeding:
  - It is an effective method of removing weeds.
  - It is a practical and efficient method of removing weeds within rows or hills of rice where weeds cannot be controlled by other means.
- Disadvantages of manual weeding:
  - It is extremely tedious and time-consuming.
  - It is not practical to use on a large-scale area of rice.
- It is difficult to distinguish weed seedlings from rice seedlings at the early stage of growth and uprooting or damaging rice cannot be avoided. This occurs particularly when the weeds growing with rice are grasses.

Mechanical methods

For mechanical weed control, straight row planting is essential. An example of a tillage implement is the interrow cultivator (*lithao*).

Weed control by tillage is achieved by the following practices:

- **Burial.** Weeds are buried in the soil thrown over them by tillage tools. If the weeds' growing points are buried, most annual weeds are killed by this method of weed control.
- **Disturbance of roots.** Passing of the tillage implement loosens the soil or cuts the root system so weeds die of desiccation before they can reestablish.
- Advantages
  - Requires less time to weed rice than manual weeding.
  - Has a lower cost than manual weeding.
- Disadvantages
  - Inability to control weeds growing close to crop plants.
  - Cannot be used effectively when the soil is too dry or too wet.
  - Improper use of tillage implements can damage the rice.

Cultural methods

Cultural methods can be defined as the alteration of growing conditions aimed at suppressing weed populations indirectly by decreasing the competitive ability of weeds or directly by encouraging weed growth at a specified period during which time direct control methods can be used.

Cultural methods consist of the following:

- **Land preparation.** Suppression of weeds is done by deep plowing, increased tillage, more appropriate timing of land preparation, and the stale-seedbed technique.
- **Cultivar grown.** Cultivars with vigorous early vegetative growth tend to be more competitive against weeds than short, erect-leaf modern cultivars. This is because short-statured erect-leaf cultivars allow more light to penetrate through the canopy and, as a result, weed germination and growth are enhanced.
  - High-tillering rice cultivars tend to suppress weeds better than low-tillering cultivars.
  - Long-maturing cultivars tend to compete better with weeds than short-maturing cultivars.
- Plant density
  - Closer rice rows tend to suppress weeds better than widely spaced rows. Closer spacing, however, requires more seeds.
  - A high seed rate suppresses weeds better than a low seed rate. However, increasing the seed rate requires more seeds.
- Fertilizer application
  - Applying all nitrogen (N) basally favors weed growth and may cause greater weed competition.
  - Using a split application of N with only a small amount applied basally helps reduce weed competition.
  - A high rate of N increases weed competition and reduces yield.
  - The optimum rate of N should be applied as the crop can fully use it to reduce weed competition.

Herbicides

The use of herbicides for weed control is important in places where agricultural labor is scarce and wage rates are relatively high. An understanding of the different types of herbicides based on time of application, method of application, and biological effect is necessary for their efficient use.

Herbicide classification

- Time of application
  a. Preplant herbicide is applied before the crop is sown or transplanted. These can be
     - Preplant foliar—the herbicide is sprayed on the existing vegetation to kill weeds before planting (e.g., glyphosate).
     - Preplant soil incorporated—the herbicide is incorporated into the soil (not commonly used in rice).
  b. Preemergence—any herbicide application prior to emergence of the weeds. The herbicide is applied to the soil surface (e.g., butachlor, pretilachlor).
  c. Postemergence—any herbicide treatment made after emergence of weeds (e.g., cyhalofop butyl, propanil).

- Method of application
  a. Foliar-applied herbicides are sprayed directly on the foliage (leaves) (e.g., 2,4-D).
  b. Soil-applied herbicides are sprayed on the soil surface where germinating weed seeds are the primary targets.
- Biological effect
  a. According to mode of action
     - Contact herbicides are applied to the foliage and kill plant tissues at or very close to the site of contact (e.g., paraquat).
     - Translocated (systemic) herbicides move within the plant (e.g., bispyribac sodium).
  b. According to selectivity
     - Selective herbicides kill or stunt some plants with little or no injury to others (e.g., propanil, cyhalofop butyl).
     - Nonselective herbicides are toxic to all plants (e.g., glyphosate, paraquat).

A combination of different weed control methods over a long period of time can effectively manage weeds in rice fields.

LESSON 4: SELECTED MAJOR UPLAND RICE WEEDS AND THEIR MANAGEMENT

(Adapted from: Galinato MI, Moody K, Piggin CM. 1999.)

OBJECTIVE

To know the characteristics and control of weeds commonly occurring in upland rice

Rottboellia cochinchinensis (Lour.) W.D. Clayton
English common name: Itchgrass

- An annual grass with vigorous growth supported by stilt roots
- Height: 1–3 m
- Flowers year-round where moisture conditions are favorable
- A single plant produces about 2,200 seeds

Management of *R. cochinchinensis*

- Cultural
  - Regular cultivation every 2–5 weeks is effective in controlling *R. cochinchinensis* because most seeds exhibit little dormancy and germinate together at the start of the rainy season.
  - Careful prevention when seeding and machinery hygiene can practically eliminate the weed.
- Chemical
  - *R. cochinchinensis* can be controlled by preemergence application of pendimethalin (1.5–2.0 kg/ha) or
  - early postemergence (3–5-leaf stage) treatment of cyhalofop butyl (0.1–0.15 kg/ha), fenoxaprop-P-ethyl, propanil (2 kg/ha),
  - or a tank-mix application of pendimethalin and fluazifop-P-butyl (1.0 + 0.08 kg/ha).

Cyperus rotundus L.
English common name: Purple nutsedge

- Perennial weed
- Grows up to 50 cm high
- Sensitive to shading
- With wiry rhizomes, bearing black, hard, egg-shaped fibrous tubers about 1 cm in diameter, with tubers chained by thin rhizomes
- May produce up to 40 t of subterranean plant material per ha

Management of *C. rotundus*

- Cultural and mechanical
    - Controlled by narrow row spacing and high plant density of crops to provide rapid shading of the soil surface.
    - Planting permanent pastures usually suppresses infestations until the field is again tilled.
    - Repeated soil disturbance early in the season is effective because tubers in the upper soil layers are vulnerable to desiccation.
    - Tillage is always most effective when soil is dry.
- Chemical
    - Tuber population can be reduced by repeated application of 2,4-D and cultivation.
    - Almost complete control can be achieved using herbicide combinations such as preplant application of 2 kg of glyphosate, followed by 2,4-D at 1 kg/ha at 20 d after sowing.

Eleusine indica (L.) Gaertn.
English common name: Goose grass

- Densely tufted annual or perennial plant, 10–70 cm high
- Culms strongly compressed, usually erect, somewhat slender
- A prolific seed producer. The number of seeds per plant averages around 4,000 but ranges from 80 to 12,000, with the highest number reported to be 137,000.

Management of *E. indica*

- Cultural
    - Young plants have a shallow root system and can easily be controlled by hoeing and hand cultivation. When established, this weed develops a strong root system and uprooting becomes difficult.
- Chemical
    - *E. indica* can be controlled by preemergence application of oxadiazon (0.75–1.0 kg/ha) or pendimethalin (1.5–2.0 kg/ha) or butachlor (2 kg/ha), or early postemergence (3–5-leaf stage or 15–25 d after emergence) application of cyhalofop butyl (0.1–0.15 kg/ha), fenoxaprop-P-ethyl (0.06 kg/ha), fluazifop-P-butyl (0.1–0.6 kg/ha), or propanil (2 kg/ha). Beyond the 5-leaf stage, higher rates of cyhalofop butyl are recommended.

Echinochloa colona (L.) Link
English common name: Jungle rice

- An erect or trailing annual
- Culms usually 10–100 cm in length in large tufts, rooting at the lower nodes
- Adapted to full sunlight or partial shade
- One plant can produce 3,000–6,000 seeds

Management of *E. colona*

- Cultural
  - Cultivation during early growth can control the weed.
  - It is readily controlled by hand and hoe.

- Chemical
  - Can be controlled by preemergence application of oxadiazon (0.75–1.0 kg/ha) or pendimethalin (1.5–2.0 kg/ha) or butachlor (2 kg/ha)
  - or postemergence (3–5-leaf stage or 15–25 d after emergence) application of cyhalofop butyl (0.1–0.15 kg/ha), fenoxaprop-P-ethyl (55 g/ha), or fluazifop-P-butyl (0.1–0.6 kg/ha).

Ageratum conyzoides L.

Common English name: Tropic ageratum

- A short-lived annual weed
- An erect, branched, somewhat odorous annual herb up to 60 cm high with rigid and stiff hairs on stem
- Flowers are numerous, white, violet, or very pale blue, clustered in heads, stalks of which are longer in the lower flowers, thereby forming a more or less flat-topped inflorescence at the top of the stem
- Can produce up to 40,000 seeds per plant

Management of *A. conyzoides*

- Cultural
  - Can be readily controlled when young by hand pulling or hoeing
- Chemical
  - Application of 2,4-D at 0.5–0.8 kg/ha or MCPA at 0.4 kg/ha within 20–30 d after emergence gives good control.
  - Butachlor and oxadiazon at planting are also effective in controlling this weed.

Dactyloctenium aegyptium (L.) Wild.

English common name: Crowfoot grass

- A spreading to slightly ascending annual or sometimes perennial grass, stoloniferous below, and rooting at the nodes
- Stems up to 1 m long, 1–3 mm thick, smooth, compressed, branching often dichotomously, erect
- Inflorescence in coarse spikes, 2–7 per raceme, 1–6 cm long, 3–7 mm thick, arranged in a fingerlike fashion
- One plant can produce up to 66,000 seeds

Management of *D. aegyptium*

- Cultural
  - Early hand weeding is recommended for control.
- Chemical
  - Can be controlled by preemergence application of oxadiazon (0.75–1.0 kg/ha) or pendimethalin (1.5–2.0 kg/ha) or early postemergence (3–5-leaf stage or 15–25 d after emergence) application of cyhalofop butyl (0.1–0.15 kg/ha), propanil (2 kg/ha), or fenoxaprop-P-ethyl (55 g/ha).
  - Beyond the 5-leaf stage, higher rates of cyhalofop butyl are recommended.

Mimosa invisa Mart. ex Colla

English common name: Giant sensitive plant

- A herbaceous, slightly woody, prostrate perennial shrub, 1–3 m long, branches angular with abundant prickles bent outward or backward, clothed with slender hairs when young
- Seed production is approximately 800 seeds per plant

Management of *M. invisa*

- Cultural
  - In general, neither cultivation nor cutting and burning are effective methods of control because regrowth from the crown and seedling establishment quickly replace the aerial growth removed.
  - Hand weeding is possible in small areas, but the thorns make weeding difficult and unpleasant.
- Chemical
  - MCPA at 0.4 kg/ha applied 25–30 d after seeding is effective in controlling the weed in upland rice.

Module 11

Management of Rice Field Rats

Evelyn G. Gergon

Module objectives:

1. To know the characteristics and behavior of rice field rats.
2. To learn how to manage rats in the rice field.

LESSON 1: ECONOMIC IMPORTANCE OF RATS, THEIR CHARACTERISTICS, AND BIOLOGY

OBJECTIVES

1. To identify the damage inflicted by rats and their signs of infestations in rice fields
2. To know the characteristics of rice field rats
3. To know the biology of rats and the factors that affect their breeding and development

What are rats?

Rats are medium- to large-sized, long-tailed rodents of the superfamily Muroidea with a single pair of chisel-like incisor teeth. Rats are typically distinguished from mice by their size; rats are generally large muroid rodents, while mice are generally small muroid rodents.

Rats are major rice pest species in lowlands and uplands, causing annual rice losses from 30% to 50% (Singleton et al 2008). In the Ifugao rice terraces, characterized by terraced landscape, rat damage can be as high as 75% (Gergon et al 2008). Rat damage is generally higher in the wet season than in the dry season.

Only four species of rodents attack rice:

1. *Rattus tanezumi* (formely *Rattus rattus mindanensis*)
2. *Rattus argentiventer*
3. *Rattus exulans*
4. *Rattus rattus* spp.

All *Rattus* species can be found throughout the Philippines except for *R. argentiventer*, which is restricted to Mindanao and Mindoro islands.

What damage is inflicted by rats?

1. Rats are the most destructive and ubiquitous rice field pests, causing losses that exceed the combined harm caused by other pests. In most Asian countries, losses to rats are higher than losses to insects.

2. They can inflict direct damage to rice in all stages of growth. They can cut whole tillers at all stages of rice growth and climb tillers to cut the panicles of mature plants.
3. They feed on seeds directly and cause losses to rice in storage.
4. They can contaminate and transmit diseases to humans such as bubonic plague, rat-bite fever, typhus, salmonella, and leptospirosis.

What are the signs of rat infestation and characteristic damage to rice plants?

Fig. 1. Signs of rat infestation and damage to rice plants.

Other characteristic damage to the rice crop is

- Missing germinating seeds
- Missing hills or plants
- Chopped young seedlings
- Irregular cuttings of stems
- Retillering of stems
- Chewed developing buds or ripening grains
- Missing grains and panicles

What are the characteristics of rice field rats?

1. Rats are nocturnal. They feed at night, with high activity at dusk and dawn.
2. They have poor vision but are sensitive to motion, smell, taste, and touch.
3. They feed on a wide variety of foods and chew continually to sharpen their teeth.
4. They have neophobia or temporary fear of something unfamiliar such as new food.
5. They are good swimmers and climbers and can travel a long distance alone. Their long whiskers and guard tails guide them in traveling.
6. They can engage in cannibalism when food is scarce.
7. A few males can mate with almost all the females in the area.

Where do rats mostly stay?

Rats are found among vegetation, weeds, or maturing fields during daytime. When rice plants are at the tillering stage, rats are in burrows along banks 75% of their time.

After maximum tillering, rats are in rice paddies 65% of their time. During fallow periods, rats are in major channels and around village gardens.

What factors affect the breeding of rice field rats

Rats can be difficult to manage because of their capacity to reproduce rapidly in high numbers and their relatively long life span of 3–4 years.

Breeding in rice field rats is linked to the rice cropping cycle. If there is only one rice crop per year, rats will have only one breeding season per year. If there are two rice crops per year, rats can also have two breeding seasons per year.

Breeding appears to be triggered by the maturation of the rice plant. *T*he rats' peak of breeding coincides with the maturing rice crop. The females first enter estrous 1–2 weeks prior to maximum tillering. Breeding then extends until harvest.

When harvesting during rice cropping is staggered by more than 1–2 weeks, rats can migrate from one field to another, causing increasingly severe damage in the last-harvested crops. Even more critically, rats born during the early part of the cropping season will become old enough to start breeding and cause a rat population explosion, resulting in thousands of rats per hectare.

What is the reproductive cycle of a female rat?

Female rats have a short gestation period of only 3 weeks. They can produce up to 18 litters or pups (average of 11–12 pups) per pregnancy period. Adult females can be pregnant again within a few days after giving birth. Overall, a female rat can produce three litters during the generative phase of growth of a rice crop or a total of 30–40 extra rats by harvest time.

Pups are born blind up to 21 days but they are ready to breed at 42 days old.

What factors affect the development of rice field rats?

1. Availability of food, water, and shelter
2. The presence of breeding sites
3. The presence of major channels and village gardens

LESSON 2. HOW TO MANAGE RICE FIELD RATS

OBJECTIVES

1. To learn the different methods of managing rice field rats
2. To learn how to establish a community trap barrier system

What are the keys to effective management of rice field rats?

a. Effective rat management involves a well-planned decision and actions in order to have a marked reduction in yield losses owing to rat populations.
b. Strategic actions for rat management are most effective if they are developed on the basis of a sound knowledge of the environment of the species to be controlled.

c. Effective rat management can be done by limiting the availability of their food, water, and shelter, and modifying their breeding sites.
d. Group or community effort is necessary for effective rat management, which should be started 2–3 weeks prior to planting rice. Conduct of community campaigns using any local rat control strategies during the peak of rat populations or when damage to the rice crop has been done is often too late for rat management to be effective.

What are the different strategies for managing rice field rats?

1. Sanitation. Practice proper sanitation by removing all straw piles in the paddies after harvest and dry-land preparation. Sanitation should also be observed throughout the cropping season and fallow period to discourage rat breeding in the area.
2. Dry-land preparation. This minimizes the presence of golden apple snails and weeds that serve as alternate food for rats.
3. Rat hunting and burrow management. Use the blanketing method by surrounding the rats' hiding places to force them to come out. Dig rat burrows and holes. Flush burrows and holes with water to force the rats to come out. Use a flame thrower by placing the nozzle with a flame into the mouth of the rat burrow while other burrows are closed to suffocate the rats.
4. Use a snap trap or other trapping device. Use snap or live traps to keep rats from entering rice paddies. Put these traps along dikes where rat footprints and pathways were observed.
5. Night rat hunting. Use a head lamp when hunting rats at night. This method is very effective during land preparation and before the rice canopy closes.
6. Water management. Increase water depth to 3–5 cm after the maximum tillering stage to minimize rat damage.
7. Practice synchronous planting or encourage planting within 2–3 weeks of the regular planting schedule within the community to prevent the extension of rice cropping and the breeding season of the rice field rat owing to the availability of food year-round and to dilute losses from rat damage.
8. Maintain levees with height and width of less than 300 mm to prevent rats from using bunds as nesting sites.
9. Remove grain spills at harvest and practice good hygiene around villages.
10. Shorten the harvest period and have a 1–2-month fallow in the dry season.
11. Lethal control can be implemented through the use of rodenticides such as acute poisons (e.g., zinc phosphide), chronic poisons, or anti-coagulants.
12. Fertility control or the use of immunocontraception, which is a form of biological control, is being studied in Australia.
13. Use predators such as the barn owl, wildcats, snakes, and birds.
14. Use other physical methods such as woven or plastic barriers as enclosures around stored grain or incorporate traps or snares called a trap barrier system (TBS) around the rice crop.

Timing of rat management options

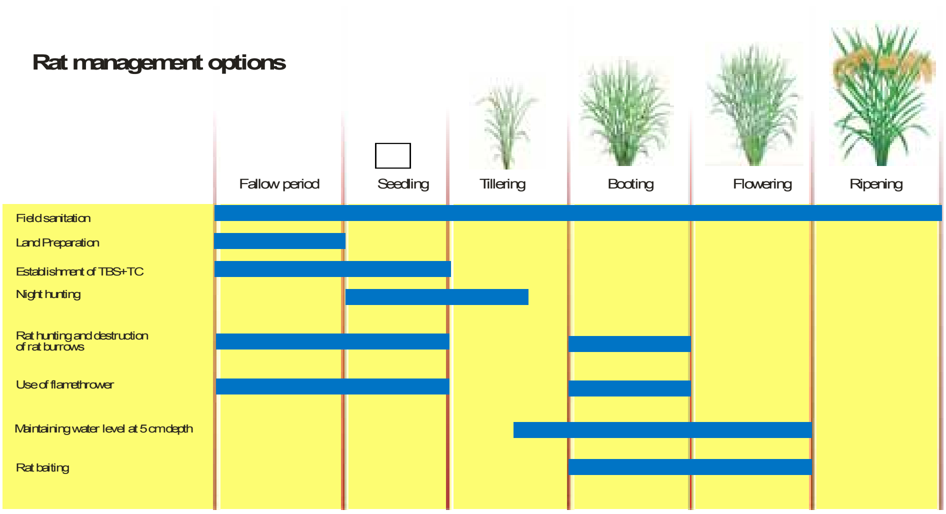


Fig. 2. Different rat management options can be used at different crop stages (adapted from Joshi et al., 2007).

In recent years, the TBS technology has been developed as a community and integrated approach to rodent pest management: hence, the name community trap barrier system or CTBS.

What is a CTBS?

The community TBS or CTBS, ecologically based rodent management without the use of toxic pesticides, was developed owing to increased resistance or tolerance of rodents to many existing rodenticides and increased concern about ecological and human health issues. One CTBS is effective for a 10-ha contiguous rice area. This method works best and is most cost-effective when it is adopted by an entire farming community. A CTBS is necessary when rat damage exceeds 5% but may not be practical when rat damage is less than 5%.

Materials needed for establishing a TBS:

1. Plastic sheet gauge 16, 70 cm wide, 2 1/2 rolls (good for 400 m^2)
2. Bamboo sticks, 1 m long
3. Stapler and staple wires, 1 box
4. Galvanized wire or nylon string
5. Labor
6. Rat traps

Steps in establishing the TBS

1. Erect bamboo stakes at 0.5-m distance. Place wire or string on the stakes to maintain their position.

2. Affix the plastic to the bamboo stakes using a stapler and the wire to support them. The stakes should be inside the plastic fence.

3. Bury the other end of the plastic 10 cm into the soil.
4. Install 1–2 rat traps inside the fence along each side and make a mound of soil leading to the opening of the trap.
5. Secure the trap tightly against the fence and provide access to the opening of the trap by making a hole in the fence opposite the trap opening.

6. Grow a rice crop, preferably aromatic rice, inside the TBS 3–4 weeks before the surrounding rice is planted and maintain a weed-free 0.5-m moat around the fence.
7. Monitor the TBS daily and collect trapped rats.


ACTIVITIES

1. Rat damage assessment. Recall the damage caused by rats in rice fields. Damage is not uniform and is usually more serious in fields near the village, in hills, or near big canals.
   a. Select sites for rat damage assessment.
   b. At each site, observe 10 rows per plot and, for each row, observe 10 hills for rat damage such as cut tillers.
   c. Determine the % cut tillers by dividing the total number of cut tillers by the total number of tillers counted and multiply by 100.
   d. Determine the % rat damage using the following scale:

Crop stage	Slight	Moderate	Serious
Tillering	5–10%	>10–20%	>20%
Booting	2–5%	>5–10%	>10%

2. Rat population assessment. There are several ways to assess rat populations such as the use of tracking tiles (20 cm × 20 cm) coated with cow's fat that show rat footprints, rice mound baits, monitoring for the presence of active burrows, and snap or live traps.

   In the first two methods, the rat activity index is measured by the % of tiles with footprints or the % of eaten rice mounds. The following scale is used:

<20%	Rat activity is low
20–40%	Rat activity is moderate
>40%	Rat activity is high

   For the burrow index, divide the number of burrows with rats by the total length (in meters) of field bunds or canal edges observed. Signs that a burrow has rats include footprints, mud and rat droppings, new soil, and pulled-out cover if the entrance was covered. A high burrow index indicates a high rat population.

For live traps, the abundance index is determined by counting the number of traps with rats over the total number of traps used multiplied by 100. For the abundance index, the following scale is used:

<3%	Rat population is low
3—5%	Rat population is moderate
>5%	Rat population is high

3. Identification of rat species and sex. In making management decisions, understanding rat populations and changes in populations is very important. To understand rat populations, the characteristics and sex of rats caught must be known.

   Collect live or freshly dead rats and describe their physical appearance. Take body measurements (head-body length, tail length, pes (hind foot) length, ear length, and body weight. Also note their reproductive organs.

   Separate the females, males, and young rats. Observe for teats and the female organs. Teats are prominent in sexually mature females but not in young females. By observing the female organ, determine whether the rat is pregnant, not pregnant, or had been pregnant.

   Record all observations.

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Module 12

Proper Harvesting and Postharvest Seed Management

Pat C. Borlagdan

Module objectives:

1. To explain the principles of harvest of and postharvest operations for rice seed
2. To learn how to harvest a rice seed crop to maintain seed quality
3. To learn proper postharvest processing and handling of paddy for “seeds”
4. To learn proper storage management for seeds

Total rice quality management involves timely operations and processes within the production to postharvest continuum. Proper time of harvesting of rice grain and proper processing and storing of seeds are keys to good-quality seed yield. Thus, it is imperative that grains intended for seeds be processed and stored properly to maintain their quality and viability.

Harvesting and threshing

1. Harvest the rice crop when one or a combination of the following criteria is eminent: 85% of the grains are straw-colored (or golden yellow as in Fig. 1) and moisture content (MC) of the grain is 22–24% on a wet basis (w.b.). However, in the rainy season, the MC could be higher. Hence, MC would not be a reliable criterion. To cope with this, farmers have developed their own best practice and expert criteria.

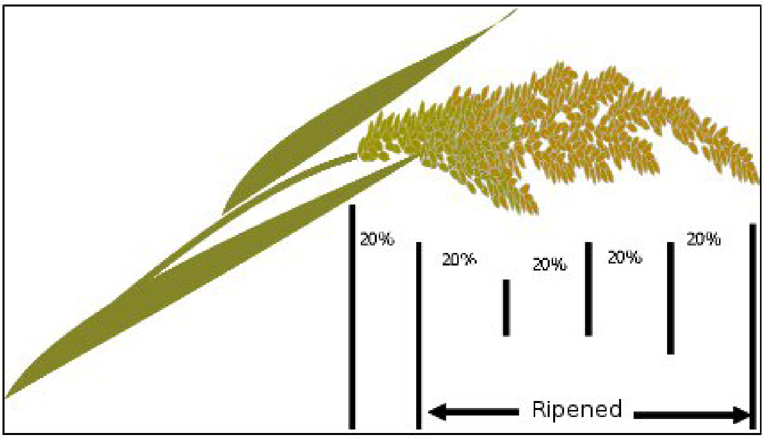

Fig. 1. Appearance of rice grains on the panicle at 80–85% maturity.

Early harvesting
- Large amount of immature grains
- Low yield or low seed quality
- Loss of viability

Late harvesting
- Longer time for attacks by rodents, birds, and pests
- Lodging makes harvesting difficult and reduces yield
- Prolonged exposure of the crop to the weather
- Excessive shattering

2. To ensure varietal purity, remove off-type varieties before cutting the mature rice crop.
3. Thresh the crop immediately after cutting to avoid quality deterioration. If a mechanical thresher will be used, clean it first thoroughly and make sure it is free of residual grains from previous threshing operations. Set the tip speed of the threshing drum to not more than 13 meters per second to avoid grain damage by mechanical impact.
4. Do not leave the cut crop piled on the field for too long. Grain temperature inside the piled rice crop could exceed 60 °C after 1 day, resulting in favorable conditions for microbial growth and eventual deterioration of grain quality.

Be careful when using mechanical threshers in order to ensure the genetic purity of your seed crop and to avoid mechanical mixtures of varieties, before and after each variety:

- Thoroughly clean the machine.
- Remove all leftover seed from nooks and crannies of the machine.
- Thresh only one variety at a time and thresh each variety separately.
- Completely clean the threshing area.

Drying of seeds

1. Drying is the critical postharvest process to retain grain quality at harvest. Reducing MC deprives microorganisms of a favorable condition for growth and metabolism. For better storage, it is recommended to dry seeds further down to 12% w.b.
2. Dry grains immediately to 14% w.b. after threshing by sun drying or by using a mechanical dryer depending on weather conditions. Per the basic rule on drying rice grains for seeds, the grain temperature should not exceed 43 °C to prevent a reduction in seed viability and germination rate.
3. When using mechanical dryers, the drying air temperature should not exceed 58 °C. This is based on farmers' best practice with mechanical (flatbed and recirculating) dryers.
4. Sun drying, when done properly, avoids mechanical and thermal damage. Two to three centimeters of grain thickness is recommended with regular stirring every 20–30 minutes or at shorter intervals to prevent thermal damage. Do not dry seeds directly on cement as the temperature may exceed 50 ºC and damage the seeds. It is best to use linings (e.g., canvas or any available material that would prevent direct contact of seeds with an easily heated surface). Per the farmers' practice, 0900–1200 is the best time for drying seeds. Afternoon solar radiation could render thermal injury to the seeds unless they are for milling purposes.

Storage

1. Clean seeds thoroughly of empty grains and other contaminants before storing.
2. Proper storage is essential in maintaining seed quality and viability after drying. Prevention of rewetting the dried grain is an important aspect. In the humid tropics, the average ambient air MC is 14% w.b. It could be more than 15% during rainy days. Rice grains with lower MC will absorb water from ambient air with higher MC, resulting in rewetting.
3. To prevent rewetting, store seeds in hermetic or airtight containers such as bottles, sealed cans/drums, and similar containers.

Photo 1. Hermetic plastic bags (Fig. 2) can be used. Hermetic or airtight seed storage prevents the growth of insects.

IRRI Super Bag

Relative to traditional storage systems, Super Bags

- Extend the germination life of seed for planting from 6 to 12 months,
- Control insect grain pests (without using chemicals), and
- Maintain high head-rice recovery—often 10% higher than in traditional systems.

Fig. 2. The IRRI Super Bag.

Hermetic plastic bags such as the IRRI Super Bag can be used (Fig. 2). Hermetic or airtight seed storage prevents the growth of insects.

4. Monitor the stored seeds and make sure the container remains airtight.
5. Open the airtight container only when the seeds will be used or sown to produce seedlings.

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Module 13

Controlling Diseases and Pests in Storage

Casiana M. Vera Cruz, Marian Hanna R. Nguyen, and Carlos C. Huelma

Module objective:

This module discusses the relevance of microorganisms and storage insects that have been shown to be associated with seeds.

Part 1. Diseases

Casiana M. Vera Cruz and Marian Hanna R. Nguyen

What are seedborne microorganisms?

These are fungi and bacteria that can be carried within or on the surface of rice seeds. Bacteria carried by seeds may be beneficial to the plants or may cause disease. Other seedborne bacteria have roles that have yet to be discovered and are said to be neutral.

LESSON 1: FUNGI ASSOCIATED WITH STORED SEEDS

OBJECTIVE

To be familiar with the fungi associated with seeds and to be able to relate the maintenance of proper storage conditions to the conditions that favor growth of fungi

Photo 1. Appearance of rice grains on the panicle at 80–85% maturity.

The growth of fungi, specifically molds, on stored rice seeds causes a decrease in seed quality because of color changes or spoilage of seeds. It is important to store seeds properly to prevent the growth of these fungi, primarily by avoiding conditions that would promote mold growth.

1. Ensure that the storage area and containers are kept clean to avoid contamination of seeds by mold spores.
2. Separate or discard batches of seeds that already contain discolored seeds (Photo 1).
3. Avoid moisture buildup in and around storage containers, and make sure that the stored grains have been dried to attain the recommended moisture content.
4. Avoid storing seeds in warm temperatures, since this would also promote mold growth.

While some molds cause problems due to spoilage of seeds and discoloration of the seed surface, there are also pathogenic or disease-causing fungi that may be present in stored seeds (Table 1). These fungi may cause disease when the seeds are sown.

Table 1. Pathogenic fungi associated with seeds.

Disease	Causal organism
Bakanae, foot rot	*Fusarium monoliforme*
Black kernel	*Curvularia spp.*
Blast	*Pyricularia oryzae*
Brown spot	*Bipolaris oryzae*
False smut	*Ustilago virens*
Glume blight	*Phoma sorghina*
Kernel smut	*Tilletia barclayana*
Leaf scald	*Microdochium oryzae*
Minute leaf, grain spot	*Nigrospora spp.*
Narrow brown leaf spot	*Cercospora janseana*
Red blotch	*Epicoccum purpurascens*
Sheath blight	*Rhizoctonia solani*
Sheath rot	*Sarocladium oryzae*
Speckled blotch	*Septoria spp.*
Stackburn	*Alternaria padwickii*
Stem rot	*Nakatea sigmoidea*

The following nonpathogenic fungi are associated with seeds:

- *Alternaria longissima*
- *Aspergillus* spp.
- *Cladosporium* spp.
- *Curvularia* spp.
- *Dreschslera* spp.
- *Fusarium semitectum*
- *Fusarium* spp.
- *Penicillium* spp.
- *Pinatubo oryzae*
- *Pithomyces maydicus*
- *Rhizopus* spp.
- *Trichoderma* spp.

LESSON 2: BACTERIA ASSOCIATED WITH STORED SEEDS

OBJECTIVE

To be familiar with the bacteria associated with seeds and to be able to relate the maintenance of proper storage conditions to the conditions that favor bacterial growth

Diseases caused by most bacterial pathogens mostly result in large economic losses due to crop damage (Photo 2) and lower yield.

Some bacteria such as *Acidovorax avenae* subsp. *avenae*, *Pseudomonas fuscovaginae*, and *Burkholderia glumae* cause noticeable symptoms on seeds (Photo 3).

For some bacterial pathogens, such as *Xanthomonas oryzae* pv. *oryzae*, their potential to cause seed discoloration is still undetermined (Table 2). Screening for these types of bacterial pathogens is essential before storage to avoid contamination of the storage area and other seed lots that are stored in it.

Photo 2. IRRI plot showing plants infected with bacterial blight.

Photo 3. Grain discoloration caused by (A) *Acidovorax avenae* subsp. *avenae*, (B) *Pseudomonas fuscovaginae*, and (C) *Burkholderia glumae*.

Table 2. Pathogenic bacteria associated with seeds.

Disease	Causal organism
Bacterial blight	*Xanthomonas oryzae* pv. *oryzae*
Bacterial halo blight	*Pseudomonas syringae* pv. *oryzae*
Bacterial leaf streak	*Xanthomonas oryzae* pv. *oryzicola*
Bacterial sheath brown rot	*Pseudomonas fuscovaginae*
Bacterial sheath rot	*P. syringae* pv. *syringae*
Brown stripe	*Acidovorax avenae subsp. avenae*
Foot rot	*Dickeya chrysanthemi*
Grain rot, bacterial seedling rot	*Burkholderia glumae*
Palea browning	*Pantoea agglomerans*
Seedling blight	*Burkholderia plantarii*

The following nonpathogenic bacteria are associated with seeds:

- *Bacillus subtilis*
- *Cellulomonas flavigena*
- *Clavibacter michiganense*
- *Curtobacterium flaccumfaciens*
- *Enterobacter cloacae*
- *Micrococcus luteus*
- *Pantoea dispersa*
- *Pantoea stewartii*
- *Pseudomonas aeruginosa*
- *Pseudomonas oryzihabitans*
- *Staphylococcus gallinarum*
- *Xanthomonas* sp.

LESSON 3: HOW SEEDBORNE PATHOGENS DEVELOP AND ARE CARRIED TO THE NEXT CROP

OBJECTIVE

To gain an overview of the general ways in which a pathogen may be transferred or carried over to the next cropping season

Pathogens can be carried to the next crop in various ways. Some pathogens are able to infect various parts of the seed via the vascular system, natural openings, or wounds caused by natural phenomena such as strong winds during a typhoon. Their presence in the seed may cause disease when seedlings emerge during the next cropping season. Pathogens or their infectious structures, such as the sclerotia of certain fungi, may also be carried passively on seed surfaces or be present in soil particles that are mixed with seeds.

Even if the pathogen does not cause sufficient damage to kill the plant, its presence in the field, whether in an infected plant part or the soil, may serve as a source of inoculum and infect other plants.

It is also important to consider that, during the transfer or trading of rice seeds to other locations, pathogens present in these seeds are also transferred. If pathogenic or disease-causing microorganisms are present, then the disease that they cause may also be transferred to other locations, which may lead to economic losses. Screening for the presence of pathogens before transporting seeds is therefore extremely important, in combination with maintaining cleanliness in the storage area and storage containers to prevent contamination.

Activity

1. Enumerate the possible sources of contamination in a farm setting and state the possible ways to avoid the spreading of seed-associated pathogens and the possible carrying of pathogens to the next cropping season.

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Part 2. Identification and management of stored grain pests

Carlos C. Huelma

Introduction

Rice and its stored products are not spared from losses during storage. Rice producers struggle to limit the postharvest losses of agricultural production caused by stored grain pests to help feed millions of people. Worldwide losses in stored products, caused by insects, have been estimated to be between 5% and 10%. However, heavier losses occur in the tropics, reaching up to 30% (Sambaraju 2008, Pimentel 1991, IRRI 1988, Sukprakarn 1989).

Proper identification of stored grain pests is an important requirement in order to properly and efficiently handle stored seeds against damage caused by infestations of postharvest insect pests and this is essential in recommendations of seed treatment. The greater the efforts to prevent stored-grain losses, the greater the quantity of higher quality rice available for the people of the rice-consuming countries of the world.

Objectives

1. Identify common and important storage insect pests in rice
2. Enumerate ways to manage storage insect pest infestation
3. Describe control and management methods against stored grain pests

LESSON 1: GENERAL CHARACTERISTICS OF INSECTS

OBJECTIVE

To identify the basic insect anatomy

Proper identification of pests such as storage insects is essential for their effective control. Identification of an insect requires knowledge of the basic insect anatomy. Adult insects have two physical characteristics in common: three pairs of jointed legs and three body regions—the head, thorax, and abdomen (Fig. 1).

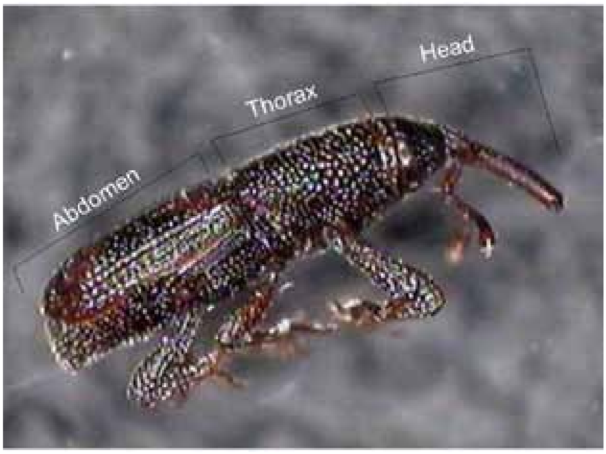


Fig. 1. Illustration of the rice weevil.

1. The head includes the antennae, eyes, and mouthparts. Antennae vary in size and shape and can aid in identifying some insect pests. Insects have compound eyes made up of many individual eyes. These compound eyes enable insects to detect motion, but they probably cannot see clear images. Mouthparts are also used to identify insects. The four general types of mouthparts follow:
   a. Chewing—cockroaches, ants, beetles, caterpillars, and grasshoppers
   b. Piercing/sucking—stable flies, sucking lice, bed bugs, mosquitoes, true bugs, and aphids
   c. Sponging—flesh flies, blow flies, and house flies
   d. Siphoning—butterflies and moths

b. The thorax contains the three pairs of legs and (if present) the wings. The various sizes, shapes, and textures of wings, and the pattern of the veins, are also used to identify insect species. The forewings take many forms. In the beetles, they are hard and shell-like (called elytra); in the grasshoppers, they are leathery. The forewings of flies are membranous; those of true bugs are part membranous and part hardened.

c. The abdomen is usually composed of 11 segments, but 8 or fewer segments may be visible. Along each side of most of the segments are openings (called spiracles) through which the insect breathes. In some insects, the tip end of the abdomen has a tail-like appendage. Insects have no backbones but have an outer supporting structure called an exoskeleton. Insects are classified under the group Invertebrates.

LESSON 2: LIFE CYCLE

OBJECTIVE
To identify the different stages in the development of an insect

Furthermore, knowledge of the life cycle of an insect can aid in identification. The life cycle is the sequence of events from egg to reproducing adult. The insect life cycle is characterized by certain metamorphosis or a radical change in appearance accompanying growth and development (Fig. 2). The different stages become distinct units of development time. Generally, the development cycle lasts 18–25 days for beetles and 28–35 days for moths.

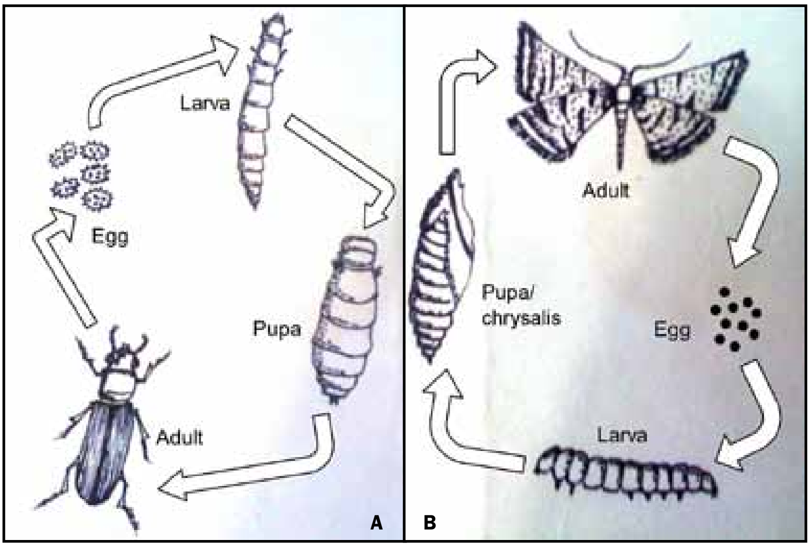


Fig. 2. General life cycle of beetles (A) and moths (B).

LESSON 3: CLASSIFICATION OF STORED GRAIN INSECTS

OBJECTIVE
To be able to classify storage insects based on feeding habits

1. Primary pests are capable of penetrating and infesting intact grain and they have immature stages that can readily develop within seeds.
   - Rice weevil—*Sitophilos oryzae* (Linnaeus)
   - Angoumois grain moth—*Sitotroga cerealella* (Olivier)
   - Lesser grain borer—*Rhyzopertha dominica* (Fabricius)

2. Secondary invaders cannot infest solid grain but feed on broken seeds, debris, weed seeds with higher moisture, and grain damaged by primary insect pests. In general, the immature stages of these species are found external to the grain. It is often thought that secondary invaders cannot initiate an infestation. However, this is untrue as almost any storage situation will have adequate amounts of broken grains and debris to

support an infestation by secondary invaders. Moreover, secondary invaders contribute directly to grain spoilage after establishment, just as primary pests do. However, the most damaging insect types are those that feed within the grain itself, causing insect-damaged seeds.

- Saw-toothed grain beetle—*Oryzaephilus surinamensis* (Linnaeus)
- Rust-red flour beetle—*Tribolium castaneum* (Herbst)

LESSON 4: IDENTIFICATION OF STORED GRAIN INSECTS

OBJECTIVE

To identify stored grain insects based on diagnostic features

About 48 storage insect pests are found in the Philippines and six are major pests of milled and rough (*palay*) rice. The major insect pests are beetles and weevils (order Coleoptera) and moths (order Lepidoptera). The three most destructive and widespread insects that infest milled rice are (1) rice moth *Corcyra cephalonica* (Stainton), (2) rice weevil *Sitophilus oryzae* (L.), and (3) red flour beetle *Tribolium castaneum* (Herbst).

The potential pests of palay with broken or damaged grains are (1) lesser grain borer *Rhizopertha dominica* Fabricius, (2) rice weevil *Sitophilus oryzae* (L.), and (3) angoumois grain moth *Sitotroga cerealella* (Olivier).

With the use of magnification, practice, and a good reference guide, it is possible to identify most storage insects. Furthermore, knowledge of the diagnostic features of some storage insect pests of rice will greatly aid in their identification.

1. *Sitophilus oryzae* (L.)—rice weevil
Coleoptera: Curculionidae

Photo 4. *Sitophilus oryzae* (L.) rice weevil. One of the most destructive insect pests of rice in storage.

Characteristics

- Adult: Red-brown with densely rounded or irregularly shaped punctures on the prothorax and elytra, a long narrow snout, 8-segmented and elbowed or club-shaped antennae, and forewings with 4 reddish brown spots (Photo 4)
- Egg: White and minute
- Larva: White with brown head, grub-like, apodous, or legless
- Pupa: White with free appendages and visible snout

Life cycle

- The egg of *Sitophilus* spp. hatches and develops completely inside a minute hole chewed in the grain by the female.
- Both adults and larvae feed but it is the legless larva that is responsible for most damage. After pupation, the adult beetle emerges from the grain, leaving destroyed kernels of grain.
- Adults can live for 2–3 months and their life cycle can be completed in 4–15 weeks depending on temperature.

Control

- Store grains without damaging the husk. *Sitophilus* spp. (2.3–4.5 mm) have difficulty biting through the solid husk of paddy grain even when the moisture content is high.
- Handle seeds properly before storage: feeding and oviposition are more likely to occur on badly damaged grains and kernels exposed by a separation of lemma and palea, or a split wider than the weevil's snout.
- Avoid storing grains adjacent to rice fields: adults are capable of flight and they can infest the grain before it is brought to storage if the granary or warehouse is close to the field.
- If possible, store grains in rooms with a temperature not exceeding 15 °C—high temperature allows completion of the life cycle faster; thus, the insect population increases faster.

2. *Rhyzopertha dominica* Fabricius—lesser grain borer (beetle) Coleoptera: Bostrichidae

C. Huelma

Photo 5. *Rhyzopertha dominica* (Fabricius)—lesser grain borer (beetle).

Characteristics

- Adult: Dark brown and cylindrical with rows of punctures on the elytra, head is deplexed and more or less concealed from above by a prothorax, which has a coarsely tuberculate anterior margin, and antennae with a distinctly separated 3-segmented club (Photo 5)
- Larva: Whitish and scarabaeiform with well-developed prolegs

Life cycle

- The lesser grain borer, *Rhyzopertha dominica* F., is a brown beetle only about 3 mm long and it lives for 2–3 months.
- Females lay 200–400 eggs loosely among the grains and the first instar larvae initially feed outside, then bore inside the rice grains.
- The pupae develop inside the rice grain, which serves as the food supply of the developing larvae.
- Both adults and larvae are voracious feeders. Unlike *Sitophilus* spp., the larvae have legs and are able to feed in grain dust and attack grains externally.
- The life cycle is completed in 4–7 weeks depending on temperature.
- Reported present in the Philippines.

Control

- Breeding stops at 18 ^{o}C, so keeping the grains at that temperature or lower will stop insect multiplication.
- Regular sampling and sieving ensure early detection for their habit is to remain inside the grain.
- They are strong fliers so storage in areas away from the field is advisable.

3. *Sitotroga cerealella* (Olivier)—angoumois grain moth
Lepidoptera: Pyralidae


C. Huelma

Photo 6. *Sitotroga cerealella* (Olivier)—angoumois grain moth.

Characteristics

- Adult: Small and pale brown (silvery gray) in color; labial palpi are long, slender, and sharply pointed; forewings are elongate, pale brown in color and with black spots beyond the center of the upper side; hindwings are fringed with hairs and pointed tips (Photo 6)

Life cycle

- The angoumois grain moth, *Sitotroga cerealella* (O.), does not feed. However, it commonly infests paddy in the field before harvest.
- Some 150–300 eggs are laid singly on or near the grains.
- After hatching, the larva bores into the grain and begins feeding on the contents. The entire larval and pupal periods are passed within the grain, so that the only stage normally seen is the adult moth.
- The emerging moth pushes out of the grain through the silk-covered opening made by the female.
- Reported present in the Philippines.

4. *Corcyra cephalonica* (Stainton)—rice moth
Lepidoptera: Pyralidae

C. Huelma

Photo 7. *Corcyra cephalonica* (Stainton)—rice moth.

Characteristics

- Adult: Brown or grayish brown moth, upper side of forewings uniformly colored pale buff brown. Head with a projecting tuft of scales. Labial palpi very short and inconspicuous in the male, long and prominent in the female. Upper side of forewing without spots but with darker thin vague lines along the veins (Photo 7).
- Larva: Creamy-white except for the brown head capsule and prothoracic tergite
- Pupa: Light color and turns brown with age

Life cycle

- The rice moth, *Corcyra cephalonica* (S.), is 12–15 mm long, with wings folded along the body.
- Infestation by C. *cephalonica* is prevalent in milled rice with a high percentage of broken grains.
- It is characterized by aggregations of grains that result from the larvae forming silken tubes to which the grains adhere.
- Reported present in the Philippines.

Control

Remilling of the grain is necessary to remove web material. Quarantine status-wise, a secondary pest.

5. *Oryzaephilus surinamensis* (L.)—saw-toothed grain beetle
Coleoptera: Silvanidae


C. Huelma

Photo 8. *Oryzaephilus surinamensis* (L.)—saw-toothed grain beetle.

Characteristics

- Adult: Flat and prothorax with six prominent teeth along the sides of the pronotum and three longitudinal ridges on its dorsal surface (Photo 8).
- The saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), is 3.5 mm long, yellowish brown to dark brown. The prothorax in the adult is separated from the abdomen by a deep furrow.
- Adults can climb up vertical surfaces (i.e., glass jars).

Life cycle

- They grow significantly in number on damaged and broken grains.
- The life span of an adult can last for several months, with females laying 300–400 eggs loosely on the surface of grains.
- The larva feeds and develops externally.
- Reported present in the Philippines.

6. *Lophocateres pusillus* Klug—Siamese grain beetle
Coleoptera: Lophocateridae


C. Huelma

Photo 9. *Lophocateres pusillus* (Klug)—Siamese grain beetle.

Characteristics

- Adult: Highly flattened, parallel-sided body. Brown to dark gray in color. Prothorax with base closely applied to base of elytra. Elytra with distinct longitudinal ridges (Photo 9)
- Larvae: Campodeiform

Life cycle

- Adults are long-lived; feed on grains and flies. Females lay eggs on the grains.
- Larvae are mobile and are external feeders.
- Reported present in the Philippines.

7. *Tribolium confusum* (Jacquelin du Val)—confused flour beetle
Coleoptera: Tenebrionidae


C. Huelma

Photo 10. *Tribolium confusum* (Jacquelin du Val)—confused flour beetle.

Characteristics

- Adult: Reddish brown. Head with a ridge above the eyes and 11-segmented antennae that thicken to form a poorly differentiated 5-segmented club (Photo 10).
- Often mistaken for red flour beetle.

Life cycle

- The confused flour beetle, *Tribolium confusum* (J. du V.), is 3–4 mm long.
- The larvae feed externally on grains. The larvae have prominent heads, three pairs of distinct legs, and forked abdomen tips, and are pale yellow.
- The confused flour beetle prefers to feed on the grain embryo.
- It is more cold-hardy than the red flour beetle and is a weak flier.
- Reported present in the Philippines.

8. *Cryptolestes ferrugineus* (Stephens)—rusty grain beetle
Coleoptera: Cucujidae

C. Huelma

Photo 11. *Cryptolestes ferrugineus* (Stephens)—rusty grain beetle.

Characteristics

- Adult: Flat and rectangular body, V-shaped, thread-like antennae, and lateral ridges on thorax (Photo 11)
- Larva: White to straw-colored with flat slender body; the posterior end of the abdomen has two dark slender horns
- The rusty grain beetle, *Cryptolestes ferrugineus* (S.), is 1.5–2 mm long and light reddish brown; can be confused with *C. pusillus*.

Life cycle

- Larvae can be found outside the grain kernel and spin cocoons and prefer the embryo to the endosperm. They thrive in hot moist grain and are cold-hardy, tolerant of low relative humidity.
- The adult is a strong flier. The head and thorax show a ridge that runs from behind the eye and across the thorax.
- Reported present in the Philippines.

9. ***Tribolium castaneum* (Herbst)—red flour beetle**
Coleoptera: Tenebrionidae

Photo 12. *Tribolium castaneum* (Herbst)—red flour beetle.

Characteristics

- Adult: Shiny red-brown to blackish brown, flat body with a broader than long pronotum, parallel-sided abdomen, and antennae with 3-segmented pronounced club (Photo 12).

Life cycle

- The larvae of *T. castaneum* feed both outside and inside the grain. The larva has a prominent head, three pairs of distinct legs, forked abdomen tip, and an elongated and cylindrical white body tinged with yellow.
- The pest is more cold-susceptible than the cold-hardy *Cryptolestes* sp. The adult is a strong flier.
- Reported present in the Philippines.

LESSON 5: SORTING OF SPECIES

OBJECTIVE

To differentiate closely related species

Often, more than one insect species will be found, and insects will need to be sorted by species to determine the number of each species. For some closely related species, the insects will need to be viewed under a dissecting microscope to do the sorting.

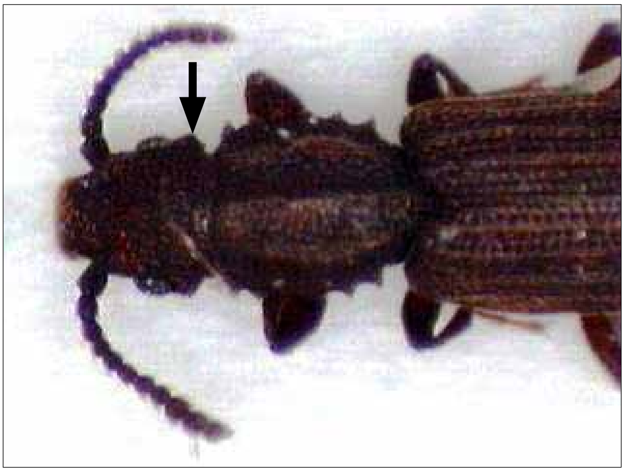
1. Adults of two species of *Tribolium* can be quickly distinguished because, ventrally, the eyes of *Tribolium castaneum* (H.) are closer together that those of *T. confusum*. Also, the last five segments of the antennae gradually broaden toward the tip for *T. confusum*, whereas the last three segments of the antennae are much larger than the rest and form a club for *T. castaneum* (Photo 13).

Photo 13. The antennae of (A) *Tribolium confusum* (J. du V.) and (B) *T. castaneum* (H.).

2. Differences in the extruded male reproductive organs separate the adults of *Sitophilus zeamais* Motsch. and *S. oryzae.* The internal morphology of the male aedeagus of *S. zeamais* is flat and has two distinct impressions. That of *S. oryzae* has an even, convex upper surface (Photo 14).

Photo 14. Male reproductive organ of *Sitophilus oryzae* (L.).

3. The greater distance between the eyes and back of the head separates an adult *Oryzaephilus surinamensis* L. from that of *O. mercator.* The adult *O. surinamensis* has a head with the length of the temple (region directly behind the eye) equal to more than half of the vertical diameter of the eye (Fig. 3). *O. mercator* has a head with the length of the temple much less than half of the vertical diameter of the eye.



C. Huelma

Fig. 3. Head of *Oryzaephilus surinamensis* Linnaeus.

4. In alcohol, an adult *Cryptolestes ferrugineus* (S.) can be readily separated from an adult *C. pusillus* by its darker abdomen.

LESSON 6: MANAGEMENT PRACTICES FOR STORAGE INSECT PESTS

OBJECTIVE

To identify management practices for storage insect pests

Common practices for the control and management of storage insect pests are as follows:

1. Know the sources of infestation of stored grains. The possible sources of infestation of stored grains follow:
   - Poultry and animal feed stored in farm buildings
   - Accumulated waste grains and feed on floors, under buildings, or under grain bins
   - Warehouses or other storage facilities where grain is kept throughout the year
   - Old warehouses with cracks and crevices in the floors and walls
   - Old containers, especially sacks
   - Vehicles used for transporting grain
   - A rice mill with small amounts of leftover grain
2. Monitor for the presence of stored grain insects
   - Search for insects between adjacent sacks; between sacks and walls; in the ears, folds, or seams of sacks; on floors and walls, especially in cracks and crevices; within the grain; and in dark corners, for these are the commonly missed hiding places of insects in storage.

- Identify and study the biology of the stored grain insect pests. Storage pests can be identified through their distinguishing marks and more obvious signs of infestations, which are the presence of live and dead beetles, flying moths, and feces or insect excreta on sacks.

3. Prevent the entry of insect pests
   - Do frequent periodic inspection of stored grains and warehouses. Using traps is excellent for monitoring pest levels.
   - Become familiar with the pests of specific crops and their signs of infestation. This is required as a basis for the recommendation of specific control measures.
   - Study the factors and risk of introduction of exotic stored grain insect pests.
4. Control measures for storage insects
   a. **Cleanliness.** Good warehouse-keeping practice is the most important, the easiest to do, the lowest in cost, and the most effective pest control measure.
   b. **Use of chemicals.** Spraying, misting, or fogging and fumigation are only supplements for keeping the warehouse clean.
   c. **Temperature.** Low temperature is probably the most effective means of making long-term storage of rice possible. But refrigerated storage is costly.
   d. **Moisture.** Most stored grain insects are unable to survive and reproduce in grain having moisture content below 9%. Sun drying does not reach that low a level.
   e. **Hermetic control.** Airtight or hermetic storage involves storing grain so that it is protected from exchange of gases or liquid with the outside environment.
   f. **Radiation.** This sterilizes or kills insects by damaging cells and producing free radicals that break chemical bonds. Radiation sensitivity is directly related to cell reproductive activity and inversely related to the degree of cell differentiation. Within a developmental stage, the susceptibility of an insect to ionizing radiation varies greatly with age.
   g. **Biological control.** This is the use of natural enemies or beneficial insects for controlling pests of stored products. Several species of beneficial insects are sold in the U.S. that attack the major insect pests in stored grain, including granary weevil, rice weevil, maize weevil, rusty grain beetle, lesser grain borer, confused flour beetle, saw-tooth grain beetle, angoumois grain moth, and Indian meal moth. The bacterial pesticide *Bacillus thuringiensis* (B.t.) can be used during grain storage to kill moth caterpillars that hatch after the grain is stored. B.t. is effective only against the larval stage of insects in the moth family, such as grain moths and Indian meal moths. Eggs, pupae, and adults are not affected. The product must be ingested by the caterpillar in order to work. B.t. kills caterpillars by damaging their digestive tract over a period of 2 or more days. There are several product formulations of B.t.

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Module 14

Crop Diversification

Joel D. Janiya

Module objectives:

1. To understand crop diversification
2. To know the principles and criteria in diversification
3. To know the advantages of and constraints to crop diversification

Introduction

Farmers often cultivate a single crop on the same piece of land year after year. In upland areas, monocrop rice is often planted and after that the area is either left fallow or, if moisture permits, a short-duration crop is planted. When a monocrop is grown and it fails, the farmer has no other source of food and he and his family suffer from hunger. In the monocrop system, food insecurity is high. To ensure food security and livelihood, crop diversification is an alternative solution.

Crop diversification may help achieve food and nutritional security, poverty alleviation, income growth, employment generation, judicious use of natural resources, and environmental improvement (FAO 2001).

What is crop diversification?

Crop diversification is a strategy of changing or selecting crops or varieties adapted to the area and this has commercial value as added income for farmers. With crop diversification, farmers move from mere subsistence farming to market-oriented farming. Crop diversification may include intercropping of two or more crops, interplanting of different varieties of the same crop, planting of short-duration crops with permanent crops, mixed cropping, and crop rotation. Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production-related activities in various crops and also to lessen risk.

Crop diversification largely depends on climatic and edaphic conditions and economic factors. The aim is to have different kinds of food crops and varieties that can withstand adverse climatic conditions. Planting of different crops in the field can provide yield from crops that are able to survive biotic and abiotic stresses on the farm. With the threat of climate change, crop diversification can increase farmers' chances of having food availability and income security.

Why is crop diversification important?

Crop diversification has become an important option to attain natural resource sustainability, ecological balance, output growth, buffer stocks, employment generation, and reduced risk (monocropping has a high risk). It may also help attain self-reliance in food crops through income-generating crops.

Advantages of crop diversification

1. Stable yield
2. High net returns from crops
3. Assures alternative sources of food
4. Reduces pests and diseases
5. Reduces the use of chemicals for pest control
6. Optimizes the use of resources
7. Sustainability

Constraints to crop diversification

1. Limited market demand for farm produce
2. Soil degradation
3. Limited availability of technology for chosen crop(s)
4. Climatic changes
5. Inadequate supply of quality seeds and improved cultivars
6. Poor basic infrastructure (roads, transportation, power)
7. Inadequate postharvest technology and infrastructure

Crop diversification can be used as a strategy for

1. Food and poverty alleviation
2. Meeting nutritional needs
3. Natural resource management for sustainable agricultural development
4. Agricultural planning
5. Employment opportunity in rural areas

Table 1 lists crops that can be rotated or intercropped with rice in the uplands and that provide added value for both the yield and quality of upland systems. The kind of crop planted depends on the suitability and acceptability of the crop in the area or country.

Table 1. Crops that can accompany rice.

Country	Cropping system
Northern Mountainous Region, Lao PDR	Rice + stylosanthes line-sowing intercrop
	Rice + maize intercrop
	Rice-pigeon pea-sticklac
	Rice-paper mulberry
Northeastern India	Rice-legume (peanut, soybean, blackgram) intercrop
	Rice followed by toria
	Rice followed by blackgram
	Rice integrated with pineapple, sesame, toria, greengram, Assam lemon, banana, turmeric, and guinea grass in sequential strips across the slope
Northern Mountainous Region, Vietnam	Spring legume (peanut or soybean) followed by summer rice
Churia and Middle Hills, Nepal	Rice + peanut intercrop
	Rice + maize intercrop
	Rice + cowpea intercrop
	Rice + soybean intercrop
Philippines	Rice (Dinorado) + rice (UPLRi5) + mungbean intercrop
	Rice (Dinorado) + rice (UPLRi5) + peanut intercrop

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Appendices

Appendix 1. Template for survey of production practices at target sites for community-based seed systems

UPLAND RICE PRODUCTION
Survey of production practices

NAME OF PARTICIPANT: ____________________
PROVINCE/DISTRICT/COMMUNE/VILLAGE: ____________________

____

I. CROPPING SYSTEM/SEQUENCE (ex. rice-rice)

a. ____________________
b. ____________________
c. ____________________
d. ____________________

II. LAND PREPARATION

Field cleaning: ____________________
a. Start of plowing (month): ____________________
b. Number of plowings: ____________________
c. Number of harrowings: ____________________
d. Interval (days) between plowing and harrowing: ____________________
e. Cost of plowing only: ____________________
f. Cost of harrowing: ____________________
g. Total cost of land preparation: ____________________
h. Source of power (animal/tractor): ____________________
i. Source of labor: ____________________

III. PLANTING

a. Start of planting: ____________________
b. Method of planting: ____________________
- broadcast: ____________________
- row-seeded: ____________________

c. If row-seeded, row spacing used: ____________________
d. Variety: ____________________
e. Cost of planting: ____________________
f. Source of labor: ____________________

IV. FERTILIZER APPLICATION

Type of fertilizer used:

a. ORGANIC

Type/brand of organic fertilizer: ____________

Source: ____________

% elemental content: ____________

Amount applied: ____________

Time of application: ____________

How many times applied: ____________

b. INORGANIC

Type of inorganic fertilizer	(please check)	Amount used (# of bags)
Ammonium sulfate:	☐	☐
Urea:	☐	☐
Triple 14:	☐	☐
16-20:	☐	☐
Other:	☐	☐

Time of application: ____________

How many times applied: ____________

V. PEST MANAGEMENT

Check the most destructive

Common insect pests:

1 ____________ ☐

2 ____________ ☐

3 ____________ ☐

4 ____________ ☐

Control measure(s): ____________

How many times applied: ____________

Timing of application: ____________

Cost: ____________

Common diseases:

1 ____________ ☐

2 ____________ ☐

3 ____________ ☐

4 ____________ ☐

Control measure: ____________

How many times applied: ____________

Timing of application: ____________

Cost: ____________

VI. WEED MANAGEMENT

Check the most destructive

Most common weed species:

1 ______________ ☐

2 ______________ ☐

3 ______________ ☐

4 ______________ ☐

Control method:

Time of application: ______________

Tools used: ______________

If herbicide(s) is used:

Name of herbicide: ______________

Rate of application ______________

Time of application: ______________

How many times applied: ______________

Time spent for spraying: ______________

Source of labor: ______________

Cost of labor: ______________

if manual/mechanical weeding was used:

When was it done?: ______________

How many times?: ______________

Time spent for weeding: ______________

Source of labor: ______________

Cost of labor: ______________

VII. HARVEST AND POSTHARVEST PRACTICES

Method of harvesting: ______________

Sharing system: ______________

Cost of harvesting ______________

Threshing method: ______________

Cost of threshing ______________

Drying method: ______________

Cost of drying: ______________

Seed storage practice: ______________

What container is used for storing rice for seeds?: ______________

How and where are seeds stored?: ______________

VIII. MARKETING

Where is the rice harvest sold?: ______________

Who buys the harvested grains?: ______________

How much is the price/kg?: ______________

How much of the harvested grain is ☐ sold? ☐ for consumption?

Appendix 2. Action Plan

Establishment of a Community-Based Seed System
SAMPLE:

Scenario building: what lies ahead?

Current situation (without CBSS and its technologies)	Future situation (with CBSS and its technologies)
Can be based on problem diagnosis in general and in particular—problems as identified through the participatory rural appraisal/scoping or environmental evaluation; community needs assessment.	What are the indicators of change? Individual farmer, community, association, others? What would you like to see in the future as a contribution of your project?

The importance of the research problem for poverty reduction
Importance is providing high-yielding varieties to achieve higher income.

Description of steps to undertake/ components and activities	Target Indicators	Funding source/ budgetary requirement	Time frame
The following are examples only 1. Site selection, identification of target groups, visioning exercises and consultations, meetings, etc. 2. Identification of farmer-beneficiaries, or formation of farmers' groups, or strengthening existing ones, or facilitating formation into a cooperative (depending on needs, resources, others) 3. Training of farmers on seed health management and on forming a community seed bank 4. Conduct of PVS demonstration trials 5. Seed production/seed multiplication 6. Introduction/provision of improved rice varieties as intercropped with other commodities and integrated crop management (ICM)	Please make the target SMART (simple, measurable, attainable, realistic, and time-bound)		

7. Training programs 8. Scaling-up activities 9. Scaling-out activities 10. Information, education, and communication materials a. Training materials b. Flip chart c. Video on CSB d. Technology brochures/bulletins and leaflets for farmers 11. Operations, financial systems, market linkages, others 12. Training or contact the government institution responsible for quality assurance, or seed certification for guarantee of quality, or establish community guarantee system 13. Others identified as important	Example: number of sites; number of farmers; number of training activities, within a time frame		

Key stakeholders and beneficiaries
(small group discussion with key partners)

Targeted stakeholders for change (next users and final users)	Next users	Final users
Stakeholders who will be involved in the project as research and extension collaborators; define their role	Examples o Agricultural Training Institute (ATI) o District—agriculture services (extension workers) o National policymaker—for upland development, national recommendation for rice cultivation for upland development to include the appropriate rice varieties and community seed bank	Examples Farmers' associations

<table>
<tr><th>Targeted stakeholders for change (next users and final users)</th><th>Next users</th><th>Final users</th></tr>
<tr><td>Targeted stakeholders to receive communication about the project</td><td colspan="2">Examples
o District—agriculture services (extension workers)
o National policymaker—for upland development, national recommendation for rice cultivation for upland development to include the appropriate rice varieties and community seed bank</td></tr>
<tr><td>Beneficiaries
What will they gain from the project?</td><td colspan="2">Examples
Farmers:
o Improved varieties for increased yield/production
o Food security/fewer hungry months
o Seed security
o Increased income from rice
o Enhanced knowledge on seed and rice production
o More active farmers' group interaction, more active community activities</td></tr>
</table>

Institutional linkages

<table>
<tr><th>Organizations (outside the project) responsible for extension/dissemination activities—

indicate here the out-scaling and up-scaling strategies or which linkages are to be strengthened/established because of the project intervention,
and whether the project has a formal agreement (MOA) or informal agreement</th></tr>
<tr><td><u>Examples</u>
o District—agriculture services (extension workers)
o National policymaker—for upland development, national recommendation for rice cultivation for upland development to include the appropriate rice varieties and community seed bank

No need for formal agreement/MOA</td></tr>
</table>

Information, communication, and dissemination strategies
(project perspective: discussion with NARES partners)

Communication and dissemination strategies used	
Next users	**Final users**
o Training materials o Flip chart	o Technology brochures and bulletins and leaflets for farmers
Factors facilitating (F) and Inhibiting (I) adoption—indicate in parentheses	
Next users	**Final users**
Facilitating factor: o Link to national program in rice production; communication with other government units took place Inhibiting factor: o National policy on farmers' use of certified seeds that can possibly pose some limitations on seed exchange	Facilitating factors: o Identification of progressive farmers who help in disseminating varieties and information o Better available/improved varieties o Team members committed to providing information to farmers' groups Inhibiting factors: o Competition with other crops that farmers believe have better opportunities o Younger generation hesitating to take on farming activities