PEDIGREA
Participatory Enhancement of Diversity of Genetic Resources in Asia

April 2006

FIELD GUIDE
FOR PARTICIPATORY PLANT BREEDING IN FARMER FIELD SCHOOLS

WITH EMPHASIS ON RICE AND VEGETABLES
FIELD GUIDE
FOR PARTICIPATORY PLANT BREEDING IN FARMER FIELD SCHOOLS; WITH EMPHASIS ON RICE AND VEGETABLES

This field guide is based on the experiences gained in farmer field schools held in Cambodia, Indonesia and the Philippines, and on the collective inputs of many contributors. In particular, staff and farmer-breeders of PEDIGREA partners Srer Khmer, Field Indonesia, PPRDI, and Wageningen UR (CGN and LEI) provided major inputs.

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The PEDIGREA programme

The Programme on Participatory Enhancement of Diversity of Genetic Resources in Asia (PEDIGREA) was established in 2002 to seek novel practical and sustainable approaches for the on-farm management of crop genetic resources. Over the past decades, increasing population pressure, land degradation and changes in farming systems have resulted in a serious decline of agro-biodiversity and erosion of plant genetic resources. This has limited farmers (and eventually breeders) in their selection work who increasingly depend on declining genetic resources, providing them less opportunities to deal with pests, diseases and options for increasing yields in the future.

PEDIGREA aims to increase the capacity of farmers to conserve and improve their genetic resources using the approaches of participatory plant breeding (PPB). Specifically, PEDIGREA aims to:

- develop locally adapted farmer-friendly approaches and technologies for crop improvement;
- improve the in situ conservation and use of crop genetic diversity;
- support local capacity development for maintaining and generating genetic resources, contributing to empowerment of farmers and other actors.

Simultaneously, the programme focuses on creating and improving marketing opportunities for local and regional farm products, and to develop farmer capacities to manage animal genetic resources.

PEDIGREA uses the farmer field school concept to implement the PPB approaches. The farmer field school concept, pioneered in Indonesia for use in integrated pest management (IPM), has become a well-known and tested instrument for the transfer of know-how to farmers. PEDIGREA wishes to build on this success and to adapt the PPB approaches for farmers' management of genetic resources.

Since 2002, pilot projects for FFS-PPB have been carried out by PEDIGREA partners with selected farming communities in Indonesia, Cambodia and the Philippines, focusing on rice and indigenous vegetables. Projects were primarily situated in rice-based farming systems with a reduced (mainly Green Revolution-initiated) genetic diversity. Additional experiences from training and participation in other on-farm crop conservation and improvement programmes, both in Asia and Africa have been integrated.

PEDIGREA deliberately aims to develop farmer-led approaches in participatory plant breeding, in which farmers, rather than scientists, decide upon the breeding objectives and materials. Using this approach, PEDIGREA intends to empower and strengthen the capability of farming communities to manage their genetic resources as part of local agro-biodiversity, thus contributing to farmers’ food sovereignty. At the same time, PEDIGREA realizes that a maximum of inputs are needed, and therefore pursues and facilitates close collaboration with other stakeholders, including scientists and policy makers. The PEDIGREA programme works on a very modest budget, and thus in a setting that is likely to be the rule in present and future farmer-led PPB programmes.
PEDIGREA Partners

PEDIGREA is a collaborative programme of five partner organisations:

- Field Indonesia (Indonesia)
- Srer Khmer (Cambodia)
- People, Plant Research and Development Inc. (PPRDI, the Philippines)
- Wageningen University and Research Centre: represented by the Centre for Genetic Resources, the Netherlands (CGN), and the Agricultural Economics Research Institute (LEI), the Netherlands
- International Plant Genetic Resources Institute, Asia and Pacific Office (IPGRI-APO), Malaysia

PEDIGREA has been registered in the Philippines as a foundation. The organisation is managed by a convenor and supervised by a board of governors, consisting of representatives from the above mentioned NGOs and institutions:
How to use this guide

This field guide is intended for use by facilitators and development workers who plan to establish participatory plant breeding projects using the farmer field school approach (FFS-PPB). It is also meant to assist facilitators and development workers on how to continue FFS-PPB activities after the initial FFS season-long training course. The guide is the result of several years of development by the PEDIGREA partners and provides a compilation of current knowledge, tools and exercises for the implementation of FFS-PPB. It is presented as a work-in-progress document, expecting that it will enrich the FFS-PPB concept and provide a basis for further development of FFS-PPB approaches, in other crops, cultures, and farming environments.

The guide addresses main issues concerned with the organisation and facilitation of FFS-PPB, and includes the following elements:

- Introduction, FFS planning and preparation (Chapter 1 and 2).
- Start-up FFS training module for rice and vegetables, including village baseline survey (Chapter 3 to 6).
- Follow-up field studies, enhancement studies and background topics (Chapter 7 and 8).
- Tools for monitoring and evaluation and community mobilisation (Chapter 9 and 10).

Three types of tools are described in this guide: basic tools, crop-specific tools and background tools. Basic tools are tools that can be used for all types of FFS-PPB training. They are described in chapters 3, 4, 8, 9, and 10. Crop specific tools have been developed for use in certain crops only, and are detailed in chapters 5 and 6. Background tools are dealing with special topics to help participants better understand the underlying issues, and are described in chapter 7.

Crops in this field guide were selected by farmers during baseline surveys as highly valued food or cash crops in the respective farming environments. Rice forms the main staple crop for many farmers in Asia. Selected vegetables are major indigenous cash crops grown in rice-based farming systems.
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## Glossary

### General terms
- **FFS**: Farmer Field School
- **FFS-PPB**: Farmer Field School on Participatory Plant Breeding
- **NARS**: National Agricultural Research System
- **NGO**: Non Governmental Organisation
- **PPB**: Participatory Plant Breeding
- **PVS**: Participatory variety selection (variety trial)

### Breeding terms
- **Agrobiodiversity**: The sub-set of biodiversity present in agricultural production systems
- **Allele**: An alternative gene for the same function and at the same DNA location
- **B1**: First backcross
- **Backcross**: A cross of a F1 with one of its parents
- **Biodiversity**: The diversity of life forms on our planet, measurable as the variety within species, between species, and the variety of ecosystems
- **Breeding line**: A group of plants from a common ancestry (cross)
- **Bulk selection**: Selection procedure in self-pollinated crops
- **Cross pollination**: Transfer of pollen from anthers of one plant to the stigma of another plant
- **DNA**: The material inside the cells of a living organism that carries genetic information
- **Dominant gene**: A gene that always shows itself
- **Emasculation**: Removal of anthers from a bud or flower before pollen is shed to prevent self-pollination
- **F1**: The first generation offspring of a (varietal) cross
- **F2**: The second generation offspring of a (varietal) cross
- **Gene**: Basic unit of heredity found in all cells of a living organism, consisting of DNA
- **Genetic recombination**: Formation of new gene combination as a result of cross fertilization between individual plants
- **Genotype**: The genetic make-up of a plant or organism
- **Germplasm collection**: A collection of genotypes of a particular species from different sources and geographic locations, often used as source materials in plant breeding
- **Heredity**: Transmission of genetic characteristics from parents to progeny
- **Heritability**: Portion of observed variance that is inherited
- **Homozygote**: Plants or other organisms carrying identical alleles of the same gene (on both homologous chromosomes)
- **Heterozygote**: Plants or organisms carrying two different alleles of the same gene (on both homologous chromosomes)
- **Hybrid or cross**: First generation offspring of a cross between two varieties or genetically different plants
- **Inbreeding**: Breeding of closely related plants or other organisms
- **Isolation**: Separation of varieties in time or space or by another barrier preventing (unwanted) pollination
- **Mass selection**: Selection procedure often employed in cross-pollinated crops
- **Mutation**: A change in a gene
- **Outcrossing**: Cross pollination between two genetically different plants
- **Pedigree selection**: Selection procedure often employed in self-pollinated crops
- **Phenotype**: Visual appearance of a plant or other organism
- **Plant character, trait or attribute**: The result of the expression of a gene
- **Progeny**: Offspring of a particular plant or organism
Progeny or pedigree testing  Evaluation of a plant genotype by testing the progeny
Recessive gene  A gene whose expression is suppressed
Recurrent selection  Selection procedure often employed in cross-pollinated crops
Segregation  Separation of two alleles from one another during the plant's reproductive phase; for self-pollinated crops the result is visible in the F2 population
Self pollination (selfing)  Transfer of pollen from an anther to the stigma of the same flower or other flower on the same plant
Variability  The level of diversity in a population
Variety (cultivar)  A group of similar plants that can be identified from other varieties within the same species through genetically inherited structural features and performance

**Flower terms**

**Anther**  The pollen bearing portion of the stamen  
**Anthesis**  Process of splitting of the anther freeing the pollen  
**Dioecious**  Flowers with male and female organs on different plants  
**Diploid cell**  Cell in seed and plant phase having a double set of DNA strings (normal situation)  
**Egg**  Female germ cell  
**Fertilization**  Union of an egg with pollen sperm to form seed  
**Floret**  Small flower from an inflorescence like in rice  
**Haploid cell**  Sperm or egg cell having a single set of DNA strings  
**Inflorescence**  A cluster of flowers  
**Monoecious**  Flowers with either male or female organs on a single plant  
**Ovary**  The enlarged basal portion of the pistil in which the seeds are born  
**Pistil**  The seed bearing organ in the flower  
**Pollen**  Male germ cell  
**Stamen**  The pollen bearing organ in the flower, composed of an anther and filament  
**Stigma**  The portion of the pistil which receives the pollen  
**Style**  The stalk connecting the ovary and the stigma
1. GENERAL GUIDELINES

1.1 The Framework

Farmer field schools on participatory plant breeding (FFS-PPB) are conducted like many other farmer field schools, but with one major difference: the span of attention and attendance for participants is significantly longer than in ordinary FFS programmes: in stead of the usual one-season-long training approach, the duration of a FFS-PPB takes considerable more time, from a minimum of 2 seasons to approx. 8 seasons in total. A good preparation in the first seasons, therefore, is crucial.

There are different levels of FFS-PPB training courses, each supporting the other in time and content: from the village baseline survey to a start-up FFS-PPB training course, and follow-up field studies, and finally enhancement studies (figure 1). Farmers may choose to follow other FFS-PPB courses on other crops or related topics, such as on animal genetic resources.

Figure 1.1: Sequence of activities in FFS courses on PPB

A community programme on PPB may cover one or several crops. In PEDIGREA, the FFS-PPB on vegetables focuses on two or three crops and is usually conducted after the FFS-PPB on rice, the farmer’s main staple crop. Once farmers have proceeded to follow-up field studies, they generally focus on two or three crops with programmes overlapping in time; for example they may study rice and two crops of vegetables, or include three crops of vegetables and no rice. Enhancement studies are FFS studies on topics related to and in support of the FFS-PPB programmes. Generally they have a much wider scope, such as a study on marketing potentials.

1.2 Organisation

The following are some basic considerations in the organization of a FFS-PPB:
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<th><strong>Considerations</strong></th>
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<tr>
<td>Size of a class</td>
<td>25-30 people</td>
</tr>
<tr>
<td>Age of participants</td>
<td>20 years of age or older. A good mix of young and old farmers</td>
</tr>
<tr>
<td>Gender balance</td>
<td>Approximately equal numbers of females and males</td>
</tr>
<tr>
<td>Facilitator profile</td>
<td>Ideally both men and women who:</td>
</tr>
<tr>
<td></td>
<td>• are a farmer him/herself and have know-how on the crops</td>
</tr>
<tr>
<td></td>
<td>• live in the same community as the participants</td>
</tr>
<tr>
<td></td>
<td>• have had prior farmer field school training</td>
</tr>
<tr>
<td></td>
<td>• have good interpersonal and literacy skills</td>
</tr>
<tr>
<td></td>
<td>• are dedicated to the programme for a period of four years or more</td>
</tr>
<tr>
<td>Duration of the start-up FFS-PPB course</td>
<td>One session per week during a period of 18 weeks, or about 4 months approx., depending on the crop</td>
</tr>
<tr>
<td>Duration of the FFS-PPB training programme</td>
<td>Total training programme varies from 2 to 8 seasons (1-4 years, with two cropping seasons per year)</td>
</tr>
<tr>
<td>Time for each session</td>
<td>Most sessions run from 7 to 11 a.m. in the morning</td>
</tr>
<tr>
<td>Number of facilitators</td>
<td>Three is normally sufficient; usually this involves two farmer-facilitators and one local district agricultural officer</td>
</tr>
<tr>
<td>Venue for the FFS-PPB</td>
<td>Participants decide where to meet; this can be under a tree, at a farm house, or in a public meeting hall</td>
</tr>
<tr>
<td>Attendance</td>
<td>Participants agree on a set of rules which includes attendance, time of the sessions, and possible sanctions for absence. Generally, farmers can be excused from one session only.</td>
</tr>
<tr>
<td>Answers to questions</td>
<td>Groups and participants can provide answers developed by themselves</td>
</tr>
<tr>
<td>What is and is not negotionable</td>
<td>Non-negotiable: basic curriculum and processes of the FFS-PPB course</td>
</tr>
<tr>
<td></td>
<td>Negotionable: topics covered in each session should be discussed among participants. Facilitators may create, in addition to basic and crop-specific topics, room for additional topics</td>
</tr>
<tr>
<td>Materials needed for each session</td>
<td>Flipchart, A4 size paper, markers, pens, masking tape and scissors; additional materials as needed.</td>
</tr>
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1.3 FFS objectives

The farmer field school on participatory plant breeding aims at helping farmer participants to become more knowledgeable, skilled and confident on matters related to the conservation and improvement of plant genetic resources. The farmer field school is therefore foremost a process of empowerment. This goes hand in hand with a process of improving local capacities, teaching farmers breeding technologies to develop locally adapted varieties that are better fitting the farmers’ local environment. Increased skills and knowledge of farmers are needed to start a process of preserving the genetic resources, varieties that may be cultivated by only a few or many farmers, containing valuable traits, which may be useful in future to increase resilience and food security. Preservation of these varieties goes hand in hand with the appreciation of their social and economic value, both by producers and consumers. These comprise the three elements needed to make the FFS-PPB programme a success.

Figure 1.2: The three basic components of FFS-PPB
Once the community has decided to start a FFS-PPB programme, a process of planning, preparation and implementation begins, involving a village baseline survey, selection of suitable germplasm, and the implementation of the start-up FFS-PPB training course. The latter aims directly at laying the foundation for the PPB programme. At the end of the season-long FFS-PPB course, participants and facilitators sit down to evaluate what they have learned and achieved, and make a planning for the follow-up field studies in the next growing seasons.

**Learning targets of the FFS-PPB main course**
At the end of the first season participants are expected to:

- be able to make variety or line selections based on pre-determined strategic breeding goals;
- understand the morphology and reproductive processes in selected crops and successfully practice varietal crossing.

**Additional results**
In addition, together with the learning goals, the course will result in:

- one or more superior varieties selected from the variety trial;
- successful crossed (F1) seed harvested, stored and ready for planting in follow-up field studies.

In the follow-up studies a process of selection and breeding begins, which may take multiple seasons and is expected to culminate in the release of one or more new varieties. Such farmer-bred varieties are expected to be better adapted and higher performing under the prevailing farmers’ environment.
2. PLANNING AND PREPARATION

2.1 Field studies

Farmers first start with a season-long FFS course. The initial FFS course on PPB involves a large set of studies; farmers learn to compare and evaluate new varieties, conduct plant growth studies, experiment with breeding techniques, and review crop improvement strategies. The field is the primary learning stage for the participants, where they can practice their studies.

Activities in this start-up course take place from just before sowing to after crop harvest. For rice and most annual crops, the FFS course takes 4 to 5 months or 18 weekly sessions to complete. A typical start-up FFS-PPB includes the following elementary field studies:

- **Variety Evaluation trial (PVS: Participatory Variety Selection)**; the study on variety evaluation or comparison is conducted in a field trial and allows farmers to build skills in evaluating a diverse number of local varieties (more than they are used to) for performance of particular pre-determined traits.

- **Plant growth and reproduction morphology**; Field studies on the plant reproductive morphology and processes aim to strengthen the farmer’s understanding of the biological processes involved in the reproduction of plants, an understanding needed for the successful operation of a cross-breeding programme.

- **Variety Crossing**; After studying the plant’s reproduction processes, farmers apply their knowledge by crossing a number of self-selected varieties, and study different methods and tools, which influence the success of hybridization.

- **Variety breeding (selection in segregating populations)**; This study allows farmers to acquaint themselves with segregation in populations and to practice different selection techniques in the field. This step may involve early and/or advanced segregating populations. The study on variety breeding depends on the availability of segregating materials from nearby plant breeding stations or other farmer-breeders and on the planting area available in the farmer’s field.
2.2 Facilitators

Most FFS-PPB courses are conducted by three facilitators, two farmer-trainers and one local agricultural extension officer of opposite gender. Good preparation by the FFS facilitators is crucial for the success of the start-up FFS-PPB. Farmer-facilitators and other facilitators are trained to plan and prepare the FFS-PPB in a training of trainers (TOT) workshop prior to the FFS. In this TOT, conducted 1 to 2 months before the FFS, facilitators prepare for the following tasks:

- to facilitate the conduct of a village baseline survey;
- to explore potential sources of germplasm for use in the FFS-PPB;
- to prepare a (draft) curriculum for a 18 week FFS course focusing on the priority crop(s) selected by the community;
- to list materials (pens and paper etc.) required for the FFS course;
- to develop a realistic budget.
2.3 Pre-selection of crops and areas

A FFS-PPB programme generally starts with identifying the most suitable crops and areas, which is done in a participatory way. Based on the programme objectives facilitators and selected farmers need to determine what area or farming system to choose (dryland or irrigated, subsistence or market driven), and what crops to select (major staple crops, cash crops, indigenous crops).

In some cases, crops are chosen before the area selection. This is often the case regarding the staple crop(s). However, one can also choose a crop category, and decide to select the (additional) priority crop(s) during the baseline survey. In that case the farming community is more involved in the selection process, which may significantly contribute to the success of a FFS-PPB.

A common approach to analyze potential areas and associated farming systems is by using secondary data from government extension agencies. After suitable areas have been identified and selected, farming communities and villages are identified for implementation of the (initial) FFS-PPB.

Guiding questions in the selection process of crops, areas and communities are:

- Is the area representative of a given farming system?
- Is the crop a major staple or cash crop for farmers?
- Is the location accessible for FFS facilitators?
- What is the prospect for farmer-to-farmer FFS and for scaling-up of the approach?

Occasionally, neighbouring communities which are not initially targeted in the planning may invite the core team to conduct a FFS-PPB in their community. Granting such request is advisable, but nevertheless consideration should be given to the community’s farming system, and selection criteria and choices regarding implementation sites of FFS-PPB made earlier.
2.4 Village baseline study

A village baseline survey on the availability of plant genetic resources is an essential step in the preparation of the FFS and aims to prepare, to validate and to sensitise the farmer community in preparation for the FFS-PPB. Using group exercises, farmers will collect necessary information concerning the status of plant genetic diversity in their farming community and the major production and marketing constraints, and they will list the (perceived) positive and negative traits of the varieties planted. Based on this assessment, farmers will then determine the attributes of the ‘dream varieties’, that are most valued in production, trade and consumption. Upon prioritization of the respective crops, these criteria will form the farmers’ breeding goals which will be used in the FFS-PPB course.

An alternative approach to planning and preparation of FFS-PPB

Faced with practical limitations in the preparation for a FFS-PPB, Field Indonesia has been experimenting with alternative planning approaches. The first problem they encountered regarded the training of trainers (TOT). It was found that although farmer-trainers enthusiastically participated in the 6 days TOT, they tended to rapidly forget most of the technical and participatory aspects discussed in the FFS curriculum, and instead focused on the novelty of the variety crossing process. Farmers and facilitators were also pressed by time, which limited the span of attention in the TOT.

To resolve this issue, Field Indonesia split the TOT into two three-day halves, the first one held prior to the FFS course focussing on technical issues, such as database establishment, biodiversity, globalization and its impact on sustainable agriculture, genes and genetic inheritance, varietal crossing, imagining the dream variety and how to make it, plant morphology and group dynamics. This was done in order to satisfy the farmer’s curiosity and to prepare the FFS curriculum. The second part of the TOT was held during the FFS to reflect on the experiences, strengthen the farmer’s facilitation skills, and to discuss some specific topics like selection techniques and the set-up of a Farmer Field Day. Also, most of the baseline survey was integrated in the FFS-PPB course itself.

Both planning methods have their advantages and disadvantages. The integration of the baseline survey in the FFS-PPB curriculum usually does not allow for sufficient time for preparation of field activities and collection of genetic materials. Field Indonesia’s approach to split the TOT and to schedule a shortened TOT during the FFS course, however, appeared a good way to reflect on the actual FFS experiences.
2.5 Village preparatory meeting

After completion of the baseline survey, leaders of the selected village(s) should be asked to organize a community meeting to analyse the results of the baseline survey and provide for the preparation of the primary season-long FFS-PPB course. This meeting is the perfect opportunity to challenge and motivate farmers to participate in the FFS. Local farmer trainers and farmers who have previously participated in a FFS-PPB, preferably of the same ethnic, cultural and linguistic background, may be invited to report on their experiences. For demonstration purposes, facilitators may also bring along photographs and displays used in Farmer Field Days.

Once the community agrees to go ahead with the FFS, various additional topics should be discussed including the selection of participants, the collection of suitable germplasm, the timing of the FFS-PPB, and the field study site. Before closing of the village meeting, the date of planting for the field studies and the date of the first FFS session should be agreed upon; also activities needed for the preparation of the FFS course should be determined and responsibilities assigned. Facilitators may need to revisit the community once or twice before the first FFS-PPB session, to monitor the progress of planned activities.

2.6 Collection of germplasm

Based on the breeding goals, which were set during the baseline survey, facilitators and farmer participants should arrange for the introduction of a number of previously untested varieties in the community, usually between 10 and 15 seed lots. Once collected, these seed lots will be included in the variety evaluation trial and compared against local varieties popular with farmers. Suitable varieties may be collected from neighbouring communities, farmers in other districts, from research stations or national and international genebanks. When the locally available varieties do not have the required attributes, there may be a need to organise a field trip consisting of farmers and facilitators, or farmers together with experts to actively search for varieties in other regions. The local organisers may also help in connecting with national and international genebanks and research institutions to request for suitable material, such as foreign varieties and segregating materials.

<table>
<thead>
<tr>
<th>Table 2.1: Sources of germplasm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source of germplasm</strong></td>
</tr>
<tr>
<td>Varieties cultivated in the</td>
</tr>
<tr>
<td>farmers’ own village</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Varieties cultivated in</td>
</tr>
<tr>
<td>other neighbouring villages</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Varieties cultivated in</td>
</tr>
<tr>
<td>other districts, regions,</td>
</tr>
<tr>
<td>countries</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Varieties stored in national and international genebanks

Acquired varieties from local farmers. Many vegetable varieties are often poorly characterised. Rice germplasm is generally well characterised, but chances that the material is adapted to the local environment are limited. It may be difficult to obtain enough seed for the studies.

Breeding materials from research institutes

Access to breeding materials depends on good relations with research institutes and sometimes requires a material transfer agreement (MTA), that may limit its use. Information concerning the origin is usually not provided.

For each variety, sufficient seed should be collected. As a rule of thumb at least five times more seed should be collected than the quantity of seed needed for planting in the variety trial. Part of the seed should be used in the variety trial, another part must be stored at a farmer’s house for back-up, and a third part should be stored at the local organisation’s office or at another suitable place for use in other FFS-PPB programmes. When only a limited quantity of seed can be collected, seed needs to be multiplied first.

Some germplasm may be received without a good description. In this case, a pre-screening trial is needed to ensure that the germplasm largely meets the farmers’ preferred attributes. All collected germplasm should be characterised and documented using a simple format through visual observation and through interviews with the farmers from which the seed is collected.

![Germplasm Collection Form](image)

**Figure 2.3: Example of a germplasm collection form**

### 2.7 Selection of participants

A FFS training usually consists of about 25 farmers. Participants should be selected from members of the farming community after the conduct of the
baseline survey, and be eligible to the following, negotionable\textsuperscript{1} criteria. Participants should:

- have farmland in the immediate village neighbourhood;
- should be active farmers with a keen interest in variety multiplication and crop selection;
- have experience in the cultivation of selected priority crop(s);
- be in good health, between 18 and 60 years old, preferably with some basic education;
- be committed to attend the trainings over the full duration of the FFS-PPB.

The list of participants, unless otherwise decided, should include male and female, young and elderly farmers. Some persuasion may be needed to get female (or male) farmers to participate in the FFS, especially in some cultural settings, and where the other sexe is predominantly involved in the decision what to plant.

During the village preparatory meeting some farmers may already sign up for the FFS-PPB, others may need more time to think about it. The list of participants should be completed one to two weeks before the first official FFS session. This allows facilitators to screen the participants and to utilise their knowledge and availability to assist in the preparation of the FFS.

Note: The best way is to let the community decide who should participate, using the above or similar criteria, since this builds a sense of accountability and ownership.

Gender sensitization exercise

The following exercise may be conducted to sensitisre the community on gender-related matters:

- prepare with participants a list of 20 activities in the farm, such as land preparation, seed selection, method of planting, weeding, pesticide application, harvesting, processing etc.;
- identify who decides, who is doing it, and why, by differentiating male or female, husband or spouse;
- discuss whether the gender balance on decisions and activities in the farm is reflected in the list of participants in the FFS-PPB course.

Table 2.2 Gender comparison of farm activities

<table>
<thead>
<tr>
<th>Activities in Agricultural Production</th>
<th>Who Decides</th>
<th>Who is doing it?</th>
<th>Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Land Preparation</td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>2. Seed Selection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Seedbed Preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Method of Planting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{1} For example, in an experiment of PPRDI in Sagkungan, Mindanao, a number of grade schoolers, aged between 11-13, took part in a FFS as full participants.
2.8 Selection of field study site

It is strongly recommended that all studies be set up in a single field, close to the village, to facilitate weekly observations, experimentation and learning. The size of a field site should usually not exceed 2000 m². The field can be a privately or community owned land. Usually, some form of in-kind compensation may be required, which could come in the form of free lunches and snacks during the FFS sessions, provided by the community or programme. A field study site qualifying for the FFS-PPB should fulfil the following criteria:

- levelled and homogenous land, representative of the local agro-ecosystem and local farmer fields;
- away from houses and big trees;
- with easy access to water/irrigation;
- not near a lighted electric post (for rice);
- fenced or near a house to keep out stray animals (for vegetables);
- within walking distance from the village;
- strategically located so that other people can see the experiments.

A meeting place should be arranged near the field study site for teaching, analysis and plenary discussions. This can be a farm house, a public building, or just a few benches under a large tree.

2.9 The first FFS session

Finally the time has arrived for the first FFS session! This opening session is conducted one to two weeks before the date of sowing and must be attended by all participants. The session is highly important because it sets the stage for the rest of the FFS. Main activities during this session include:

- meeting between the participants, getting to know each other;
- explaining mutual expectations, agreeing on a facilitator-learner covenant;
- planning of field studies and field layout;
- preparation of a workplan and assignment of responsibilities.
Expectation Setting
Both farmers and facilitators raise expectations. Facilitators are required to present the basic outline agreed for the day or week ahead that will help participants to consider the learning activities and to provide the inspiration needed towards meeting the demands of the programme. It will give participants a basis to later evaluate the activity. In return, facilitators may expect the participants to have a good degree of commitment and participation in the FFS course. A participant therefore is expected to know not only the goal of the activity, but also what is required from him/her to achieve that goal and to do whatever he/she can to bring it to that end. The expectation also provides the facilitator a basis for evaluation of the activity.

To stimulate active commitment, facilitators and farmers may prepare and agree on a learning covenant. This facilitator-learner covenant is a set of practical principles clearly describing the roles and responsibilities of the facilitators and participants. For example, it may set the time for the weekly sessions, and the definition of being late or absent, but it may also mention that facilitators are expected to state the goal of the activity and close each session with an evaluation. The contract can act as a constant reminder throughout the FFS of the mutual obligations and can be very helpful in keeping the FFS on track. The usefulness of a facilitator-learner covenant should be discussed and the content mutually agreed upon during the first FFS session.

2.10 Layout of Field Studies
All studies should be conducted preferably in one field (Figure 4). The study field lay-out, including the location of the nurseries, should be discussed thoroughly and mapped out well with the participants one to three weeks before planting. Two types of maps should be prepared: a map depicting the layout of the entire field with the location of the different varieties, and a map with planting instructions on the required plant spacing for the selected crop.

Variety evaluation trial (PVS)
The size of the variety evaluation study depends on the number of varieties that farmers may wish to include in the study, the number of plants of each variety sown in each plot, and the number of replicates. The number of plants or hills per plot may vary per crop but should not be less than 30 for vegetables and 100 for rice. The layout of the variety evaluation should be as simple as possible. A partially replicated evaluation trial is usually sufficient; in this design one control variety is planted for every four varieties (Figure 5).

Other, more complicated, designs may be used, with two or more replicates; however, this type of designs is usually not advisable for the FFS-PPB, as farmers are not familiar with the more complicated data analysis involved. When the field is not uniform or sloping, the variety trial should be designed in such way that all variety plots experience the same variation. For example, on a hilly terrain, the plots should be planted parallel against the elevation gradient.
Plant growth and reproductive morphology
For this study usually a separate plot with plants of different varieties is planted to facilitate the study on the topic of plant reproductive morphology. Since the study involves flower dissection and uprooting of plants, using plants of the variety trial itself should be avoided, as this may interfere with the results of this study.

VARIETAL CROSSING
For the performance of variety crossings the same plot can be used as for the plant morphology study. Facilitators should ensure that the flowering of the different varieties is sufficiently synchronous by planting each variety in three subsequent periods. In particular, this is necessary when farmers wish to cross short-duration modern varieties with traditional varieties with long maturation periods. For most vegetables, the flowering period stretches over a relatively longer period, so that periodic planting is usually not required. In the case of rice, plants can be uprooted, potted, and placed near the meeting venue for demonstration, the making of crossings and for observation.

Variety breeding (selection in segregating populations)
For selection purposes, each progeny population should be planted in a separate plot, and plants should be planted one seedling per hill. Parent varieties of the segregating population should be planted adjacent to the study plot for comparison.

For all studies the following standard procedures apply:

- Each variety needs to be kept separate and labelled to avoid admixtures. Nurseries need to be protected with a cage against birds and foraging animals. Labels, signs and markers should be placed in the field, and a map of the field trial should be maintained, which will assist participants in identifying the varieties and populations.
- Field preparation such as ploughing should be done two to three weeks before direct sowing or transplanting. Plant spacing, soil tillage, fertilizer practice, weeding and pesticide spraying should be as per farmer’s practice.
Figure 2.4: Field layout for farmers’ field studies in the FFS-PPB on rice (figures indicating the different varieties, with no. 1 as control)

Figure 2.5: Example of an instruction for a planting layout in a variety plot
Workplan

The final task during the first FFS session is to prepare a *workplan* which sets the different tasks and responsibilities in the period between the first FFS session and the sowing and planting of the field studies. Workplans should describe the activity, when it should be done, who will participate, coordinate, and what materials are needed.

Workplans should be discussed two to three weeks before the planting of the trial, provided that the varieties and sources have been identified and seed is available. Farmers may need more time to collect the seed. If so, a field trip may be organised at least one month before the initiation of the FFS to allow for the seed to be collected.
3. VILLAGE BASELINE SURVEY

3.1 Introduction

The village baseline survey is usually the first activity in the farming community where the FFS is to be implemented and aims to build a foundation for the conduct of the FFS-PPB. The specific purpose of the village baseline survey is threefold:

- to increase the level of understanding of the local status of genetic diversity and the dynamic forces that drive them;
- to generate awareness among farmers concerning their role in on-farm crop improvement;
- to lay the foundation for the conduct of the FFS-PPB i.e. setting breeding objectives.

Many of the methodologies described in this chapter have been developed and tested in different cultural and environmental settings in farming communities of Asia and Africa over a substantial period of time.

The baseline survey uses group dynamics through targeted exercises as its main approach. In addition to group dynamic processes, semi-structured interviews of focal groups with feedback to the plenary are conducted, which fill-in information gaps identified during the group exercises. Facilitators should make sure that a good representation of the village community, both young and elder farmers, male and females is achieved.

While tools have been developed primarily for literate farmers, the survey can also be used in largely illiterate farming communities. If illiteracy is substantial, facilitators should make some adaptations, for example:

- use samples of live plants as much as possible;
- make use of visual tools like drawings;
- use symbols and pictograms in stead of names of varieties and traits;
- use units of beans or pebbles in stead of numerical figures for ranking purposes.

Farmers discussing genetic diversity

Final results of group work and interviews should be reported back to the plenary meetings, while at the end of the survey results of the survey should be reported back to the entire village community. In preparing for such
meeting, facilitators may use a simple reporting format for documentation. The documented results, which may include a short analysis concerning gaps in know-how and skills in the farmer community, will help the community and the facilitators to revisit the breeding objectives during the FFS-PPB.

3.2 Overview: steps in the village baseline survey

The village baseline survey involves six steps. A sequence of three days is usually sufficient to complete the survey. An extra day may be needed for verification of data and reporting. Each step involves consultations within the community and may include one or more exercises. Steps involved are:

1. Understanding farmer production systems and identifying crops that play an important role in this system.
2. Identifying existing varieties, characterising the performance and preferred/non-preferred traits, and assessing changes in genetic diversity over time.
3. Identifying farmer’s breeding goals and preferred attributes.
4. Analysing the existing seed systems within and between communities, and identifying gender roles.
5. Describing the markets and market channels for selected crops and varieties.
6. Final selection of priority crop(s) for FFS-PPB.

When the programme staff or the community already has settled on a priority crop, such as in the case of rice, step 1 (except interviews) and 6 can be omitted. A possible schedule for the survey has been elaborated below.

Table 3.1: Schedule for a village baseline survey

<table>
<thead>
<tr>
<th>Preparation of Team</th>
<th>Team reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1: 8-12 am</td>
<td>Day 4: Verify data, consult farmers if needed and prepare survey report</td>
</tr>
<tr>
<td>1. Identification and prioritization of crops and varieties</td>
<td>Day 3: 8-12 am 5. Crop market analysis</td>
</tr>
<tr>
<td>Day 2: 8-12 am</td>
<td></td>
</tr>
<tr>
<td>2. Continued: Evaluation of Genetic diversity</td>
<td></td>
</tr>
<tr>
<td>3. Setting of breeding objectives</td>
<td></td>
</tr>
<tr>
<td>Day 3: 8-12 am</td>
<td></td>
</tr>
<tr>
<td>5. Crop market analysis</td>
<td></td>
</tr>
<tr>
<td>Day 1: 2 – 5 pm</td>
<td></td>
</tr>
<tr>
<td>2. Evaluation of Genetic Diversity</td>
<td></td>
</tr>
<tr>
<td>Day 2: 2-5pm</td>
<td></td>
</tr>
<tr>
<td>4. Seed System Analysis</td>
<td></td>
</tr>
<tr>
<td>Day 3: 2 – 4 pm</td>
<td></td>
</tr>
<tr>
<td>6. final crop selection, finalization and wrap- up</td>
<td></td>
</tr>
<tr>
<td>Day 1: 8-9 pm</td>
<td></td>
</tr>
<tr>
<td>Team prepares next day</td>
<td></td>
</tr>
<tr>
<td>Day 2: 8-9 pm</td>
<td></td>
</tr>
<tr>
<td>Team prepares next day</td>
<td></td>
</tr>
<tr>
<td>Day 3: 4-5 pm</td>
<td></td>
</tr>
<tr>
<td>Collect data sheets for day 4</td>
<td></td>
</tr>
</tbody>
</table>

The tools described should be used in a flexible way and adjusted or omitted depending on time, place and social settings. In case farmers cannot meet
on subsequent days, or are limited in terms of time available per day, the survey can be implemented over a period of several days or even weeks.

Identification of crops and farmer production systems (step 1)

Purpose:
- to understand the crop genetic diversity at community level;
- to understand the use of certain crops and varieties, explaining why farmers plant these crops;
- to arrive at a first selection of priority crop(s).

In this exercise participants will prepare a list of crops that are cultivated in the community and categorise these crops using different sets of criteria. In the first part, crops are listed and categorised using criteria for ease of multiplication, in the second part, crops are categorised using a four-square analysis providing information concerning the use and importance of certain crops in the community. At the end of the exercise, participants have gathered sufficient critical information to be able to select one or more priority crops. This exercise may not be needed if the community or the programme has already settled on a priority crop.

Crop listings and categorization

Time: 2 hours

Groups of 4-5 participants should list on a paper roll the crops that they plant, use and consume or market in their community. Depending on the focus also wild, (semi)-perennial (bushes) and perennial crops (trees) may be listed. Allow sufficient time for participants to complete this exercise (usually this takes at least 40 minutes). Prior to this exercise participants should be requested, if the situation allows, to collect live materials such as seeds, roots or complete plants grown in their community, which facilitates the determination of crop names and types. Such approach also helps farmers in the listing process, especially illiterate farmers. To save on time, participants may be informed the day before to collect the materials. Display the plant or plant parts on a wall or table for easy reference.

Once completed, facilitators prepare a final list of unique crop names, to be compiled in the plenary. If names are not familiar, verify names listed by individual farmers. Check for possible duplications, such as synonyms, plant parts collected and used from the same crop, and names of subspecies (varieties). Categorize the vegetable species using the table below.
Table 3.2: Crop listing and categorization

<table>
<thead>
<tr>
<th>Crops</th>
<th>I. Crops multiplied from seed by farmers</th>
<th>II. Crops vegetative multiplied by farmers</th>
<th>III. Crops never multiplied by farmers / always purchased from outside community</th>
<th>IV. Herbal crops cultivated</th>
<th>V. Herbal crops collected from the wild</th>
<th>VI. Crop trees and shrubs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2.</td>
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<td>3.</td>
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<tr>
<td>4.</td>
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<tr>
<td>5. etc</td>
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</tr>
</tbody>
</table>

* Crops may be listed in more than one column

Four Square Analysis

*Time: 1 hour*

This exercise will inspire farmers to assess the value of the listed crop in the community, especially in terms of marketability, consumption and other uses. This may lead participants to discuss why crops are maintained in the community and for what purpose. The exercise can best be performed in a plenary discussion.

Ask participants to list crops using the four categorisation blocks in table 2 below.

Table 3.3: Four Square Analysis (Crops)

<table>
<thead>
<tr>
<th></th>
<th>Large areas</th>
<th>Small areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many households</td>
<td>A. List of crops</td>
<td>B. List of crops</td>
</tr>
<tr>
<td>Few households</td>
<td>C. List of crops</td>
<td>D. List of crops</td>
</tr>
</tbody>
</table>

Note: there can be duplication of crops horizontally or diagonally but not vertically, i.e. crops that are grown by a few households cannot be grown by many households, but crops grown in small areas can also be grown in large areas.

In the plenary, discuss what participants mean by few/many households, and by large/small areas in their community (usually few households = less than 5% of total household). In addition, discuss with participants the following issues:

- Why some crops are only grown by a few households on large areas (C)?
- Why many farmers maintain only small areas for certain crops (B)?
• Why some crops grown are maintained by only a few households on small areas (D)?
• What crops are most profitable and why?

For this categorisation all crops listed in table 3.2 may be used, but if time is a constraint, the exercise can be limited to the crops listed in column I, II and III only. Crops listed in Column IV, V and VI usually will not fit in a PPB/PVS programme because of problems in multiplication or because of the extended growth cycle.

Results of a four square analysis in vegetables

Semi-structured interviews

Interviews with resource farmers in the community provide a general impression of their farming systems, revealing important issues such as constraints in production, marketing, and other socio-economic problems. If time allows, facilitators may further elaborate on specific problems experienced in the farmer’s production systems.

Crop Prioritization

Time: ½ hour

For the final prioritization, facilitators may use only the crops that are listed in box A and B of the four square analyses in table 3.3. Crops that are grown only by a few households may be excluded as it is unlikely that the community as a whole will benefit from breeding these crops, unless the participants or programme have indicated that these crops are underutilized, have considerable potential and should be promoted in the community.

From the list of vegetable crops, select one or more (with a maximum of six crops) for further analysis in the baseline survey. Various criteria for crop selection may be used, such as: commercial attractiveness, role in the local diet and use in the kitchen, and extent of planted area in the community, cultural/ traditional aspects, etc. A variety of selection methods can be used such as: ballot box, cards with individual preferences, or just plain hands voting.
3.3 Analysis of genetic diversity (step 2)

Purpose:
- to characterize and classify varieties planted by farmers in the community;
- to understand why farmers decide to grow particular varieties;
- to understand changes in genetic diversity over time.

Once the priority crops are chosen, participants should list the varieties grown by the farming community and characterise them separately for each crop. This exercise offers a well-structured method to identify the positive and negative traits in the existing varieties and to determine trends in genetic diversity and preferences over time. At the end of this exercise, participants should have a good idea what makes them decide to grow these varieties.

The exercise consists of three parts. In the first part, varieties are listed and characterised, in the second part, the varieties are classified in terms of value and importance in the community using the four-square analysis, and in the third part participants determine the changes in diversity and variety preferences over time. Group discussions may be complemented by semi-structured interviews with focus groups to obtain answers to remaining questions.

Variety listings and categorization

*Time: 2 hours*

Groups of 4-5 participants focus on one crop. Ask participants, a few days prior to this exercise, to bring as many samples of varieties for identification, description, and discussion of preferred traits. Use table 3.4 below to list in the top row the names of the varieties grown in the community. Then ask farmers to discuss and decide what are the top-7 characteristics or traits (more is possible but more cumbersome) that are preferred by farmers in this particular crop. Farmers then score the varieties for trait no. 1 by using a ranking score for variety performance of 0 (worst/not desired) to 9 (best/highest desired) or 1 to 5. In most cases it is better to let farmers score individually to reflect individual preferences within the group and calculate the average score.
However, some participants like to work by consensus and should be allowed to do so.

Farmers discussing the characteristics of local vegetable varieties

Then, ask participants to recall and list a maximum of three negative characteristics (e.g. hairiness) below the positive characteristics. This listing is not mandatory and if farmers cannot find any such characteristics, they should leave it open.

Note: Be sure to stick with the scoring method indicated above to avoid confusion when it comes to adding scores and comparing varieties. For example: productivity is a positive characteristic scored 0-9, while hairiness can be perceived as a negative criteria and should be scored from 0 (very hairy=not desired) to 9 (not hairy=desired).

Table 3.4: Variety characterisation table (crop wise)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Variety 1</th>
<th>Variety 2</th>
<th>Variety 3</th>
<th>Variety 4</th>
<th>Variety 5 etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
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<tr>
<td>6.</td>
<td></td>
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<tr>
<td>7.</td>
<td></td>
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<td></td>
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<tr>
<td>8.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Participants then prepare the total ranking score and compare the varieties, upon which the groups can present the results in the plenary. Discuss the results and find out whether the highest final score matches with the farmer’s most popular variety and with the area planted in the community.

Note: for (primarily) illiterate communities, varieties should be identified by a live sample (fruit, seeds etc) or a small drawing, which is recognized by all group members to represent this particular variety. See paragraph 3.1 for more suggestions.
Cour square analysis

Time: ½ hour

This four square analysis is similar to that in step 1, but rather than for crops, a categorisation of varieties within a crop is made to measure their value and importance in the community. The exercise can best be carried out in a plenary discussion. Ask farmers to categorize the varieties of the specific crop using table 3.5 below.

Table 3.5: Four Square Analysis (varieties)

<table>
<thead>
<tr>
<th></th>
<th>Large areas</th>
<th>Small areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many households</td>
<td>A. List of varieties</td>
<td>B. List of varieties</td>
</tr>
<tr>
<td>Few households</td>
<td>C. List of varieties</td>
<td>D. List of varieties</td>
</tr>
</tbody>
</table>

Identify with the farmers:

- Why some varieties are only grown by a few households on large areas (C)?
- Why many farmers maintain only small areas for certain varieties (B)?
- Why some varieties grown are maintained by only a few households on small areas (D)?
- What varieties are most profitable and why?

The bean ranking method

This exercise is appealing for everyone, both literate and illiterate farmers, and works as follows:

- Each group member or individual is handed 20 beans (or pebbles) per characteristic.
- Ask him/her to distribute the 20 beans among the varieties, giving the most number of beans to the variety that scores highest for these criteria and none or few beans to varieties that score lowest.
- After each individual has cast his/her score, the beans are counted and the score is recorded.
- At the end of the exercise the scores are added and varieties ranked.

Note that the bean ranking method only measures the relative performance but not the absolute performance; as such it does not accurately measure the performance level.
Time line analysis

*Time: 2 hours*

In this exercise, farmers visually recall the varieties that have been grown by the community between now and 30 years back. It is an important exercise because it shows the dynamics of the local production system as well as the vulnerability of the community to external influences.

This exercise is crop specific, so if farmers choose to study two or more priority crops, the exercise should be repeated for each crop. Each group of 4-5 participants may focus on one crop at a time. Make sure that a good mix of farmers is represented in each group. Alternatively, groups of elders and youngsters, or male and female may be formed, to reveal specific know-how existing with these social segments of the village community.

A simple timeline is drawn on a large piece of paper. Discuss time perceptions and time divisions (e.g. 10 years) and indicate the points between ‘now’ and ‘then’.

Note: in some communities time is measured in non-standard units. In illiterate communities, time perception is usually measured by recording major events, such as drought, bush fires, civil war etc.

Ask farmers to indicate which varieties are grown now, 10 years, 20 years, and 30 years ago respectively. Participants draw the varieties and/or write the name of the variety in the particular block of time. Groups then discuss what made farmers to grow or reject these varieties and draw with arrows and pictures:
- when the variety was introduced and when it was lost;
- what factors have caused the loss of varieties;
- major events that have caused loss of genetic resources;
- factors that have caused the (re) introduction of new varieties.

Back in the plenary, all groups present their drawings. Discuss the level of genetic diversity for each crop, whether this level is desirable, and if not, what should or can be done to improve diversity.

Note: To save time, facilitators may decide to use a simple table version of the timeline exercise, and discuss the trends in genetic diversity. This, however, is less visual and may not provide the required depth of discussion, hence should be avoided when possible.

Semi structured interviews

*Time: 1 hour*

Additional questions may be asked in semi-structured interviews with small groups or key individuals (during lunch or after closing of the day’s session) to clarify farmer decisions to keep certain crops and varieties and general selection procedures as well as farming system patterns.
3.4 Setting of breeding goals (step 3)

Purpose:

- to prioritize desired variety traits;
- to identify desired breeding and selection goals.

In this exercise farmers will focus on the traits that they wish to see in a particular variety ('dream variety'). In this exercise, farmers will be able to broadly set their breeding goals.

Priority setting

Time: 1 hour

Once again present Table 3.4 on variety characterisation and ask participants to list the top five criteria that need improvement in the current crop. Request participants to prioritize the criteria by using individual ranking methodologies, such as ballot box, cards, or just plain voting by hand, and finalize the ranking method.

Note: it may be advisable before prioritisation to group the characteristics using the following broad categories:

- agronomic characteristics;
- characteristics for taste, texture and appearance;
- cooking and processing characteristics;
- characteristics valued in storage and transportation.

It is particularly important to discuss the criteria in detail (e.g. length of fruit: how long?, resistance to particular pests and diseases: which pests, which diseases? etc.). Ask also for criteria that do not appear in the previous lists or in the current varieties grown. Groups should present and discuss findings in the plenary and summarize the results.
3.5 Seed system analysis (step 4)

Purpose:

- to understand who maintains genetic diversity in the community (internal sources);
- to identify the external sources of genetic diversity, availability and access.

This part of the survey attempts to provide additional information on the availability and the farmers’ capacity to access genetic resources, both within and outside the community. At the end of this exercise, farmers have a better picture of the available sources of seed. This understanding will allow them, in the course of the FFS-PPB, to access a more diverse pool of genetic resources and improve their seed systems.

Resources mapping

Time: 2 hours

Ask groups of 4-5 farmers to draw a circle in the middle which represents their own community and to draw other circles representing nearby communities. Far away communities that are frequently visited such as major cities may also be identified with a circle. Participants then draw important markings such as buildings, monuments, houses of prominent people and farmer fields on the paper sheet for recognition; they should also indicate their own living quarters. Each group should focus on only one crop. Ask participants to indicate on the map:

- the location of the most important seed suppliers in the communities, if possible they should name the shops and persons;
- where they usually obtain seed material for own planting;
- the type of varieties;
- the quality of seed material and price level;
- sources of not normally available material.

Upon presenting their drawings in the plenary, participants should indicate what their difficulties are in accessing seed of desired crop types or varieties.

Note: A quick alternative method for use as resources mapping is conducted by using table 3.6 below. This table may be used if time is short and farmers are familiar in using tables and figures.

**Table 3.6: Seed System Analysis**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Source of seed</th>
<th>%</th>
<th>Name of supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. eggplant</td>
<td>Variety 1</td>
<td>Internal – self Internal – other farmer</td>
<td>20% 40%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outside- seed store (kiosk)</td>
<td>40%</td>
<td></td>
</tr>
</tbody>
</table>
Selection strategies
Semi-structured interviews with small focus groups or key individuals are a convenient way to ask questions concerning seed selection strategies used in genetic resources management. Prior to this interview ask the villagers to point out who are the crop seed experts in the community, who then should be invited to join the focus group. Ask questions particularly related to:

- type of person/gender engaged in seed selection before and after harvest;
- person(s) in the household who is responsible and decide(s) on the source and type of variety to plant;
- procedures and criteria for selection before and after harvest;
- consistency in selection criteria;
- application of breeding goals in farmer’s selection strategies.

Confronted with the outcome of this discussion, participants may once again confirm the validity of the breeding goals.

Semi-structured interviews
Visits to seed traders and retailers will, in addition to resources mapping, indicate the range of genetic material available from the supplier side. As traders are often not available for group discussion, normally surveyors accompanied by farmers will need to visit their shops and retail outlets for interviewing. This provides the added benefit of observing the physical status of the shop and the quality of seed packaging. Additional information may be collected on:

- the origin of the seed (seed companies-public/private – hybrid/open pollinated);
- time of year when available;
- seed price.

Findings should be reported back to the plenary to facilitate the discussion on how to improve existing seed systems.

3.6 Crop market analysis (step 5)
It may not be possible to fully understand the dynamics of crop markets in the short time set for the survey. However, since markets are important factors in determining genetic diversity, two short exercises can be included in the baseline survey. At the end of these exercises, participants will have an overview of the existing markets and market channels, and an idea of the contribution of certain crops and varieties to income generation in the community.

Importance of markets for income generation

*Time: 1 hour*

Ask farmers to indicate how many households (out of the total number of households) have planted selected crops during the last years and what proportion of the harvest was meant for consumption, respectively for sale. Use table 3.7 below for compilation.
Table 3.7: Village market analyses

<table>
<thead>
<tr>
<th>Crop</th>
<th>No of households planted last year</th>
<th>Estimate ha planted in community last year</th>
<th>Estimate production in community last year</th>
<th>% of harvest used for own consumption</th>
<th>% of harvest used for sale to market</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. pumpkin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: it may sometimes prove difficult to generate these figures for the whole community. In such cases, a simplified compilation can be prepared by asking each participant whether he/she personally planted the crop last year, how much he/she planted, and how much of the harvest he used for consumption and for sale to market.

Market chain analysis

This exercise can best be conducted with a focus group consisting of key individuals (farmer/traders) using the semi-structured interview method. Visits to markets and trading places are advisable.

Request farmers to indicate what kind of people are involved in the process from sale at the farm gate to final sale to consumers for 1) local market, and 2) city market.

Use cards or a map to write down the names of people and arrows to indicate the flow of the process of marketing vegetables. Note down the daily timeline of the marketing process. Discuss bottlenecks in the market process and possible solutions.

Ask farmers whether they see opportunities in the market for new types of varieties. Findings of the interviews are reported back to the plenary for discussion.

Finally, after completion of these exercises, discuss with the participants which market factors have played a role in the past to develop the present market system, and which factors have influenced the level of genetic diversity in the community?

3.7 Final prioritisation and crop selection (step 6)

Purpose:

- to review the breeding goals;
- to arrive at a farmers’ selection of two or three crops for the FFS-PPB programme.

Time: 1 hour

In this final wrap-up session, a number of key decisions should be taken. In order to facilitate these decisions, facilitators, in collaboration with key
farmers, summarize the results of the different steps in the survey to the convened participants.

Farmers then should make a final priority ranking of the crops that are most preferred for inclusion in the FFS-PPB programme, and repeat once again the process of setting the breeding goals for the selected crops. This exercise concludes the baseline survey.
4. BASIC TOOLS FOR FIELD STUDIES

4.1 Introduction

In the FFS-PPB curriculum three types of tools have been distinguished:

1) Basic tools, these can be used in all field studies throughout the FFS-PPB programme. These tools are designed to guide the participants in their breeding work.

2) Crop-specific tools, these tools have been developed for field studies on specific crops to guide participants on topics of, for example, plant morphology, varietal crossing and plant selection.

3) Background tools; these are exercises which aim to provide participants more background information so that they can understand the topic better.

All tools for FFS-PPB are designed to be used in a flexible manner. Depending on the absorption capacity of the participants and the setting of the FFS session, they may be used either as is, altered, or if really necessary, some may be skipped altogether.

Most of the crop-specific tools can be easily modified to fit other crops. Rice tools can be adapted to suit other self-pollinating cereal crops such as wheat. Tools for vegetables like bitter gourd can be adapted to fit other crops of the same family like sponge gourd, pumpkin or wax gourd.

In this chapter, we will discuss the basic tools for FFS-PPB: agreeing on aspects to be observed in the field and GEAN.

4.2 Planning field observations

This exercise consists of three parts:

- reviewing of the breeding objectives;
- planning observations and determining scoring methods;
- setting time tables for making observations.

It is strongly recommended to take sufficient time for each of these exercises, as the outputs have important implications for the rest of the FFS-PPB and for follow-up studies. It is advised to implement these tools right at the start of the FFS course.

Facilitators should ensure that at least a basic set of observations has been planned and scoring methods are available at the beginning of the FFS-PPB.

After reviewing the breeding objectives, it is suggested to briefly discuss part 2 and part 3 of the exercise, and to subsequently revisit these exercises at the appropriate time during the growing season to finalize the observation details. This will help in optimizing the effectiveness of the exercise.
Document the results of the planning for display in the FFS meeting place. The results should be visible throughout the entire FFS-PPB for reference, which facilitates the conduct of the weekly GEAN observations (see 4.3).

**Part 1: Review of breeding objectives**

**Time: 2 hours**

Conduct the exercise in small groups of 4-5 farmers. Ask participants to bring live plants or plant parts of different varieties for identification, description, and discussion of desired variety traits.

Introduce the topic by explaining the issue of the ‘dream variety’. Discuss the difference between individual and group preferences (working by consensus), and the need for strategic goal setting in crop breeding.

Facilitators then can choose one of the following approaches to discuss the breeding objectives:

**Option 1:** Present the findings of the baseline survey, in particular the goal setting process (step 2 and 3), and discuss each of the exercises again to validate the choices made. This approach is suitable when most of the farmers in the FFS-PPB have participated in the village baseline survey.

**Option 2:** Reconduct part of the baseline exercises, especially steps 2 and 3, and compare the outcome with that of the baseline survey. This approach should be chosen when a considerable number of participants in the FFS are new.

Particularly focus on:

- strengths and weaknesses of cultivated varieties;
- four square analysis on the use of varieties in the community;
- setting and prioritization of breeding objectives.

Discuss the group work in the plenary and summarize the results.
Part 2: How to make observations and attach scores in the field?

In order to make the field studies more accessible to farmers, they should take part in the process of setting aspects to be observed in the field and field scores. This will ensure that farmers observe characteristics that are essential to them, and that the observations are carried out in a way that they can understand. Once observation aspects have been determined, they may be used as a standard in the local FFS-PPB programme.

**Evolving breeding objectives**

Breeding goals may change over time, even during the FFS-PPB course. For instance, farmers may change their position on certain priorities, or realize that very broad criteria were set at the beginning but need to be made more specific in order to be effective. For instance, pest resistance is a favoured breeding objective in many FFS-PPB, but further specification for translation into observations is needed based on the type of insect and insect damage. Facilitators should be aware of the evolving breeding objectives and therefore re-discuss the objectives from time to time.

*Field observations in GEAN*
Method

Time: 2 hours

1. Groups select two or three breeding criteria from the final list of breeding objectives prepared in part 1 and determine how they would like to score the breeding for such criteria in the field. Demonstrate the procedure by working out one or two breeding criteria using the outline in table 4.1 and the following questions:

   • *How do you usually observe these criteria in the field?* List the observation criteria. Note that each criterion may have more than one aspect to observe, for example criteria like “good fruit appearance” may be studied by three or more types of observations: colour, shape, and smoothness of skin.

   • *How would you score the observation in the field?* Scoring can be done in various ways; it can be simple or complicated, but also effective and non-effective. In the above example of fruit appearance, farmers may decide to use the simple score + or - (approved, not approved) or score by comparison with the local control: 1= better than the control, 2= same, and 3=worse, or use a score of 1 to 10 (1=bad, 10=excellent). On the other hand, plant height can be simply measured in cm.

   • *How many plants do you need to observe?* It is important to integrate the farmers’ sense of accuracy in the observation. Usually, the number of observed plants depends on the criteria and the observed variation in the plot. For example for criteria like fruit appearance it may be sufficient to observe a few plants only. Measurement of productivity, however, requires considerable more plants to observe, as production varies with growth environment, pest and diseases incidence, and field management practices.

Two different methods of observation

Field observations should match the literacy level of the farmer community participating. Experience has learned that there are two approaches: the selection tag method and the notebook method.

- The *selection tag method*; this is the simplest way of observation in the field. Farmers use sticks or colour ribbons to select varieties or individual plants which meet their criteria. For example, they may select plants with good fruit appearance. Upon data analysis, they may compare the performance of the different varieties or lines by counting the number of selected plants per plot.

- The *notebook method* is the more advanced method. In this method farmer participants use pre-set criteria and a note book, in which observation data are recorded. These data are then compiled after returning from the field and used in the further variety analysis.

Both methods can be used at the same time. Those who are less familiar with data analysis may use the selection tag method. Others, including educated farmers and farmer facilitators, may use the notebook method, which allows the group to work out the variety comparison in more detail.
## Table 4.1: Example of setting field observations in vegetables

<table>
<thead>
<tr>
<th>Breeding Objective</th>
<th>Observation criteria</th>
<th>Scoring method</th>
<th>Number of fruit or Plants per plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good fruit appearance</td>
<td>1. fruit colour = more yellow</td>
<td>Compare with control: 1=more yellow, 2=same, 3= more green</td>
<td>10 fruits per variety</td>
</tr>
<tr>
<td></td>
<td>2. fruit shape = more round</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>1. fruit skin = smoother</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>Yield</td>
<td>1. weight of fruit harvested</td>
<td>Kg</td>
<td>Entire plot</td>
</tr>
<tr>
<td></td>
<td>2. weight of marketable fruit</td>
<td>-do-</td>
<td>-do-</td>
</tr>
</tbody>
</table>

2. Ask groups to present the results in the plenary. Take sufficient time to elaborate on the various ideas on observations and scoring techniques. Decide on the most effective approach. Ensure that the results are farmer-generated and not science or scientist-generated, in other words it should reflect the farmer’s level of education, experience and know-how.

*Note*: For illiterate farmers it is advised to use simple scoring methods, such as comparison with local controls, or scoring methods using colours rather than figures. Also use symbols to identify the various criteria.

### Part 3: How to set the time for making observations?

Some field observations are made at the beginning of the cropping season, others at the end, and some throughout the season. In this exercise farmers will elaborate the time table for making observations and evaluation of the breeding process. Experience has learned that farmers get confused when all data are compiled at the end of the FFS-PPB; in order to compare varieties and breeding lines it is much better to draw conclusions at regular intervals throughout the season. This will assist farmers to acquaint themselves with the evaluation techniques and build their knowledge and skills.

**Method**

*Time*: 1-2 hours

1. Draw a timeline on a large piece of paper indicating the start and end of the FFS-PPB season with vertical lines indicating months and weeks (see figure 7).
2. List the breeding objectives and planned observations compiled in part 1 and 2
3. Next to each observation, participants should indicate on the timeline:
   - when to observe the criteria in the field; note that more than one observation time point is possible;
   - when to evaluate the aspects observed and summarize the results.
4.3 Genotype-Environment Analysis (GEAN)

The Genotype - Environment Analysis, or in short GEAN, is a weekly activity conducted during the entire FFS-PPB course(s) to guide participants in their field studies, especially on aspects of data collection, analysis and decision making. GEAN activities start as soon as the first seedlings emerge and only end at harvest time. In GEAN farmers focus on three kinds of observations:

1. **Genotype observations**: these are observations on variety traits and attributes and form the most important element in the GEAN. The activity of making genotype observations provides a direct link with the breeding goals and the observations set by farmers at the start of the FFS course (see 4.2)

2. **Environmental observations.** This element focuses on environmental factors in the study field and involves data collection on environmental aspects of biotic origin (pest and disease prevalence, weeds), a-biotic origin (weather, water), and human interference (fertilizer application, spraying)

3. **Observations on Genotype by Environment interactions**; in this last section, farmers determine whether or not there is an influence of the environment on the observed attributes or traits in the field. This analysis is necessary as interaction may distort the results of the variety comparisons.

At the end of each GEAN session, participants discuss the results and decide on the following issues:

- Which variety has performed best?
- What further action is required?

Limit the decision to two or three observations per week. Elaborate on the field activities needed for preparing the next week’s session.

The weekly GEAN exercise includes two parts: field activities and subsequent data analysis.
4.4 GEAN field activities

Time: 1-2 hours

1. Agree at least one week before each session what aspects will be observed and which criteria will be used, using the observation time table. Choose 3-4 criteria per session.

2. Take the GEAN form (Figure 4.2) and enter the aspects to be observed and the scoring methods in the first section.

3. Before heading to the field, review the aspects to be observed and the scoring techniques. Also review the environmental aspects to be observed, such as rainfall during last week, pest infestations or fertilizer applications. Prepare for any additional task, such as making drawings of the field, or the drawing of infested plants.

4. Each small groups of 4-5 farmers are expected to observe and collect the data from 3 or 4 varieties. Enter the results in the respective sections on the GEAN form. In the variety evaluation study make sure at least one control variety plot is included for comparison.

5. Complete the form by drawing conclusions on environmental aspects and possible interactions in the second section.

6. Make any remark with regard to field work that should be carried out in the next week in the third section.

7. Back in the meeting the various groups should discuss the results and summarize these on a large sheet of paper.
Figure 4.2: Example of a weekly GEAN sheet

**FARMERS’ WEEKLY OBSERVATION SHEET (GEAN)**

**General information**

- **Group No.**: 1
- **GEAN No.**: 5
- **Date of observation**: 13 August 2004
- **Week after sowing**: 7
- **Week after transplanting**: 5
- **Weather during last week**: Sunny
- **Plant stage development**: Tillering
- **General appearance**: Fair
- **Cultivation practices during last week**:

1. **Criteria observation**

<table>
<thead>
<tr>
<th>Objective/ Criteria</th>
<th>Observation /Score</th>
<th>Variety plot 1</th>
<th>Variety plot 2</th>
<th>Variety plot 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plant height</td>
<td>Cm</td>
<td>31-41</td>
<td>35-40</td>
<td>33-49</td>
</tr>
<tr>
<td>2. No of tillers</td>
<td>No.</td>
<td>6-10</td>
<td>4-9</td>
<td>7-11</td>
</tr>
<tr>
<td>3. Pest resistance</td>
<td>Harmful Insects count</td>
<td>4-6</td>
<td>3-5</td>
<td>5-9</td>
</tr>
<tr>
<td></td>
<td>Beneficial insect count (on 5 plants/plot)</td>
<td>6</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>4. Disease Resistance Etc.</td>
<td>Tungra (score 1-10)</td>
<td>5-8</td>
<td>2-4</td>
<td>5-6</td>
</tr>
</tbody>
</table>

2. **Environmental observations and interactions**:

- Weather condition in past week
- Sprayed insecticide affected variety 1
- Weeds in variety 3

3. **Recommendations for next week**:

Weeding needed
4.5 GEAN data analysis and compilation

After data collection in the field, the participants will sit down in the meeting place to analyse the results and reach conclusions. The following methodologies for data analysis have been found to be useful. Some methods are better than others, the effectiveness of these methods differs depending on the cultural and educational background of the participants.

Visual comparison

Most farmers are familiar with the method of visual observation and usually need little time to learn this, even in illiterate communities. Over the years, various participatory visual methods have been developed. Visual comparison methods can also be used in parallel with other, more elaborate, data analysis methods described below.

1. Selection tag method: farmers can use coloured sticks in the field to identify individual plants or use coloured tags to rank the varieties or lines for performance. They may also use simple tables with coloured tags for visual display of results (Figure 4.2).

2. Simple visual comparison; participants rank the varieties for overall performance, or for a particular trait, such as vigour or fruit colour, using a scale of three: good = 🍇, average = 🍇, and bad = 🍇

3. Simple pair-wise comparison; participants compare the varieties with a control variety. For example, they may list the varieties that are better performing than the control with a plus (+) and those that are below standard with a minus (-). Group scores may be collected (the number of plus scores subtracted from the minus scores) and compiled in a table:

Table 4.2: Pair-wise ranking with control variety

<table>
<thead>
<tr>
<th>Control Variety</th>
<th>Variety A</th>
<th>Variety B</th>
<th>Variety C</th>
<th>Variety D</th>
<th>Etc....</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>-</td>
<td>+/-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
4. Full pair-wise comparison; use pair-wise ranking to compare all varieties with each other for overall performance or for specific criteria in a full pair-wise comparison table (table 4.2). Group or individual scores can be compared and compiled in a summary table using colours or numbers.

**Table 4.3: Complete pair-wise ranking**

<table>
<thead>
<tr>
<th></th>
<th>Variety A</th>
<th>Variety B</th>
<th>Variety C</th>
<th>Variety D</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>//</td>
<td>2</td>
</tr>
<tr>
<td>Variety B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>///</td>
<td>1</td>
</tr>
<tr>
<td>Variety C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>/</td>
<td>3</td>
</tr>
<tr>
<td>Variety D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

**Data summary tables**

Visual methods are limited in their use. For more effective comparison, farmers may opt for numerical scoring methods, such as ranking of 1-5 (in which 1 is very bad, and 5 is excellent). The approach, evidently, requires elementary administrative skills of farmers. The following approaches have been found useful.

1. Simple comparison table; data scores are entered in the table and summed up per variety. Ranking is based on the total or average score per variety.

**Table 4.4: example of a simple comparison table**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plant height (cm)</th>
<th>Rank (based on preferred height of 100 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>80</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>105</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>125</td>
<td>3</td>
</tr>
</tbody>
</table>

2. Multiple comparison tables; when there are different traits or traits that contain different components, a multiple comparison table may be applied. Colours or numbers may be used to enter a ranking score. This type of table is especially suitable at the end of the season when participants compare the varieties based on all the criteria set by farmers. In principle, the same ranking method can be used as in simple comparison table.
Table 4.5: Example of a multiple comparison table for taste

<table>
<thead>
<tr>
<th>Trait</th>
<th>Observation</th>
<th>Variety A Score</th>
<th>Variety B Score</th>
<th>Variety C Score</th>
<th>Variety D Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>Texture</td>
<td>Good</td>
<td>average</td>
<td>bad</td>
<td>average</td>
</tr>
<tr>
<td></td>
<td>Aroma (1-10)</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Sweetness (1-10)</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Sum of ranks</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Final ranking</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*Ranking: 1<sup>st</sup> - yellow, 2<sup>nd</sup> – orange, 3<sup>rd</sup> - brown, 4<sup>th</sup> - red

**Compilation of multiple criteria**

It may be difficult to construct a final ranking with multiple attributes. This could confuse some farmers. The difficulty arises when farmers assign more weight to some criteria over others. Simply summing up the individual ranking scores would obscure the overall evaluation. For example, farmers may prioritize yield over plant height, therefore the criteria for yield should have a higher weight than plant height.

A solution to this is to prioritize the characteristics, and list the most preferred characteristics at the top of the table, and the least preferred at the bottom. Total scores/ranking may be calculated only for the top half of the table.

Alternatively, farmers may calculate index figures to balance the comparison, but this method involves a certain amount of abstraction which is not always well understood by farmers. Indexing assigns a certain weight (score 1-5) for each criterion which is multiplied with the ranking. Varieties are thus compared by calculating the sum of the different index figures.

**Data analysis using graphs**

Farmers may use graphical displays to compare varieties. This is particularly recommended in situations where time series are available, such as for plant vigour, pest infestation or rainfall.
Finally, graphs can be used to identify to which extent variety performance is influenced by the environment. This is particularly recommended for objectives such as yield, which are usually more influenced by environmental factors. The partial replicated variety evaluation trial is designed to facilitate this type of analysis. The following describes a simple graphical analysis of genotype x environment, using the control variety as replicated standard.

1. First plot the sums of the collected variety data, for example on yield, in Figure 4.2.
2. Then plot the replicated results of the control variety and draw a horizontal line through the highest and lowest data point.
3. If the result of a variety, other than the control, falls above or below the marked lines, it may be concluded that the variety is significantly higher respectively lower performing than the control variety. If the result falls within the two marked lines, the variety is not significantly different, in other words the variety is equally well performing.
Figure 4.4: Example of a simple G x E analysis using graphic display
5. **TOOLS FOR RICE**

Rice is one of the most ancient cultivated crops in the world; historical references found in Chinese writings some 5000 years ago show that rice cultivation predates many of the world’s oldest civilisations. Nowadays rice is by far the most important staple crop for farmers in Asia, responsible for 90% of the total production in the world. Despite a tremendously wide genetic diversity, and, since the 20th century, intensified professional breeding, there is a shortage of new, locally adapted varieties, to meet the diverse producer and consumer demand. FFS-PPB programmes in rice are well suited to address this issue and assist in developing new rice varieties adapted to the local environment; at the same time these programmes also help with the growing need for conservation of genetic resources.

In this chapter we will describe the tools for the first season FFS-PPB on rice.

5.1 **Plant morphology and growth stages**

Rice is a cereal crop with very distinct morphological features. This session on morphology and growth stages of rice helps farmers to structure and share their knowledge on the rice plant with others.

**Method**

*Time: 3 hours*

Make sure a few large drawings are available depicting rice plants in their various growth stages for presentation purposes. Prepare for sufficient materials such as measuring stick, magnifying glasses and drawing materials.

**Group Activity**

1. Split up in groups of 4-5 farmers. Inform groups prior to the session to collect samples of rice plants from the field at different growth stages. Ensure that entire plants are dug up including stem, leaves, panicles and roots. Collect as many samples as possible. For comparison include plants of different varieties.

2. Observe the plants carefully and note the differences between the various plant growth stages, and varieties of the same crop. Make drawings of the different plants and plant parts.

3. Add names, such as: roots (primary, secondary, tertiary roots), stem (node, internode), leaf (blade, midrib, collar), flower (floret, seed, spikelet, axis, panicle, flag leaf). Briefly describe the functions of the different plant parts.

4. Give additional tasks. Select assignments that are suiting the particular FFS situation, for example:
   - Starting from the date of planting, use a timeline to determine the approximate date of flowering and harvest for the most popular
variety grown by farmers, and determine the respective growth stage intervals, e.g. 1) vegetative stage, 2) reproductive stage and 3) ripening stage. Compare results with other varieties in the field study.

- Take several varieties and measure the first internode. Note how many tillers come out of the first and second nodes and how many will be productive tillers. Observe if there is a relationship between the length of the first internode with the number of tillers and the presence and growth of the first and second node with productive tillers.

5. Groups will display the drawings on the wall and present their findings in the plenary. Elaborate on the drawings by referring to the names of plant parts and add or correct missing elements.

Topics for discussion:
- At which growth stage is the rice plant most sensitive to heat or water stress?
- What are the pests that are commonly observed in the different growth stages?
- In which stage is the plant most responsive to fertilization?
- Which cultural practices do you apply to make the plant produce more tillers and how does this affect yield?

Figure 5.1: The rice plant
Table 5.1: Key phases in the plant growth development of rice

<table>
<thead>
<tr>
<th>Development Stages</th>
<th>Growth Phases</th>
<th>Key Development Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vegetative</td>
<td>Germination &amp; Emergence</td>
</tr>
<tr>
<td>2</td>
<td>Seedling</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tillering</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Stem elongation</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Reproductive</td>
<td>Panicle initiation</td>
</tr>
<tr>
<td>6</td>
<td>Panicle development</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Flowering</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ripening</td>
<td>Milk grain</td>
</tr>
<tr>
<td>9</td>
<td>Dough grain</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Physiologically mature grain</td>
<td></td>
</tr>
</tbody>
</table>

5.2 Reproductive Morphology

The reproductive phase of rice takes about 35 days; it begins at the start of panicle formation and ends at flowering. This phase is the most critical phase for rice improvement. Breeders intervene in the natural pollination processes in order to cross varieties with preferred characteristics. This study lets farmers understand better the flower morphology and reproductive processes of the rice plant which in turn will help and guide them in the technical aspects of the hybridization work.
Method

**Time**: 3 hours

Ensure availability of sufficient materials such as: scissor, scalpels, magnifying glasses, forceps, tape, as well as drawing materials. Conduct this session when most varieties in the variety trial are in flowering stage. See box 6.4 for background information.

1. Split up in small groups. Observe in the field plants with flowering panicles of different varieties. Randomly select five plants per variety and count how many tillers have panicles and how many do not. Note down how many panicles are heading and how many are flowering. Share the results.

2. Collect some panicles from different varieties, attach a label for identification, and return to the meeting venue. Draw the panicles and florets before, during and after the flowering stage. Open the flower with a scissor and picture all the different parts that can be seen inside the flower.

3. Present the results of the small group and discuss findings with the rest of the class. Explain the names of the different flower parts, the reproductive process, and the concept of self-pollination versus cross-pollination.
Topics for discussion

- Do all tillers flower at the same time? Do all flowers in a panicle flower at the same time?
- What are the functions of the different parts of the flower? When is pollination taking place?
- What are the basic differences between rice flowers and flowers of: 1) maize, 2) pumpkin, 3) common bean?
- Which part of the flower becomes the grain?
- Is rice a self-pollinating or cross-pollinating crop?
The Rice Flower

The rice flower is contained in a tiller with panicle that bears a large number of single-flowered spikelets (unit of flowers). The single flower (or floret) is surrounded by a lemma and palea, leafy structures that form the hull or husk that encloses the threshed grain. As in other flowers, a pistil (or the female) and stamens (or the male) are present which makes it a perfect flower (see also box 6.1 for description of a perfect flower). Each spikelet has 6 stamens and one pistil.

The stamen has two parts, one is the anther that holds the pollen and the other is the filament where the anther is attached. The pistil has three parts namely, stigma, style and ovary. The stigma receives the pollen from the anther, the style holds the stigma and the ovary will become the fruit (rice seed) once the pollen has entered the style and fertilized the egg cells. Rice like most cereals is self-pollinating, occasionally it is cross-pollinated by wind (less than 1%).

Figure 5.4: A rice flower (floret or spikelet) with male and female parts

Pollination in rice flowers occurs while the spikelet is still closed. Once the spikelet opens, it is impossible to perform hybridization (or artificial crossing) since the pistil (female) has already been pollinated by the stamen (male) of the same flower. This means that the female is already starting to produce seed. Thus, it is not possible to cross the variety with another variety. Hence, open florets are no longer suitable for hybridization. In order to cross one variety with another variety, it is important to remove the anther (male) in the female parent variety before it pollinates the stigma (female), which is before the opening of the flower.
5.3 Selecting parent varieties

The choice of germplasm is crucial for the success of a breeding programme; therefore farmers assisted by the trainers must carefully select varieties for crossing experiments. For example: a breeder may have a high-yielding pest susceptible variety and a low yielding pest resistant variety in the field, but wishes to combine the characteristics. In order to do so, he must make a cross between the two varieties, so that genes can re-combine:

\[
\text{high-yielding, pest susceptible} \quad + \quad \text{low yielding, pest resistant} \quad \rightarrow \quad \text{high-yielding, pest resistant}
\]

It is advisable to use traditional varieties when making a cross with modern varieties since these varieties are usually well adapted to the local environment: they grow well in soils with low fertility and often have some degree of natural pest and disease-resistance. Make sure to include an adequate number of crosses as 50% on average will fail to produce seed. Also make varietal crosses in both directions (reciprocal), by using a variety sometimes as male and sometimes as female, to increase the rate of success.

The exercise below aims to assist participants prior to varietal crossing to identify individual as well as group preferences. It helps farmers also to monitor the success of the crossing.

Method

*Time: 2 hours*

This session is conducted after the demonstration of crossing varieties, but before field practicing it.

1. Split up in groups of 4-5 farmers and ask them to prepare a list of preferred varietal crosses. This should be based on what they know about these varieties and on the observations made in field studies. Specify the reasons for making a particular cross (table 5.2).

2. Collect and combine the group results for discussion in the plenary. Make a list of variety crossings and prioritize in accordance with popularity (number of times listed).

3. Discuss making variety crossings, starting with the most popular cross, elaborate the characteristics of the parent varieties, and the reason for making this particular cross. Compare with the breeding objectives.

4. Prepare a final list of variety crossings using table 5.3. In this table list the selected varieties both on the left and on the top and indicate in the table how many crosses farmers wish to make.

*Table 5.2: Example of a variety crossing list*

<table>
<thead>
<tr>
<th>Cross</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety A x Variety B</td>
<td>Short Maturity</td>
</tr>
<tr>
<td>Variety D x Variety A</td>
<td>Pest resistance, high yield</td>
</tr>
<tr>
<td>Variety E x Variety B</td>
<td>High yield</td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
</tr>
</tbody>
</table>

50
Table 5.3: Example of a variety table (in no. of crosses)

<table>
<thead>
<tr>
<th>Variety plants</th>
<th>Variety 1</th>
<th>Variety 2</th>
<th>Variety 3</th>
<th>Variety 4</th>
<th>No. of crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father plants</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variety 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variety 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variety 3</td>
<td>3</td>
<td>3</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Variety 4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: use the crossing table as a reference to monitor the results of variety crossing in the field: how many were planned, how many performed? Compare group or individual performance, and later in the process rate the success.

Topics for Discussion
- Why do we need to make reciprocal crosses?
- How many successful crosses do we need to make in order to build a breeding programme?
- How many crosses can you manage?

5.4 Varietal crossing technique

Controlled crossing is the key to contemporary plant breeding. It introduces new variability which allows farmers and breeders to select improved lines in the progeny using preferred characteristics. This exercise will familiarize farmers with the different techniques involved in the crossing of rice varieties.

Method

Time: The varietal crossing work in the field may stretch over a period of several days and involves four steps:

Step 1: Preparation and Emasculation
Step 2: Pollination
Step 3: Inspection
Step 4: Harvest

Make sure that there are sufficient rice plants available in flowering stage. It may be necessary to plant the different varieties in stages to synchronize the flowering. Ensure necessary materials such as: small scissors, dissecting needle, fine forceps, glassine bags (water proof), tape, paper clips, tags, ball pen, and magnifying glass.
Field session 1: Preparation and emasculation

Time: 2 hours; afternoon between 3 and 5 pm, one day before hybridization

1. Select the cultivars to be emasculated. Selection will depend on the breeding objectives. Use the variety crossing table prepared earlier.

2. Select healthy plants. Rice is ready for emasculation when the panicle has emerged for about 50 to 60% from the boot. Florets (or spikelets) are ready for emasculation after emergence from the boot and prior to flower opening. Select panicles where most of the spikelets will be fully opened the next morning. One way to check this is when the third part (lower part) of the panicle is about to emerge from the boot.

3. Trainers then demonstrate emasculation and let farmers practice as follows:
   a. Remove the flag leaf sheath carefully to avoid breaking of the stem.
   b. With the use of fine scissors, remove all pollinated and immature spikelets. Pollinated spikelets appear translucent and often have anthers clinging outside while immature spikelets are mostly found at the base of the panicle. Remove the spikelets from the panicle if the anthers are more than ½ of the length of the spikelet (these spikelets have already been pollinated). Also remove the spikelets from the panicle if the anthers are at the lower end of the spikelet (these spikelets are immature). The middle part of the panicle will be emasculated.
   c. Cut the spikelets obliquely (from the middle part to the top of each spikelet. This enlarges the opening and makes the removal of the anthers easier
   d. Remove all six anthers carefully. Use a needle or fine forceps. Gently press the anthers with the tip of a forceps or needle against the side of the spikelet and lift them out. Do not injure the pistil. (See Figure 15). Emasculate 25-50 spikelets. The variety with the emasculated spikelets is called the female parent variety.
   e. Cover the emasculated spikelets with a glassine bag (to protect the pistil, to prevent contaminants from entering the spikelet and to prevent the pollen of other varieties from pollinating the pistil).
   f. Write the initials of the breeder, name of the female parent variety and date of emasculation on the glassine bag.

Cutting of spikelets and removal of anthers
9. Fold the bottom edge of the glassine bag over the spikelets and secure with a paper clip (see Figure 16). Do not place the paper clip on the stem as this may injure the stem.

4. At the end of the afternoon session verify that the number of emasculated flowers corresponds with the type and target number of crossing.

Field session 2: Pollination

*Time: The following morning between 6 am and 12 Noon*

1. Trainers demonstrate the pollination process and let farmers practice.

2. Select the variety for use as male pollinator. Cut a blooming panicle from the male parent variety (about 25% of the spikelets should be open). Dip the panicle in water then slide your fingers over the spikelets to remove pollen grains of other varieties that may be clinging to the surface of the spikelets. Place the male pollinator in a glass of water with the stem immersed and then leave it under direct sunlight. Wait for the spikelets to bloom or open.

3. When the spikelets of the male pollinator start to bloom and open (i.e. when the anthers start to stick out of the spikelets and there is yellow powder on your finger when touching the spikelet) it is time to start the hybridization.

4. Remove the glassine bag that covers the emasculated spikelets. Pollinate the emasculated spikelets by gently shaking the male pollinator over the emasculated spikelets (see Figure 3). Notice the pollen dropping in the emasculated open florets. Place the glassine bag over the pollinated panicle and secure with a paper clip. It is important to work quickly to take advantage of the period of maximum pollen shedding. Moreover, rice pollen is viable for only 5 minutes; hence, pollen grains must reach the pistil (female) immediately upon shedding.

*Pollination of emasculated spikelets*
5. Place the female plant variety in an area protected from wind, rain and pests but with good exposure to sunlight. If the weather is not good (for example when raining), the female parent plant may be pollinated on subsequent mornings because the stigmas of emasculated spikelets usually remain receptive for 4 to 5 days after emasculation.

6. Add the name of the male parent on the glassine bag. Attach a label on the panicle with details of female and male parent, date of crossing and initials of the breeder. (It is custom to write the female parent first followed by the male parent). Fix the plant to a bamboo stick to prevent the panicles from falling down.

7. Continue with other crosses. At the end of the field session, count the number of crosses and make a record in the crossing table.

Field session 3: Inspection

Time: 3-4 days after the hybridization

1. If pollination is successful, the ovary should begin to swell in 3 or 4 days. This can be distinguished by the appearance of the white endosperm from the floret. The spikelets may be inspected 5 or 6 days after pollination. Be careful to cover the spikelets again with the glassine bag after inspection to protect the seed from pests and diseases.

2. Count the number of successfully pollinated flowers and record the results in the variety crossing table. Compare with targets and review the rate of success by computing:

\[
\% \text{ successful crosses} = \frac{\text{no. of florets with seed}}{\text{total no. of pollinated florets}} \times 100
\]

Rice floret with grown endosperm
Field session 4: Harvest

**Time: 4 hours, at harvest maturity**

1. The crossed seeds can be harvested 25 to 30 days after pollination. The seed is mature when it loses its green colour. When the seeds mature, cut the panicles, hand-thresh the seeds and remove the glume remnants that adhere to the base of the seeds.

2. Place the harvested seeds in moist tissue paper or cloth and allow the seeds to germinate. Soon after germination, before roots entangle, transfer the seedlings to pots filled with clay and water (simulate paddy condition).

3. If the crossed F1 seeds can not be germinated immediately after harvesting, they may be stored. Air-dry the naked (or uncovered) seeds for a week and place them in small envelopes marked with the female and male parent varieties. The seeds will remain viable for 1 month if stored in a glass container (example: bottle).

4. Grow the female parent variety alongside the F1 plant. If the F1 plant looks like the female parent variety, then it is selfed and crossing was not successful. If the F1 plant looks different, the crossing was successful.

*Topics for Discussion*
- What is the purpose of the breeding objectives in varietal crossing?
- How can you check whether crossing is successful?
- What is the success rate of your crosses?
- What methodologies can be used to synchronize the flowering of the parent varieties?
- Why is it necessary to develop skills in plant breeding?

### 5.5 Selection in segregating populations

The aim of this element of the field studies is to practice line selection in segregating material.

The use of segregating rice materials received from breeding stations allows farmers to study selection techniques as early as in the first FFS-PPB season. This segregating material may involve either F2, F4 and/or F6 generation seeds.

In the PEDIGREA programme increasing numbers of farmers have learned to perform their own crosses and share the offspring with fellow farmers who are engaged in or start a new FFS-PPB programme. In most start-up FFS-PPB, farmer-generated segregating materials are introduced for learning and development purposes. In this way novice farmer-breeders and more experienced farmer breeders can benefit.
Selection in a segregating F2 population

Method

Time: 3 hours for teaching, field sessions are conducted throughout the growing season

Ensure a healthy field lot with segregating populations of different generations, and use a measuring stick and drawing material.

1. During the FFS-PPB farmers will conduct up to four different selection rounds in the field: in the vegetative stage, the flowering stage, the ripening stage and at maturity. Selection criteria for each stage should be applied based on the breeding objectives, and field observations should be documented. Note measurement on traits such as germination, tillering, panicle length, early maturity, etc.

2. During each selection round, walk through the plot and inspect each individual plant. Mark outstanding plants with a bamboo stick or ribbon. Assign different sticks, ribbons or colours per selection round to identify the plants. Make drawings of outstanding plants.

3. Perform the final selection round just prior to harvest. Select as many plants as possible for the next generation. Do not select less than 10% since preferred characteristics or special combinations of characteristics may not yet be visible and otherwise may be lost. In the F2, the selected number of plants may be slightly more (20%) than in later generations. For example, when a F2 plot consists of 500 plants, select between 100 and 150 plants.

4. After harvest, dry the panicles or thresh the seed and put the seed in a bag. Panicles or seed may be bulked, depending on the selection technique used. Attach a label to identify the parent varieties in the cross and the generation.

5. Dedicate some time to explain the breeding cycle of rice, the cause and use of segregation, and the techniques involved in bulk selection. Let farmers practice by drawing the diagrams of rice breeding involved in bulk selection (see background topics in chapter 7).

6. Optionally, elaborate on the principles of pedigree selection and modified bulk selection. This may depend on the FFS situation.

Topics for discussion
- What is the reason for the high amount of variation in the plots under study?
• Are the plants in the segregating plot very different from the parent varieties?
• How many generations are needed to select a new stable variety?

5.6 Cooking and eating quality evaluation

This study element aims to evaluate the grain characters and eating quality of stable lines in the field trial and to get an understanding of farmer’s preferences and selection criteria. The latter can be used to adjust the breeding objectives.

At the end of the season, farmers and facilitators carry out a cooking quality or gastronomic evaluation. Only stable lines, varieties and advanced breeding lines (F5 or later generations) available in sufficient quantity can be evaluated. Although it would be good to start testing as early as possible, segregating lines at the early generation are not yet stable enough and quantities too small for standard evaluation.

This evaluation can be part of a Farmer Field Day or implemented in a day-long session in the framework of the FFS.

Method

*Time: 5 hours, usually an entire morning or afternoon*

The exercise should be well prepared. Find a suitable place to conduct this evaluation and make sure all necessary tools, such as kitchen wear, cooking equipment, plates and tags are available to conduct this evaluation.

1. Jointly design the evaluation form. Ask farmers what they would look for in the rice grains when they eat it. What is good rice for them?

2. List the criteria and rank them. Ask farmers how they would like to measure the different criteria. For example: On a scale of 1-5 with 5 as the highest. Also, ask how they will classify aroma and taste.

3. Prepare the form. The form may look as the example below.

**Table 5.4: Example of an eating quality evaluation form for rice**

<table>
<thead>
<tr>
<th>VARIETY CRITERIA</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Chalkiness</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2: Consistency</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3: Aroma</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4: Colour</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>13</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Scale 1 to 10, 1=lowest, 10 = highest
4. Use the same water and grain measurement for each variety, for example one cup of water and one cup of rice. Cook the different varieties under the same conditions preferably at the same time. For ten varieties, prepare at least five stoves for cooking. Do not use any salt or other additions.

5. Place each cooked variety on a plate and line them on a table (keep the plate covered to maintain the freshness and moisture). Alongside the cooked rice, trainers can place the milled rice. Do not disclose the variety name, as farmers may be influenced by their earlier preferences. Just number the cooked rice. Facilitators should keep the variety name for each entry secret or place the name under the plate for reference. After every two or three plates and tasting of a couple of varieties, facilitators can place a glass of water for farmers to drink before they continue.

6. Give farmer the evaluation form. Farmers stand in line in front of the table. Instruct the first farmer to taste the first entry, consider the score, and fill the form. He/she moves to the second entry while the second farmer tastes the first entry and so forth. After tasting all the varieties, ask farmers to tally their scores and rank their preferences. This is the individual evaluation result.

7. On a big piece of paper facilitators prepare the evaluation form and ask each farmer to fill in their scores. The score for each criterion will be totalled and the varieties ranked. This will be the group evaluation result.

8. Finally reveal the variety names. Elaborate the results using the topics for discussion.

*Topics for discussion*
- What variety entries performed better than the control variety?
- Are there any eating quality characteristics that need to be more emphasized in the breeding program? Should we adjust the breeding objectives?
- How can we improve the evaluation method?
6 TOOLS FOR VEGETABLES

6.1 Cucurbit crops

The cucurbit family represents a large and highly diverse range of vegetables that are popular among farmer communities throughout Asia and the rest of the world. The family includes crops like pumpkin, wax gourd, cucumber, bottle gourd, loofah (sponge gourd, ridge gourd), water melon, honey melon, squash, and others. Although the morphology of plant and fruit types differs, most crops have very similar features regarding:

1. Plant and flower morphology
2. Crop growth development
3. Type of pest and diseases affecting the plant
4. Reproductive processes (monoecious/single sex flowers, insect pollinated)
5. Suitable breeding and selection methods

Crops in the cucurbit family are grown primarily for their fruit and have been adapted to suit very different environments and consumer demands. Fruits are eaten fresh as sweets or used in salads, and are valued in green or mature form and used in a variety of culinary dishes. Some cucurbit crops feature important secondary purposes as well. For example, consumers savour stems, leaves, flowers and seeds. Many plant parts also exhibit medicinal values. Some crops are even used for non-food purposes, such as in the case of sponge gourd and bottle gourd. This reflects the great diversity in the cucurbit family.

Table 6.1: Major crops in the Cucurbit family

<table>
<thead>
<tr>
<th>English Name</th>
<th>Scientific Name</th>
<th>Local Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpkin/Squash</td>
<td><em>Cucurbita moschata</em></td>
<td>Waluh</td>
</tr>
<tr>
<td>Cucumber</td>
<td><em>Cucumis sativus</em></td>
<td>Bonteng</td>
</tr>
<tr>
<td>Bottle gourd</td>
<td><em>Lagenaria leucantha</em></td>
<td>Timun</td>
</tr>
<tr>
<td>Bitter gourd</td>
<td><em>Momordica Charantia</em></td>
<td>Kukuk</td>
</tr>
<tr>
<td>Snake gourd</td>
<td><em>Trichosanthes Anguina</em></td>
<td>Pare Pait</td>
</tr>
<tr>
<td>Wax gourd</td>
<td><em>Benincasa hispida</em></td>
<td>Pare Welut (=eel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bligo</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indonesia</th>
<th>Cambodia</th>
<th>Philippines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waluh</td>
<td>Lo’pov</td>
<td>Kalabasa</td>
</tr>
<tr>
<td>Bonteng</td>
<td>Trasak</td>
<td>Pipina</td>
</tr>
<tr>
<td>Timun</td>
<td>Treung</td>
<td>Upo</td>
</tr>
<tr>
<td>Kukuk</td>
<td>Klouk</td>
<td>Upo</td>
</tr>
<tr>
<td>Pare Pait</td>
<td>Moreah</td>
<td>Ampalaya</td>
</tr>
<tr>
<td>Pare Welut (=eel)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bligo</td>
<td>Trolach</td>
<td></td>
</tr>
</tbody>
</table>

Wax gourd
| Angular Loofah | Luffa acutangula |
| Sponge gourd | Luffa aegyptiaca |
| Water melon | Citrullus vulgaris |
| Emes (Oyong) | Nor Noung |
| Sekwa | Ov Leuk |
| Sponge gourd | Patola |
| Bonnet gourd | Cucumis sativus |
| Water melon | Bonteng Suri |
| Bonnet gourd | Bonteng Suri |
| Sponge gourd | Trasak Srow |
| Water melon | Srow |
| Most cucurbit crops are grown as cash crops. This places high demands on the market channels and the marketability of the crop. Knowing the customer preferences will add to the effectiveness of the participatory breeding programme. Participatory breeding in cucurbit crops is well appreciated by farmers in tropical countries, even though commercially bred varieties are available for some cucurbit crops.

6.2 Plant morphology and growth stages

This session on morphology and growth stages of vegetables helps farmers to structure and share their knowledge on the plant with each other.

Cucurbit crops have very distinct morphological features in terms of plant habit, flowering, and fruiting. Unlike cereals, which have very distinct vegetative and reproductive growth phases, the plant growth stages in cucurbits overlap each other. The plant continues to grow, flower and produce new fruits until the entire plant ages and dies off.

Figure 6.1: Plant growth stages of vegetables in the Cucurbit Family
Method

Time: 3 hours

Make sure a few large drawings are available depicting cucurbit plants in the various growth stages for presentation purposes. Prepare for sufficient materials such as a measuring stick, magnifying glasses and drawing materials.

1. Ask participants prior to the session to collect samples of Cucurbit plants. Any cucurbit crop is suitable. Ensure that entire plants are dug up including stem, vines, fruits and root systems. Collect as many samples as possible. For comparison include plants of different varieties and different crops.

2. Split up in groups of 4-5 farmers. Participants observe the plants carefully and note the differences between the different growth stages, the crops, and varieties. Make drawings of the plants and plant parts, name the parts and mention their function.

3. In addition, give farmers one or more of the following tasks:
   - Assess the number of days between germination and flowering, fruiting, fruit harvest, and seed maturity. Prepare a timeline and indicate the respective number of days for each interval. Using this timeline, estimate the approximate dates of flowering, fruit harvest and maturity of the crops and varieties used in the farmer field studies.
   - Count the number of male and female flowers on the plant and compute the female sex rate as follows:

\[
\text{Female sex rate} = \frac{\text{no. of female flowers}}{\text{total no. of flowers}} \times 100
\]
• Count the number of fruits and female flowers and compute the fruiting rate:

\[
\text{Fruiting rate} = \frac{\text{no. of fruits}}{\text{no. of female flowers}} \times 100
\]

• Determine what plants are self-pollinated and which ones cross-pollinated.

4. Let groups present their findings in the plenary. Display and discuss the drawings. Ensure that participants understand the growth stages and terminologies used.

**Topics for discussion:**
- Why do not all flowers produce fruits?
- What happens when there is too much rain?
- In what stage is the plant most sensitive to heat or water stress?
- In what stage is the plant most responsive to fertilization?
- What cultural practices do you apply to produce more fruits?

## 6.3 Plant reproductive morphology

In this exercise farmers acquaint themselves with the flower characteristics and biological processes involved in the reproduction of the cucurbit plants. This session precedes the demonstration and practice of variety crossing.

Most cucurbit plants have a *monocious flower, which means* that flowers of both sexes appear on the same plant. A flower can be either male or female, but not both. The flowers are thus *incomplete*. This is a typical characteristic of cucurbits, and as a result the crop is mostly out-crossing or cross pollinated by nature. Other well known crops with monocious flowers are: maize and cassava.

Female flowers are easy distinguishable by the ovule (baby fruit) below the petals, which develops into a fruit after pollination of the stigma. Male flowers have anthers in stead. The ovule is divided into 4 to 5 segments, each with many egg cells.

*Figure 6.2: Male and female flowers of pumpkin*
Method

Time: 3 hours

Ensure the availability of the following materials: forceps, magnifying glass, scissors, scalpel and drawing materials.

1. Split up in groups of 4-5 farmers. Ask the groups to collect as many flowers from as many crops as possible in the neighbourhood. Flowers may be taken from the field, from the flower garden, from trees or bushes in the backyard or from the wild. Also include flowers of cucurbit plant(s) for comparison. Spread the collected flowers on the table.

2. Assign each group to study four different flowers, one of which should be a cucurbit flower. Participants use scissors, scalpels, forceps and magnifying glasses to study the different parts of the flower including the ovule with stigma and egg cells, and stamen.

3. In additional, assign each group the following tasks:
   - make a drawing of the flowers studied, add names and functions of the flower parts
   - indicate which of the flowers are complete or perfect, and which are incomplete
   - make a drawing of the Cucurbit plant’s life cycle

4. Groups present and discuss their findings in the plenary. Discuss the results and ensure that the reproduction processes are clear to everyone.

Topics for discussion
- What other crops have monoecious flowers?
- Do you know any crop with dioecious (perfect) flowers?
- How can you identify the female and male parts of a plant?
- Which part of the flower becomes the seed?
- How can you tell a flower is pollinated or not?

Perfect and incomplete flowers

Flowers that contain both female and male parts are termed perfect. Flowers that contain only male or female structures are called incomplete. Incomplete flowers may have only female structures (pistillate) or have only male structures (staminate). Female and male flowers may be found on the same plant. These types of plants are termed monoecious (cucurbits), if the flowers are found at different locations on the plant. If the incomplete male and female flowers are only found on different plants, the plants are referred to as dioecious.

6.4 Pollination study (the bee exercise)

This exercise is designed to observe insects in the field and how they are acting as pollinators between flowers of the same plant and in-between
plants, even in-between varieties, which help farmers to understand the need for isolation.

In cucurbits, flowers are primarily pollinated by insects, such as bees, butterflies, flies, and beetles. Insects are attracted to visit the flower because of its colour and nectar, and by doing so they carry some pollen to the next flower, thereby facilitating the pollination process. Besides colour and smell, the insect’s visiting behaviour is also strongly influenced by environmental factors including day and night fluctuations, sunshine and rainfall, and flower opening and closing. These aspects therefore have a major influence on the pollination process.

![Insect pollination](image)

**Method**

**Time: 3 hours**

Ensure each participant has a notepad. For this exercise, the facilitator should also bring a stopwatch.

1. Split up in groups of 4-5 farmers. Enter the field in early morning (7am) and focus on a number of cucurbit plants in flowering stage. For this study element, there should be at least 5 newly open flowers available for observation. Mark a number of observed plants, with bamboo sticks.

2. Explain farmers that they are to be assigned insect ‘expert’, and their task for today will be to count special types of insects, that play a role in the pollination process. Show the insect pictures and ask each group member to select their study field. Each study field consist of a number of plants marked with bamboo sticks. In the notepad the farmers should make four columns, each one for every insect: bee, butterfly, beetle and fly (other types of insects may be added).
3. Each farmer in the group is given the task to count the number of insect landings on the selected flowers or selected plants within the trial plot during a stretch period of 15 minutes. Be sure to write down date, time, temperature and weather conditions for each count. Once the preliminary environmental information is complete, farmers are ready to start with the activity. The procedure goes as follows:

- The leader or facilitator gives the signal to start; the counting can begin.
- Farmers observe carefully; every time an insect enters the area and lands on a flower of one of the selected plants, the farmer makes a

---

**Flower Morphology:**

Perfect flowers generally contain a female structure, consisting of a style with stigma, and a male structure, consisting of stamens with anthers.

- **sepal** - usually leaf-like; green, and protect the bud as the flower develops within
- **petal** - structures of which the size, shape and colour accounts for the attractiveness to a specific pollinator. Wind-pollinated flowers may lack petals.
- **pistil** - lies within the centre of the petals; vase-like in appearance. May be simple or compound, and contains a single reproductive unit called a carpel which usually has three parts; the stigma (enlarged, sticky knob); the style (slender stalk); the ovary (an enlarged base). The ovary contains ovules (where production of female egg cells occurs).
- **stamen** - made of 2 parts; anther (sack-like container in which pollen grains develop) and the filament (slender stalk).

![Flower Morphology Diagram](image)
tick in his notepad for the respective insect observed. In case an insect leaves the plot and comes back again, the farmer should count it again. If the insect jumps to another flower in the same plant or plot, the farmer ticks it also once more.

- After 15 minutes the facilitator blows a wizzle. Farmers then stop counting and summarize their group results and report their data to the facilitator. After this they move on to another observation plot.

4. Continue until the groups have completed all trial plots. If tracking insects is difficult, each farmer may select only one insect and track insect movement on the flowers in the study plot.

Table 6.2: Example of an insect landing score table

<table>
<thead>
<tr>
<th>Group:</th>
<th>Date:</th>
<th>Time:</th>
<th>Temperature:</th>
<th>Weather Condition:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEE</td>
<td>BUTTERFLY</td>
<td>ANT</td>
<td>FLY</td>
<td></td>
</tr>
</tbody>
</table>

5. Repeat the exercise later in the day or on a different day in order to study environmental interactions on the roaming behaviour of the insects, such as the effect of time and temperature, and weather conditions. On some days pollinators are scarce, especially when it is windy, rainy or cool. Farmers should not feel discouraged if they do not see many insects. This is part of the exercise. Expect data sheets to be returned with zeroes in some categories. In ecological sciences, negative data (in this case, not finding something set out to observe) can be just as important as positive observations.

6. Groups should then go back to the meeting venue, compile the insect scores and elaborate on their findings.

Topics for discussion
- What insect is the best pollinator?
- Can you explain the differences in “insect landing scores” and flying behaviour at different times of the day and week?
- What is the influence on insect activity of: time of the day, temperature, rainfall?
- At what time of the day insects are most active and why?
- Assess the maximum distance over which insects can pollinate two different plants in an open field.
6.5 Timing of cross pollination

This is a general preparation study for the FFS-PPB training course, especially suitable in case more exotic varieties have been introduced into the field studies.

For performing successful crossings, farmers need to determine the appropriate time for the activities involved in variety crossing, such as bagging, tagging, pollination and monitoring. In this series of three small exercises, farmers will study the flower development stages from budding to fruiting and determine the optimal time for crossing. Between species, but also within species (among varieties) there is considerable variation in the flowering process.

Method

Time: 5 hours

This activity involves a series of short exercises conducted over a period of 2-4 days. Because of the time consuming nature of the study it is good to assign part of the exercise as homework to farmers or farmer groups between different FFS sessions.

Ensure that sufficient plants in flowering stage are available in the field. Necessary materials such as magnifying glass and drawing material should be ready.

Field study 1: Flower opening and closing

1. Study the flowers and determine at what time of the day the flower opens and when it closes again. Observe and note any differences between cucurbit crops and differences between varieties of the same crop. Record the time of opening and closing. Determine if the same flower opens and closes only one time or more times.

2. Farmers present their findings in the plenary meeting and elaborate the results. Based on the observations determine the best time for bagging of the female flower, which is generally 12 hours before flower opening. Also determine the best time for pollination, which should be immediately after flower opening.

Field study 2: Selection of buds for bagging

1. Split up in small groups. Each group heads to the field in the afternoon and selects 10 flower buds in different stages but close to flowering, attaching a small tag for identification, describing the stage of bud development: small, medium, large.

2. Return the next morning to observe the results. Determine which of the flower buds have developed into mature flowers and describe or draw the type of bud.

3. Groups present their findings for discussion in the plenary.

4. In the plenary, prepare a timeline and draw the various flower development stages from budding to fruiting and indicate the exact
timing for bagging, flower opening and closing, and possible time for de-bagging.

Note: Most problems in varietal crossing relate to the optimal timing for pollination in cucurbits. While the stigma remain receptive for 24-36 hours after opening of the flower and exposure, pollen is only able to germinate for a couple of hours after anthers emerge in the early morning (afternoon for sponge gourd). For bitter gourd, pollen germination decreases sharply after 11 am. Apart from the viability of pollen, also the way pollen is applied in the crossing is important; make sure that all lobes of the stigma are fertilized.

Topics for discussion
- When is the correct time for manual pollination?
- What is the purpose of bagging?
- Why do we need tags?
- Can we make varietal crossings without bagging?

6.6 Selection of parent varieties

This exercise is similar to tool 5.3 in rice and aims to assist farmers to select suitable parent varieties for crossing.

Farmers select varieties for crossing when they cannot find preferred criteria in one and the same variety. For example: a breeder has a high-yielding bad fruiting variety and a low yielding variety with excellent fruiting characteristics. If he/she wants to make a high-yielding pest good fruit quality variety he must cross the variety, so that genes can re-combine:

\[
\text{high-yielding, } + \quad \text{low yielding} \quad \rightarrow \quad \text{high-yielding, good fruit appearance} \quad \text{good fruit appearance} \quad \text{good fruit}
\]

Prior to the varietal crossing practice it is good to elaborate on the varieties for crossing, so that farmers understand the difference between individual and group preferences. Finally adopted preferences should reflect the breeding objectives.

Method

Time: 2 hours

1. Identify varieties with preferred traits and list desired varietal crossings and reasons for such crossings using table 16

2. Discuss the results and prioritize the crosses. Compare the reasons with the breeding objectives.


4. Use the crossing table to monitor the crosses during and after field practices and to compare group and individual performances in the crossing work.

Topics for discussion
- Why do we need to make reciprocal crosses?
- How many successful crosses do we need to build a breeding programme?
How many crosses can you manage?

6.7 The technique of variety crossing

In this study we will demonstrate the manual crossing process.

Cucurbits are naturally out-crossing or cross-pollinated crops. Pollination primarily takes place by insects, such as bees, flies and beetles, which fly randomly from one flower to the other attracted by the smell of nectar and the color of petals. Since insects do not differentiate between flowers, some degree of self-pollination is inevitably, when female flowers are pollinated by male flowers of the same plant. The success of pollination varies depending on the insect behavior, and the factors affecting this behavior, such as distance between plants, field barriers, temperature and rainfall. Making artificial crossings for breeding purposes aims to control these processes manually.

Making crossings implies that the farmer-breeder chooses parent varieties to cross and start a breeding programme. In cucurbits, no emasculation is required to perform the crossing because of the presence of monoecious flowers. Varietal crossing can be performed in two ways:

- Planting two varieties in an isolated spot. This is the easiest, most productive and low-cost way to perform varietal crossing. Beforehand, breeders should know what varieties to cross. To prevent self-pollination, out of every three rows, select one row to be used as pollinator (male row) and two rows to be used as receptor (female rows). During the flowering period, daily remove the male flowers from the receptor plants. When fruits are ready for harvesting, only pick the fruits from the receptor plants, and extract seeds for the subsequent breeding and selection programme (this procedure is for example also used in the production of maize hybrids).

- Manually perform the crossing work. This option is used when isolation is not possible such as when multiple varieties are planted close together, for example in a variety trial.

Method

Time: 8 hours total

The crossing work in the field stretches over a period of several days and involves four different steps:
- Step 1: Preparation
- Step 2: Pollination
- Step 3: Inspection
- Step 4: Harvest

Ensure that there are sufficient healthy plants in flowering stage available in the study field. Prepare for necessary materials such as: forceps, tape or rubber band, glassine bags (fit to the size of flowers), waterproof marker pens, and tags.

After demonstration of the crossing practice, let farmers practice themselves, and subsequently let them make their own crosses.
Demonstration, practice and performing actual crossings can be done in one week on subsequent days, or in different FFS sessions during a number of weeks.

Field Session 1: Preparation

*Time: 2-3 hours, one day before crossing (afternoon)*

1. Prior to the crossing practice, review the crossing table prepared earlier.
2. Head for the field in the afternoon. Select female flower buds that will open the next day. Once the buds have been identified, cover them with a glassine bag to prevent insects from entering. Tie the bag at the bottom carefully with a small rubber band or tape. Be sure not to damage the peduncle.

3. Write the variety’s name on the bag
4. At the end of the exercise enter the varieties and number of bagged flower buds in the crossing table.

*Figure 6.4: Bagging of pumpkin flower*

*Farmer demonstrating variety crossing technique in loofah*
Field Session 2: Pollination

Time: 2-3 hours, in the early morning or afternoon following field session 1

1. Inspect the bags on the female flowers and observe if they are still intact and the flowers have opened.

2. Review the crossing table for selected male parents.

3. Proceed with collecting freshly opened male flowers on the plants of selected parent variety and put the flowers in a plastic bag identified with the name of the male variety.

4. Prior to pollination carefully remove the glassine bag from the female flower. Gently rub the pollen of the anthers on the exposed stigma. Be sure to touch all lobes. Once again pull the bag over the flower and tie it with a rubber band or tape.

5. Add the name of the male parent variety on the bag. It is custom to write the mother plant first followed by the father plant. Also write the date of crossing and initials of the breeder for identification.

6. At the end of the exercise, count the number of crosses and enter both the father variety and the number of crosses in the crossing table.
Field Session 3: Inspection

*Time: 2-3 hours, a few days after the pollination*

1. 3-4 days after crossing remove the bags and observe the crossed flower. By this time the flower petals have dropped. If pollination was successful, the ovary (the baby fruit) is clearly visible and growing. In case it was not successful the flower has wilted altogether.

2. Attach a tag to the stem just below the successfully hybridized flower, so that it is easily visible. On the tag write the name of the parent varieties, with female parent first, the date when the cross was made, and initials of the farmer-breeder.

*Example of a crossing label*
3. Count the number of successfully pollinated flowers and make a record in the crossing table.

4. Calculate the percentage of successful crossing by computing the success rate as follows:

\[
\text{% successful crosses} = \frac{\text{no. of flowers with baby fruit}}{\text{total no. of pollinated flowers}} \times 100
\]

5. Discuss the results from the variety crossing table in the plenary. Compare and review the targets, number of actual crossing with the rate of success.

**Alternative crossing method**

Some farmers, for example in Indonesia, do not use glassine bags. They consider glassine bags to be expensive. Also, glassine bags have shown to cause a high rate of failure because of humidity build-up inside the bag, especially in non-vine crops like pumpkin. In stead, farmers tie petals in the budding stage with a rubber band to prevent the flower to open the next morning. At the time of crossing, the rubber band is removed and the male flower is tied on top of the female flower with petals overlapping to prevent insects to enter the flower.

Note: the above described crossing process can also be used to enforce self-pollination (pollination of male and female flowers of the same variety), e.g. when a variety has to be maintained in its original form.

**Topics for discussion**

- Why do we need to monitor the flowering stages of the parent varieties?
- What is the use of a variety crossing table?
- What is the reason for the low success rate of your cross?
- What is the most productive and cost-efficient way to hybridize two varieties?

**6.8 Harvest and seed storage**

In this study farmers will plan for the harvest and discuss issues related to harvest and storage. See further issues on village genebanks chapter 8.

In plant breeding, harvest time is one of the most critical periods in the season. At harvest, the selected varieties, plants and crosses must be carefully identified, harvested, threshed and stored. Seeds of fruits are extracted after harvest, or - if the fruit can be stored long enough - just before re-planting. Seed lots must be identified with tags and labels and entered in bags to avoid admixtures. Clean storage rooms must be prepared to carry over the fruit and seed to the next season. Additional fruits may be harvested for further post-harvest evaluations like cooking quality, taste and shelf life.
Method

Time: 3 hours

Prepare for sufficient material including notepad and drawing materials.

1. Discuss the farmers’ methods of harvesting, drying and storage. Focus on the farmers’ practices to keep different varieties separate.

2. Consider differences between the farmers’ practices and the requirements for breeding using the table below. Elaborate on the requirement to avoid admixtures, keep records of the various fruit and seed lots, and the need for seed bags and clean storage spaces. Discuss the various topics by asking where farmers foresee problems.

3. Prepare a work plan for the harvest in the field studies and assign responsibilities.

Table 6.3: Comparison of farmer’s and breeder’s system of harvest and storage

<table>
<thead>
<tr>
<th>Component</th>
<th>Farmers’ system</th>
<th>Breeders’ system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety Cross for Selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Harvest evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-testing of variety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planting in own field Etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: in the field study on variety evaluation farmers tend to retain seed from varieties that appeared promising. Such practice is not reliable since pollination occurs in all directions and the harvested seed will not be true-to-type anymore. To multiply the original varieties, farmers should retain seed from the original source. If such is not possible, because few seeds were received, farmers can make selfings within the selected variety.

Topics for discussion
- What are the main difference between the farmer’s system and the breeder’s system of harvesting?
- Do you have sufficient labels, bags, drying areas and storage space to handle the different varieties and lines?
- Where can you get original seed to keep the variety true-to-type?

6.9 Cooking and eating quality evaluation

This study provides tools for farmers to develop methods to test the local preferences and to evaluate the eating qualities of a number of varieties.

For most farmers, the fruit characteristics such as shape, colour, processing qualities, texture and taste, are as important as the absolute yield. A fruit is almost worthless if it does not have the correct appearance and properties for the food that consumers eat. It is therefore important to evaluate the cooking and eating qualities of the varieties tested.
Some cucurbit fruits are consumed while immature, like bitter gourd, wax gourd and cucumber, while others are consumed in mature form like pumpkin and bonnet gourd. This has implications for the timing of the exercise. For fresh fruits the evaluation can be scheduled halfway the growth season; for mature fruits, this session need to be postponed to the end of the growing season.

Evaluation of the fruit’s cooking quality requires some special preparations, as each variety need to be processed and prepared exactly in the same way. Prior to the evaluation, farmers therefore need to agree on how to prepare the food and what type of ingredients to use.

![Eating quality evaluation of pumpkin varieties](image)

**Method**

*Time: 5 hours, it usually takes a whole morning or afternoon to complete this session*

This exercise should be well prepared. Facilitators and farmers should find a suitable place to conduct this evaluation and ensure necessary materials are available such as: kitchen wear, cooking equipment, plates and tags.

This exercise can be part of the Farmer Field Day workshop celebrating the end of season’s activities in the Farmer Field School. Officials and other villagers may be invited to participate in this evaluation. The evaluation may be followed by a presentation of the overall results and final evaluation.

1. The first activity is to agree on the dishes: is the fruit consumed fresh or processed, and - if processed - what are the main culinary dishes. Select a maximum of three main dishes for evaluation. Discuss and agree on the preparation methods.

2. List for each of the dishes the main criteria for evaluation by asking participants the question: what determines a good quality dish? Then agree on the measuring scale. For instance, dishes may be evaluated for criteria like aroma, texture, colour, or cooking time, and measured on a scale of 1-5 using 5 as the highest preferred and 1 as the least preferred (do not use 0 for computational reasons). Conduct this activity in separate groups of male and female participants to reveal potential gender differences.

3. Finally agree on the dishes that should be prepared, the way of preparation, the list of criteria to be measured, and the measuring scale. In the preparation, do not use any salt or spices.
4. Prepare the evaluation form for each dish.

Table 6.4: Example of an eating quality evaluation form for vegetables

<table>
<thead>
<tr>
<th>Name: _____________________</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop: __<strong><strong>BITTER GOURD</strong></strong></td>
<td></td>
</tr>
<tr>
<td>Dish: ________________<strong><strong>FRESH</strong></strong></td>
<td></td>
</tr>
<tr>
<td>Date of evaluation: <em><strong>October 3rd 2004</strong></em>_________</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIETY</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRITERIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1: Aroma</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2: Texture</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3: Sweetness</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4: Colour of</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>flesh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>13</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Keep the varieties separate during the preparation process.
6. During the evaluation do not show the farmers any names as they may be influenced by seeing the name of their preferred varieties. Give each entry a number code and note down the details with name and origin in a notebook. Place each dish on a plate and line it on a table with identification number. Place a glass of water after every dish to allow the tester to rinse his mouth before testing the next dish.
7. Instruct the first farmer to taste the first entry and to record his score in the form. He/she then moves on to the second plate and so on. When finished, ask the farmers to re-check their entries for each criterion and write their name on it.
8. Compile the participant’s scores by variety in a summary table and rank the varieties accordingly. Finally reveal the variety names and discuss the results.
9. Repeat the procedure with the other dishes farmers wish to evaluate and document the results. Discover potential differences in taste by grouping farmers by gender (male/female), by age (young/old), or by any other nature (ethnic, origin, education etc).

Topics for discussion
- Which varieties performed better than the control variety?
- Are there any eating quality characteristics that need to be emphasized more in the breeding program?
- How can you improve the evaluation method?

6.10 Yard-long Bean (String Bean)

In PEDIGREA, experience is currently building with regard to crops like yard-long bean (string bean) and eggplant, especially in the Philippines. In the following sections, we will briefly describe the morphology and crossing
practices in these two crops in order to assist farmers in the implementation of the FFS-PPB training courses. For a general description of the different steps involved and the materials needed, one is referred to the previous paragraphs.

Background
Native to Southeast Asia, yard-long bean is a mostly climbing plant, and a close relative of the cowpea or black-eyed pea. It comes in different varieties, from the more common pale green pod variety to the more slender darker green one to a deep brownish red variety. The vegetable is popular among farmers and usually grown on poles, although also free-growing varieties are available. Young pods of yard-long bean are used as a cooked vegetable, mostly combined with rice as the main dish. In Indonesia, fresh young pods are consumed in salads. Sometimes, also shoots and young leaves are consumed.

Plant morphology and growth stages
Like other fruiting vegetables, the growth stages of yard-long bean overlap. After germination, growth is very fast. Flowering starts usually in the 5th week after sowing and the harvest of young pods starts 2 weeks later. Depending on the crop health and intensity of harvesting, senescence starts 1½-2 months after sowing and the plant dies after 3-4 months. Pods can reach a length of one yard (90 cm), hence the naming.

Flower morphology
Yard-long bean is a naturally self-pollinating crop, although some degree of cross-pollination by insects occurs. Emasculation or the removal of anthers before the style becomes receptive is required. Flowers are fairly large and easy to manipulate, the keel is straight, beaked and not twisted. Flowers have few floral nodes per raceme.

Figure 6.6: Cross-section of the flower of yard-long bean
Variety crossing technique

Below a rapid and effective method of hand emasculating and crossing of yard-long bean is given. It consists of removing the upper half of the petals starting with a partial cut opposite the style and stamen.

Method

Ensure sufficient materials for emasculation and pollination are available: scissors, glassine bags, forceps, dissecting needle, paper clips, magnifying glass, pen and tags. Use a notebook and variety crossing table to record the parent varieties and number of crosses made.

Field session 1: Emasculation

1. Select the varieties to emasculate in the field. For this a crossing table can be used. Choose flower buds destined to open the following morning. These buds have reached their maximum unopened size and have started to pale slightly. Select the first developing bud on the raceme for crossing, which tend to set pods more easily than later developing buds, and remove other buds. This diverts all nutrients in the peduncle into one pod increasing success rate, and it avoids confusion in labelling.

2. Hold the bud selected for emasculation firmly but gently in such a way as to avoid any stress at the fragile attachment of the bud and raceme. Make a cut in the centre of the bud starting from its straight edge. The cut can be made using forceps, small scissors, or even long thumbnails. Cut about two-third the width of the unopened bud. Be careful not to damage the edge of the bud that encloses the style and stamens.

3. Grasp the upper portion of the folded petals by the thumb and index finger and gently tear off the cut segment. This leaves the upper portion of the style, stigma and stamens free and exposed. Remove the 10 anther sacs with forceps. Take care not to touch the receptive green tipped stigmatic surface.

4. Dip the scissors or forceps in alcohol (75-95%) before proceeding with the next emasculation. Repeat the emasculation process using other flowers.

5. After completing the emasculation, record the number of emasculated plants in the crossing table.

Field session 2: Pollination

Ideally, the flower should be cross-pollinated immediately after emasculation, although it is possible to wait until the following morning. In the latter case bagging is necessary after emasculation to prevent unwanted contamination. Demonstrate the pollination process and repeat each step as follows:

1. Collect freshly opened flowers from the parent variety to be selected as male. Place the flowers in a plastic bag, close it and attach a label with the name of the variety. Store the bag with the flowers in a shady place until used for crosses. The pollen remains viable for a maximum of 12 hours.

2. To perform pollination, the anther sacs must be exposed. Do this by removing or slip backwards the innermost petals of mature open flowers.
Use the pollen on the hairy necked style as a brush to rub pollen grains on the green circular stigma.

3. Use one flower to pollinate up to four emasculated buds. Only the oblique arranged disc-shaped stigma at the tip of the style is receptive, not the hairy portion beneath.

4. Affix a small tag listing the crossing and date to the raceme or peduncle beneath the pollinated flower bud. Do not allow hands, equipment and other objects to touch the receptive portion of the stigma and the anther sacs.

5. Upon completion of the crossing procedure cover the crossed flower with a glassine bag to keep insects out and to minimize the risk of contamination. Alternatively place the plants under a wooden cage with fine mesh netting for 5 days. Take care to exclude and remove crawling and flying insects from the plants during and immediately following pollination. Even ants, which are often attracted to the nectarines, can cause self-pollination.

6. Check if each group has completed their exercises and record the crosses in the crossing table.

![Figure 6.7: Technique of emasculation and crossing in yard-long bean](image-url)

1. Cut about two-thirds the width of the unopened bud
2. Gently tear off the cut segment.
3. Remove all anther sacs.
4. Pollinate the emasculated bud

**Figure 6.7: Technique of emasculation and crossing in yard-long bean**
Field session 3: Inspection

Unfertilized flowers drop off within 24 hours after anthesis and the unfertilized ovary may remain attached for 48 hours after anthesis. You can make a good check on the success of a cross three days after anthesis.

1. Observe the plants daily until three days after pollination. Note unfertilized flowers to drop off.

2. After 7-10 days, check for the percentage of successfully pollinated flower buds by counting the number of pods developed per cross as follows:

\[
\% \text{ set seed} = \frac{\text{no. of flower buds with pods}}{\text{total no of pollinated flower buds}} \times 100
\]

3. After 18-22 days the pods are ready for harvest

**Tips for crossing**

3. To increase the percentage of fruits set per plant in hand-emasculated crosses:

- Leave only one bud for crossing purposes on each raceme and peduncle.
- Allow only 2-3 crosses per plant
- Increase the humidity by regularly applying a fine mist over the top of the plants with a spraying device; avoid hot temperatures
- Regularly irrigate the plants to improve seed setting and development

6.11 Eggplant

Introduction

The eggplant originates from India and is now generally grown as a vegetable throughout the tropical, sub-tropical and warm temperate areas of the world. The varieties display a wide range of fruit shapes and colours, ranging from oval or egg-shaped to long club-shaped, and from white, yellow, green through degrees of purple pigmentation to almost black. An increasing number of F1 hybrid varieties is available in the market. However, many farmers still prefer to keep or exchange their own seed. Fruits are popular in the market as they are used in many dishes, either boiled, fried or stuffed. Unripe fruits are sometimes used in curries.

Plant Morphology and Growth Stages

Although semi-perennial, eggplant is usually grown as an annual with a cropping season duration of 5-6 months. Seeds are small and need a nursery for planting. Plants are bushy and because of the need for a wide planting distance, they require a larger than average area for the field studies. Flowering starts in the 6th to 8th week after transplanting and the
harvest of the fresh fruits begins 2 weeks later. Similar to other vegetable fruits, growth stages overlap.

**Plant reproductive morphology**

Eggplant is normally a highly self-pollinating crop, although there is ample opportunity for cross-pollination by insects. The rates of natural cross-pollination may vary from 0 to 8.2% (average 2.7%), depending on variety, location, and insect activity. The flower is normally perfect, having functional male (anthers) and female (pistil) parts. The flowers are borne solitarily or in clusters of two or more. In the solitary flowering type, flower drop is very low, whereas in the clustered flowering type, flower drop may be as high as 80%. Fertilization in mature flowers occurs between 6:00 and 11:00 in the morning. However, this is influenced by the daylight, temperature and humidity, and the exact timing should be determined by observation and experience.

**Variety crossing technique**

Ensure sufficient materials for emasculation and pollination are available like: scissors, glassine bags, forceps, dissecting needle, paper clips, magnifying glass, pen and tags. Use a notebook and variety crossing table to record the parent varieties and number of crosses made.

**Field session 1: Emasculation**

Emasculation should be done in the afternoon between 3 – 5 p.m. prior to the opening of the flower.

1. Choose bud flowers that will open during the following morning.
2. Open/ incise the flower bud by cutting the petals using a dissecting needle and scissors, then remove the 5 anthers.
3. Cover the emasculated flower with a glassine bag.
4. Put a breeding tag with name of parent varieties, date of emasculation, and name of the breeder.

**Figure 6.8: Eggplant flower before and after emasculation**

**Field session 2: Pollination**

1. Pollination should be done the following morning, between 7 – 10 am.
2. Inspect the bags on the emasculated flowers and observe if they are still intact and the flowers have opened.
3. Collect freshly opened flowers in the selected variety used as male and put these in a plastic bag and write the name of the variety on the bag. These flowers will serve as the male parent.
4. Carefully remove the glassine bag from the emasculated flower.
5. Cut the petals of the male flower
6. Gently rub the pollen of the male flower on the stigma of the female flower
7. Cover again with glassine bag
8. Add the name of the male variety on the breeding tag, and date of pollination.

Pollination of emasculated flower of eggplant

Field session 2: Inspection

1. After pollination, wait for 3-4 days and inspect the crosses.
2. Remove the bags and check if the baby fruit is developing and the tag is still attached.
3. After 7-10 days, check for the percentage of successfully pollinated flowers by counting the number of baby fruits developed per cross as follows:

\[
\text{% set seed} = \frac{\text{no. of flower buds}}{\text{total no of pollinated flower buds}} \times 100
\]

4. After 25-30 days the fruits are mature and ready for seed harvest.
7. **BACKGROUND TOOLS**

Background tools aim to provide participants with more background information so that they can better understand the topic under study. They may be used and discussed during the start-up FFS-PPB course depending on the capacity of the farmer participants and the time available during the course. Usually the topics need to be re-discussed during the follow-up field studies after the start-up course.

7.1 Genetic diversity

This topic allows farmers to become familiar with the different aspects of genetic diversity, understand why genetic diversity is important for breeding new crops, and to become conscious of farmer’s role in managing genetic diversity.

**Method**

*Time: 1-2 hours*

The issues can be best discussed in the 2nd or 3rd week of the FFS course. Two to three resource persons discuss the topics in small farmer groups using short lectures, group debate, and group activities in a rotating fashion. Topical lectures should be short and together with the ensuing discussion not more than half an hour each. Results of the group activities should be reported back to the plenary and discussed.

**Structure of presentation**

- Importance of genetic diversity
  - Levels of diversity: biodiversity vs agro-biodiversity
  - Advantages of genetic diversity
- Causes of genetic erosion.
- Key role of farmers in managing genetic diversity
- Summary and conclusion

**Group Activity:**

1. Arrange participants in 4-5 members per group. See to it that each group is properly represented by age groups and gender.
2. Ask each group to recall the landscape (especially the agricultural landscape) of the village 25 years ago and draw it on a sheet of paper. After finishing, ask again each group to draw the *present* landscape (again focusing on agriculture) in the village. Encourage groups to discuss the issues before preparation of the two drawings.
3. Ask the group to compare both drawings and identify the noted differences or changes and if possible identify the causes.
4. Groups then present the drawings and the result of the discussion in the plenary.

**Questions:**

1. Make a list of crops or varieties in your area that have been lost over the past 50 years. Do you know of any Centres of Crop Diversity in your country?
2. Why do you think your community needs genetic diversity?
3. Who will benefit from genetic diversity: farmers, breeders or consumers? Why?

4. Explain what you can do to broaden the genetic diversity in your community.

**Definitions (1)**

**Biodiversity.** The variety of life forms: the different plants, animals and microorganisms, cultivated and wild, the genes they contain and the ecosystems they form. Biodiversity is usually considered at three levels: genetic diversity, species diversity and ecosystem diversity.

**Agro-biodiversity.** This includes in the first place the variety of *domesticated* life forms. It contains those plants and animals that have been adapted for use by humans such as food, medicine, nutrition, building materials, etc. Most of the cultivated crops cannot survive in the wild, since they are dependent for their survival on the farmer’s management and human managed agro-ecosystems. Agrobiodiversity also includes other life forms occurring in farming systems, such as pollinators, soil micro-organisms and those species mainly occurring in farming systems, such as certain birds. Although extensive, agro-biodiversity is only a small part of total biodiversity.

**Crop-domestication.** A process involving thousands of years of farmer selection by farming communities in ancient civilizations starting with wild species that developed into domesticated species. This selection has altered the characteristics of early crops to adapt to new environments and human handling, ultimately producing major food crops as we know them today like rice, corn, vegetables, palm, rubber etc.

**Centres of origin or diversity.** The locations in the world where particular domesticated plants originated or show a high level of diversity respectively. The centres of origin are rich in wild alleles (part of gene). In and around the areas of domestication this resulted in primary centres of genetic diversity. Through human movements and trade, also additional centres of diversity have been created.

**Genetic diversity.** The variation within species that is attributable to differences in hereditary material (genes). For example, the genetic diversity in the hundreds of varieties of potatoes can be seen by their differences in size, shape, colour, taste and rate of growth. Genetic diversity enables farmers to grow crops under a range of varying conditions and adverse environments, and allows them to better manage uncertainties, such as pest, disease and droughts. Genetic diversity also assists both farmers and breeders to select and breed for better crops and varieties to satisfy present and future demands in production and consumer preferences.

**Genetic erosion.** The loss of genetic diversity caused by either natural or man-made processes, such as replacement of many farmers’ varieties by few modern varieties, changing socio-economic conditions influencing consumption patterns favouring new farming systems and varieties, changes in climate patterns, habitat destruction, centralization of plant breeding in few institutions and multinational corporations, calamities like major pest and disease outbreaks, drought spells and civil war, and the loss of farmers’ role as plant breeders.
7.2 What is Participatory Plant Breeding (PPB)?

This exercise focuses on the two systems of breeding, the farmers’ system of breeding, and the institutional system of breeding. The exercise will assist participants in determining what should be done to improve the farmers’ and institutional breeding systems and to make optimal use of the comparative advantages of the two breeding systems.

Traditionally, farmers take part in the breeding process only in the conventional way, being evaluators and users of final varieties. Their participation in the breeding process appears to be barred by the traditional perception that separates science and users of technology. Influenced by this concept, breeders, scientists and policy makers are generally not well aware of the actual and potential benefits of on-farm crop improvement, and the comparative advantages of the two systems of breeding.

Method

Time: 2-3 hours

The general structure of this session is similar to the previous one. Depending on the resource persons, the time available, and the level of comprehension of the participants, group activities are held either in a simple or in a more elaborate fashion.

Structure of Presentation

• Definition and purpose of PPB
• How can farmer communities start with PPB?
• Parallel breeding systems: collaboration with research?
• Group activity
• Summary and conclusions

Group Activity

1. Allow the groups some time to elaborate on what is meant by the breeding components presented in table 1. If necessary provide further explanation.

2. Groups then should discuss and decide, for each of the components, on the strengths and weaknesses of the farmers’ breeding system and the institutional breeding system.

3. Upon completion of this exercise, participants may discuss how to utilize the two breeding systems in the most optimal way by elaborating, first of all, the potential improvements in the farmer’s breeding system, and subsequently how to use, support and promote the institutional breeding system.

4. Findings should be discussed and compiled in the plenary.
Table 7.1: Comparative analysis of the two breeding systems

<table>
<thead>
<tr>
<th>Breeding Component</th>
<th>Farmer breeding system</th>
<th>Government/ Institution breeding system</th>
<th>How to Improve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strength</td>
<td>Weakness</td>
<td>Strength</td>
</tr>
<tr>
<td>Genetic Conservation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breeding objective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to parent materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breeding techniques</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection techniques</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetic progress</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variety trials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision making</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each plant breeding system thus has comparative advantages and disadvantages. To meet the needs for genetic conservation and crop improvement the two systems of plant breeding are both needed. When completed, participants should realise that the two systems are complimentary. In the areas where one system is weak, they will identify aspects in which the other system is stronger, and the other way around.

Questions:
1. Explain what is meant by farmer-professional breeder partnerships. Give a few examples how such partnerships can help the local farmer breeding system in your community.
2. What can be done otherwise to promote participatory plant breeding in your area?

Options:
1. If the comprehension level of the farmers is more limited, groups should focus on the experiences with farmer’s system of breeding (the first half of the table). Subsequently, resource persons can explain the strengths and weaknesses of the government/ institutional breeding system, after which groups may continue with discussing on what can be done to improve their farmers’ breeding system.
2. In case the level of education of the participants is above-average, it may be suggested to additionally focus the discussion on what should be done to support and promote participatory plant breeding in the local farming communities. Particularly, attention may be given to political and policy matters such as: farmers’ rights issues, breeding crops for local adaptation, and breeding for certain stress conditions (drought/heat/salinity).
Identification and scoring of harmful and beneficial insects in the field

This exercise, which is adopted from FFS on Integrated Pest Management, assists participants to identify insects and other arthropods and organisms in the field to learn their function in the rice and vegetable ecosystem, the damage they incur to the plant or fruit.

Pest resistant varieties are frequently on top of the farmers’ priority list for breeding. Most farmers, however, have difficulty identifying insects, including differentiating between harmful and beneficial insects, and relating damage to particular insects. This often results in farmers spraying with broad-spectrum chemicals killing all insects.

In FFS-PPB, there is a need for farmers to not only identify harmful and beneficial insects, but also to identify levels of tolerance and resistance to pests in plant varieties in order to make successful selection possible. The exercise is best used in connection with the weekly GEAN observations, and intends to build skills and know-how on scoring for pest resistance in the variety evaluation study and in the evaluation of breeding lines.

Definitions (2)

*Participatory Plant Breeding.* a relatively new concept in plant breeding that seeks to enhance the role of farmers in the conservation and development of crop genetic resources (specific objectives see chapter 1).

*Parallel breeding systems.* The term parallel refers to the existence of two systems of breeding: the informal farmers’ system of breeding and the formal institutional system of breeding. In practice, these two systems of breeding are intertwined. Strengths and weaknesses are complementary in many ways, which suggests that a closer collaboration is beneficial. This may result in a breeding system that is better equipped to meet the needs of producers and consumers in future.

*Natural selection.* A process driven by competitive forces of nature. When, for example, two different varieties with short and tall plants are planted together, natural selection can favour one variety over the other, so that in the next generation the frequency of one of these traits is increased.

*Farmer selection.* This type of selection is governed by human preferences and can enhance or withstand natural selection forces.

*Breeding cycle.* The breeding process has five components: The setting of breeding objectives, creating variability, conducting selection, generating and testing new varieties, and diffusing new varieties. Together, these components form the breeding cycle. Professional breeders usually manage different breeding cycles at the same time.

*Variability.* The occurrence of genetic or genotype differences. Before starting a breeding cycle, breeders inventory germplasm to increase the genetic variability. There are four methods to increase variability: germplasm introduction, variety crossing, mutation, and introgression. Breeders usually focus on the first two methods; the others are more difficult to operationalize.
Method

Time: 2-3 hours

Participants should take 30 minutes for field observations and collecting insects, and one to two hours for sorting, classifying and identification of insects. The activity may be repeated once or twice during the season. One or two resource persons/insect specialists should assist participants in classifying the insects.

Material:
- collecting equipment (plastic bags, jars, weep net, aspirator, fine hair paintbrush);
- alcohol (to kill and preserve insects and other organisms);
- hand lenses (at least 2 per group);
- large sheet of paper and markers.

Group Activity
1. In small groups explore the rice or vegetable field and observe insects, other arthropods or organisms, and note down what these small animals are doing.

2. Collect all kinds of insects, arthropods and other organisms by putting them in a plastic bag with little alcohol.

3. While small groups are sorting collected insects, facilitators draw up a table matrix on paper to note down the results.

4. A plenary group discussion is held to discuss the different insects, other arthropods and organisms collected by the groups, and to list them in the first table. Ask questions to participants to get more information on the observed rice or vegetables ecosystems and field management, such as:
   - What does it eat (e.g. plant-feeder, insect-feeder, decomposers)?
   - Where is it found (e.g. on leaves, stem, fruit, soil, weeds)?
   - What stage is it in (e.g. eggs, larva, nymph, pupa, adult)?
   - How does it feed (e.g. chewing, sucking, piercing, rasping, scraping)?
   - How does it move (e.g. flying, jumping, crawling)?
• What type of organism is it (e.g. spider, fly, beetle, butterfly, bug, wasp, slug and insect pathogens)?

5. The plenary group will tally each collected animal or other organism and make a check against each group’s collection.

Other suggestions for processing the information:

• With what insects did we have difficulty in the group? How many unknowns are there?
• Which way of grouping organisms do you think is most useful for your decision-making in rice or vegetable production?

Table 7.2: identification of collected insects

<table>
<thead>
<tr>
<th>Common name</th>
<th>What does it eat?</th>
<th>Insect feeder</th>
<th>Decomposer</th>
<th>What stage is it in?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>Plant feeder</td>
<td>Egg</td>
<td>Larva</td>
<td>Pupa</td>
</tr>
</tbody>
</table>

Table 7.3: listing of harmful and beneficial insects

<table>
<thead>
<tr>
<th>Pest</th>
<th>Predator</th>
<th>Parasite</th>
<th>Total</th>
</tr>
</thead>
</table>

7.4 Genes and genetic inheritance

In this session participants explore topics on genetics, gene recombination and segregation, which will help them to better grasp the breeding technologies applied, and when certain selection techniques can be used and when not. The principals of genetic inheritance are explained in a traditional way, using Mendel’s discoveries in the 19th century in group exercises. Facilitators will find the necessary background information for this session in the text boxes.

Warming up

*Time: 1 hour*

The experience is that farmers are more familiar with the mating of animals than plants. Introduce the topic by referring to the farmer’s practices in mating animals. Focus on farm animals like chicken, ducks, pigs or goats.

1. Select a farmer who is the most active animal ‘breeder’ in the village and ask him to tell what he does to improve or maintain animal breeds. Picture a situation where one male and female animal with contrasting
features are mating; take for instance the example of a white hen and black cock.

2. Then involve participants in the discussion using the following questions:
   - If you allow these animals to mate, what type of characteristics would appear in the offspring: would these be similar to the mother’s, the father’s, in-between or a blend?
   - What determines the appearance of the animals in the offspring? Does it depend on the environment (sunshine, cool weather), the strength of the father, the genes, or something else?
   - Do you think we can predict the outcome of the cross? If so, how?

Note: facilitators may explain the following terms: gene, allele, DNA, phenotype and genotype, and elaborate on their function in the plant’s lifecycle (see definitions in glossary) Stress that genetics apply equally to plants, animals and humans.

The Mating Bag (Bean Exercise)

This exercise is an excellent tool to illustrate farmers the random but predictable processes of gene re-combination and segregation. By using this exercise farmers will be able to reflect on the crossing process and to compare theory with practice and observation in the field. The example draws on the discoveries of Mendel (the first to discover genetic inheritance in the 19th century) lying the basis for the basic hereditary theories of modern breeding. Mendel experimented with green peas and a number of different single-inherited characteristics like flower color and seed color. The example in particular is drawn from his experiment with green and yellow colored seed.

Note: green pea is a strictly self-pollinating crop and the parent varieties are entirely homozygous. This crop is comparable with other leguminous and cereal crops like common bean, yard-long bean, rice and wheat.

Method

*Time: 2 hours*

Materials: paper bags, about 500 white or black bean seeds (or other contrasting colour; for the advanced exercise use two additional seed colours)

*Group Activity*

1. Introduce the principles of genetic inheritance using the diagrams in box 7.1 and 7.2 as example. Focus on the different phases in the plant’s life cycle, and subsequently on the expected segregation. Explain that in this exercise we are going to test these principles. Then hide the diagrams and proceed with the mating bag exercise as follows.

2. Use two bags and fill the first bag with 50 yellow seeds and the second with 50 green seeds. Write P1 (female) on the first and P2 (male) on the second bag and explain that the beans are (haploid) male pollen or female egg cells, produced by a diploid plant. The parent plants are homozygous with seed color features respectively yellow (YY) and green (GG). Explain that yellow color is dominant over green color, meaning that combination YG has a yellow appearance.
3. Ask participants to predict the seed color appearance produced on the first offspring (F1 plants). Collect the farmer’s responses. (Answer: uniformly yellow). Participants then should come forward and draw one seed each from the male bag and the female bag, combine the two in their hands, and record the perceived appearance as ‘green’ or ‘yellow’ on a sheet of paper. Collect the results and compare with the earlier notes. Discuss the outcome.

4. In a similar move, participants predict the seed color appearances produced on the F2 plants. Participants deposit all their (F1) seed in an empty bag. This represents the F1 plants. Mix the bag of seeds well. Note that the bag contains seed (alleles) of yellow and green in the same frequency. Each participant then draws two seeds at random from the bag and combines the two seeds in front of them. Each combination represent one plant. Similar to the first exercise, ask participants to record the appearance on a sheet of paper. Collect the expected and actual results and discuss the outcome. (Answer: ratio of 3 yellow and 1 green; Since pollen and egg cells produced on the F1 plant will contain the Y allele and the G allele in equal frequency: 50%, the resulting combination in the offspring is 3:1).

5. Discuss the findings and explain the principles of segregation using the following 2 x 2 matrix:

```
<table>
<thead>
<tr>
<th>Pollen</th>
<th>Egg cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>YY</td>
</tr>
<tr>
<td>G</td>
<td>GY</td>
</tr>
</tbody>
</table>
```

Y=yellow, G=green  Yellow dominant over green

Figure 7.1: Genetic inheritance for seed color in the F2 offspring

Note:
1. the ratio 3:1 may not be exactly achieved which is because of a small number of participants. Repeat the exercise and add up all combinations.

2. For advanced farmers, the Mendel’s mating bag exercise may be repeated using the following changes
   - No dominance or incomplete dominance; by using the above example, the YG combination will not appear yellow but as yellow-green colored seed, resulting in three different colors in the offspring.
Ask participants what would be the segregation in the F1 and F2 populations. Answer: the seed color of the F1 plants is 100% yellow-green, the segregation in the F2 will be 1:2:1 respectively for yellow, yellow-green, and green seed.

- **Co-dominance**: this option may be additionally discussed. Results will be the same as above, but where incomplete dominance will result in yellow-green, co-dominance result in yellow spots and green spots (compare with spots in cows and chicken)

- **Combination of two genes**: use two gene sets (alleles) for respectively color (yellow/green: Y and G) and seed shape (round/wrinkle: R and W), where yellow is dominant over green, and round is dominant over wrinkle. Tip: use the above 2 x 2 matrix first to calculate the segregation for each individual gene set, and then use a 4 x 4 matrix to make all possible combinations with the outcomes. Answer: segregation in the F1 is 100% yellow+ round seed; the segregation in the F2 will be 9:3:3:1 for the combinations respectively: yellow + round, yellow + wrinkle, green + round, and green + wrinkle seed.

3. Design your own experiments with real plants using single-inherited characteristics in collaboration with breeders at research institutes.

**Questions**
1. Explain how it is possible that there is segregation in the field study on participatory breeding.
2. What happens when green is dominant over yellow?
3. Why is gene recombination important in the crop’s evolutionary process?
4. What is the impact of the reproduction process on genetic diversity?

**Genes in the Plant’s Lifecycle**

Plants consist of billions of cells. These plant cells contain a double set of DNA which together holds the genetic information or genetic code needed to shape the plant and its characteristics. One DNA string originated from the paren, the other from the mother. Each crop has a distinct number of DNA strings, for example rice has 12 different DNA strings, which doubles in plant cells to 24 (2n=24 for rice), for pumpkin 2n= 40, and for Loofah 2n=26. Each DNA string comprises of thousands of genes that hold the information code.

Genes of diploid plants (double set of DNA strings) have either two of the same alleles or contain two different alleles for a certain trait. If the alleles are the same, the plant is called homozygous for that trait, if different it is called heterozygous. Male pollen and female egg cells generated in respectively anthers and ovula of the plant’s inflorescence or flowers are the only haploid cells in the plant and contain a single set of DNA string. When the pollen tube penetrates the stigma and fertilizes the egg cells, the two cells merge forming a zygote, containing a double set of DNA once again. This eventually produces a seed, and after germination produces a new diploid plant, which completes the plant’s lifecycle.

This gene recombination is a random process, which means that the alleles re-combine completely ‘by chance’. Manipulation of this process by humans takes place in selection following cross pollination, which is extensively used in modern breeding.
The Plant's Life Cycle

Female sex cells are called egg cells which are formed in the embryo sac or ovule and connected with the stigma, which is the structure that is the pollen receptive structure. Male sex cells are called sperm or pollen, which is formed in the anthers. Pollination is the transfer of pollen from the anther to the stigma of the flower. This may take place by wind, water or by animals. Animals benefit from the act of pollinating; birds, bees, beetles, bats and others receive nutrients from the flower. At the same time, the flower's pollen is carried from one plant to another, allowing pollination to occur.

When the (haploid) sperm and egg are joined in the process of fertilization, a zygote results. From the zygote, an embryo develops which eventually is enclosed within a seed covered by fruit. From the seed subsequently a new plant may then develop and the cycle continues.

Figure 7.2: Recombination of genes in the plants' lifecycle
Mendel’s Genetics

In the 19th century, Gregor Mendel, a little known Central European monk, discovered the basics of genetic inheritance. Through the selective growing of common pea plants (Pisum sativum) over many generations, Mendel discovered that certain traits showed up in offspring plants without any blending of parent characteristics. For instance, the pea flowers are either purple or white—intermediate colors do not appear in the offspring of hybridized pea plants. Mendel observed seven traits that are easily recognized and apparently only occur in one of two forms.

1. **flower color** is purple or white
2. **flower position** is axil or terminal
3. **stem length** is long or short
4. **seed shape** is round or wrinkled
5. **seed color** is yellow or green
6. **pod shape** is inflated or constricted
7. **pod color** is yellow or green

The observation that there are traits that do not show up in offspring plants in the form of intermediates was critically important, because the leading theory in biology in those days was that inherited traits blend from generation to generation, and that inheritance was influenced by the things we do during our lifetime.

Mendel picked common garden pea plants for his research because they can be grown easily in large numbers and their reproduction can be easily manipulated. Pea plants have both male and female reproductive organs. As a result, they can either self-pollinate themselves or cross-pollinate with another plant. In his experiments, Mendel was able to selectively cross-pollinate purely bred plants with particular traits and observed the outcome over many generations. This was the basis for his conclusions about the nature of genetic inheritance.

In cross-pollinating plants that either produce yellow or green peas exclusively, Mendel found that the first offspring generation (F1) always has yellow peas. However, the following generation (F2) consistently had a 3:1 ratio of yellow to green.

Phenotypic segregation in the F1 and F2 population
This 3:1 ratio occurs in later generations as well. Mendel realized that this is the key to understanding the basic mechanisms of inheritance.

He came to three important conclusions from these experimental results. The inheritance of each trait is determined by “factors” (now called genes) that are passed on to descendents unchanged.

- That an individual inherits one such unit from each parent for each trait.
- That a trait may not show up in an individual but can still be passed on to the next generation.

It is important to realize that the pea crop is self-pollinating and in this experiment the starting parent plants were homozygous for pea colour, a single gene inherited trait. That is to say, they each had two identical forms (or alleles) of the gene for this trait—2 yellows or 2 greens. The plants in the F1 generation were all heterozygous. In other words, they each had inherited two different alleles—one from each parent plant.

The above becomes clearer when we look at the actual genetic makeup, or genotype, of the pea plants instead of only the phenotype, or observable physical characteristics.

### Genetic Segregation in the F1, F2 and F3

Note that each of the F1 generation plants (shown above) inherited a Y allele from one parent and a G allele from the other. When the F1 plants breed, each has an equal chance of passing on either Y or G alleles to each offspring.

With all of the seven pea plant traits that Mendel examined, one form appeared dominant over the other. Which is to say, this allele masked the presence of the other allele. For example, when the genotype for pea colour is YG (heterozygous), the phenotype is yellow. However, the dominant yellow allele does not alter the recessive green one in any way. Both alleles can be passed on unchanged to the next generation.
8. TOPICS FOR FOLLOW-UP FIELD STUDIES

8.1 Guidelines for follow-up field studies

Farmers generally highly appreciate the new opportunities provided to them through FFS-PPB, in particular the studies on variety crossing and selection, aspects which they always thought to belong to scientists and professionals at research stations. Through FFS-PPB this suddenly becomes theirs, providing them the capacity to select and breed for new varieties by themselves. Most farmers, therefore, are keen to continue with the field studies, as this gives them a sense of autonomy and recognition.

Most follow-up field studies are organised in the cropping season immediately following the completion of the FFS-PPB course. In this way, farmers who are curious about the results of their studies, can straight away see and analyse the results for themselves, while the freshly harvested seed can be re-planted without delay avoiding the need for long-term seed storage.

Follow-up field studies are conducted over a minimum of two and a maximum of eight seasons. After a number of plenary sessions, the field studies are carried out in two or three small groups of eight to ten farmers under the guidance of one or more farmer-facilitator(s). The studies aim to continue developing the skills and knowledge of participants in selection and breeding.

In addition to follow-up field studies, farmer groups may decide to arrange for enhancement studies. These studies, which can be short or long, usually have a broader scope, and are conducted to support the FFS-PPB programme.

The following are some considerations in the organization of the FFS-PPB follow-up field studies:

<table>
<thead>
<tr>
<th>Issues</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of follow-up field studies</td>
<td>Variety rehabilitation, variety breeding of self-pollinating and cross-pollinating crops respectively, village seedbanks</td>
</tr>
<tr>
<td>Duration of follow-up field studies</td>
<td>Minimum of two seasons (for variety rehabilitation) and maximum of eight seasons (full-fledged variety breeding)</td>
</tr>
<tr>
<td>Frequency of FFS sessions</td>
<td>Every week or every other week, depending on how many crops are studied</td>
</tr>
<tr>
<td>No. of farmers participating</td>
<td>8-10 farmers per small group, up to three small groups in total per community</td>
</tr>
<tr>
<td>Pre-requisite for participation</td>
<td>Participants should have completed the start-up FFS-PPB course and must be willing to invest time to continue at least for two seasons</td>
</tr>
<tr>
<td>Field layout</td>
<td>Plots are either planted in one big field or in different fields. Size of the individual</td>
</tr>
</tbody>
</table>
plots depend on the number of hills required per breeding generation

<table>
<thead>
<tr>
<th>Issues</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group dynamics</td>
<td>Joint group sessions are usually held during the first season. After this, participants are split up in small groups of 8-10 farmers, conducting their own programme. The small groups can focus on a particular crop, field location, and breeding objective. Groups regularly exchange and discuss results. PPB communities seasonally share their results with farmers in other communities and exchange materials.</td>
</tr>
<tr>
<td>Facilitators</td>
<td>At least one farmer-facilitator per community. Usually each small group is guided by a local farmer-facilitator.</td>
</tr>
<tr>
<td>Resource persons</td>
<td>Senior facilitators may be invited for special topics.</td>
</tr>
<tr>
<td>Village genebank</td>
<td>Each FFS-PPB community may have its own village seedbank. This can be a separate room, a seed bin or cupboard, where farmers store their breeding materials.</td>
</tr>
<tr>
<td>Enhancement study</td>
<td>Crop marketing and market diversification</td>
</tr>
<tr>
<td>Coordination</td>
<td>District FFS-PPB programme is coordinated by a team consisting of senior farmer facilitators supported by a local organisation. The team is the first in line to support the farmer facilitators in the follow-up field studies. They are also responsible to recruit and train new facilitators and facilitate the farmer-breeder network forums.</td>
</tr>
</tbody>
</table>

8.2 Selection techniques in self-pollinating crops

After farmers have crossed their varieties, planted and harvested the F1, and sowed the ensuing F2 generation, they encounter considerably more variation than they are used to observe in a single population of self-pollinating crops. Farmers need to learn how to handle this high amount of variability by using selection techniques. Once they have learned to use the selection techniques, this high amount of variability opens up large potentials for the selection of new varieties on-farm.

In self-pollinating crops, the F1 is homozygous and uniform; the F2, however, is profusely segregating. This allows selection for plant genotypes with desired combination of traits. With each following generation, the level of homozygosis again increases, until the breeding population has become stable enough to start testing for yield and adaptability, finally resulting in the release of a new variety.
Whereas the population in the F1 is small (generally only 10-20 seeds are harvested), the F2 should be as big as possible, which allows for maximum segregation and selection potential.

### Tips for follow-up studies in variety breeding

- To verify whether a cross has been successful, plant both the parent varieties adjacent to the F1 plot. The F1 plants should be different from the original parent varieties.
- Plant the parent varieties in the border rows adjacent to the segregating plots to compare the original traits and performance with the traits in the selection populations. This allows farmers to verify breeding progress under the same farming conditions.
- Increase the F2 population to allow for maximum segregation and selection potential.
- To avoid damage to the main field, select a duplicate field for testing the selections for resistance or tolerance to stress conditions, such as drought, pest and diseases. This can best be done in the F4 or F5.

The four most commonly used selection methods in the breeding cycle of self-pollinating crops are bulk selection, pedigree selection, modified bulk/pedigree (semi-pedigree) selection, and back-cross selection.

---

**Farmer-breeder selecting plants in the field**

### Bulk selection

In the bulk selection method, after making the initial cross, the segregating progenies are propagated till F4 or F6 without selection. Once a high degree of homozygocity is reached, individual selection with progeny testing is applied. Each field is about the same size (2000-5000 hills). Plant or panicle (pedigree) selections are made in the F6, and planted in rows for selection in the F7. Preliminary yield tests are conducted in the F8. Finally, the best populations are multiplied and tested for adaptability starting from the F9 onwards.

There are some variations on this selection procedure, such as:
• *Negative and positive bulk selection respectively.* In this method only individuals with trait values greater or less than some threshold level are used for breeding. Values are set either by roguing poor performing plants (negative selection), or by selecting plants above the specified level (for example all plants above 100 cm). This modification of the bulk method slightly increases selection pressure. In the latter (positive) selection method, at least 30-40% of plants in the population should be selected to avoid a loss of plant genotypes.

• *Single-seed-descent method:* in this alternative bulk method only one seed is retained of each plant in the population and bulked; no selection takes place at all from F2 until F6. The method ensures that certain plant genotypes are retained in the bulk population until head selection in the F6. This method avoids the loss of valuable traits and is applied especially in case when desired traits are recessive and, because of non-desired dominancy, difficult to observe.

![Figure 8.1: Scheme for bulk selection in self-pollinating crops](image)

**Pedigree selection**

In the pedigree selection method the progeny (or offspring) of a single plant is tested, which allows for a much more precise selection technique.
Pedigree selection starts in the F2: single well performing plants are selected and separately harvested. The seed is then grown in plant rows in the F3. Complete rows may be accepted or rejected. In the accepted rows well performing plants are selected and again separately harvested for continued progeny testing in the F4 and F5. Plots in the F5 can be slightly larger to allow for preliminary observations for yield. In the F6 the rows have become fairly uniform, which allows for wider testing, including eating quality, in the F7 and F8.

Various modifications of this selection technique can be made. Preliminary yield trials may start as early as the F4. Selection for stress conditions may take place in separate and parallel trials.

**Figure 8.2: Scheme for pedigree selection in self-pollinating crops**

**Modified pedigree/bulk selection (semi-pedigree)**

This is a combination of the above selection techniques. In this method bulk selection is applied from the F2 until the F4, which is followed by pedigree selection. Application of each of these methods depends on the situation, the available area and capacity of the farmers to manage the field studies, and the number of varietal crosses.
Backcross selection

In the backcross method the F1 is crossed with one of the parent varieties. This method is used in order to increase the frequency of desired traits that are found only in one of the parent varieties such as yield or resistance to stress, pest or diseases. Multiple backcrossing may be required to increase the potential for selection of desired (resistant) types. After completion of the backcrossing one of the above selection methods may be used for further selection.

Table 8.1 Advantages and disadvantages of the selection methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk selection</td>
<td>• Easy to carry out,</td>
<td>• Weak selection pressure</td>
</tr>
<tr>
<td></td>
<td>• Little administration required</td>
<td>• It takes longer to create a new variety, usually not less than 9 generations</td>
</tr>
<tr>
<td></td>
<td>• Less area needed</td>
<td>• Testing for yield and adaptability only starts in F8</td>
</tr>
<tr>
<td></td>
<td>• Makes use of natural selection processes</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Allows for more crosses to handle with the same workload</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pedigree selection</td>
<td>• Selection progress is visible even in early generations</td>
<td>• More administration; more difficult to carry out</td>
</tr>
<tr>
<td></td>
<td>• Selection pressure is relatively high</td>
<td>• More area, labour and administration required</td>
</tr>
<tr>
<td></td>
<td>• Takes about eight generations to create a new variety</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Modified pedigree/bulk</td>
<td>• Easier to carry out than pedigree method</td>
<td>• It takes a longer time to create a new variety than in the case of pedigree selection</td>
</tr>
<tr>
<td>(semi-pedigree)</td>
<td>• Less labor and area required</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Makes use of natural selection processes in the early generations</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Allows for more than one cross to handle at the same time</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Back-cross</td>
<td>• As above</td>
<td>• Requires multiple crosses</td>
</tr>
<tr>
<td></td>
<td>• Maximises chances for selection of specific criteria found in only one parent</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
Method

Time: 4-5 hours

The purpose of this FFS session is to demonstrate the selection methods in segregating populations of self-pollinating crops. By the end of this session, farmers should be able to describe the breeding cycle and explain the basic selection methods for self-pollinated crops.

Structure of presentation
- Discuss the breeding cycle of self-pollinating crops
- Explain the four types of selection techniques
- Focus on the crops under study
- Group activity
- Summary and conclusion

Group Activity:
1. Small groups prepare large sheets of paper and on each of this paper illustrate the four types of selection techniques.
2. On completion of the diagrams, groups write down the strong and weak points of the selection methods.
3. Each group then presents their diagrams and the list of strong and weak points in the plenary for discussion.

Topics for discussion
- Which selection method is easy to implement?
- Which selection method uses less time to produce a new variety?
- Which selection method requires most land and administration?
Table 8.2: Pedigree Selection – suggested population size and selection pressure

<table>
<thead>
<tr>
<th>Generation of Crossing</th>
<th>Number of plants or lines sown or transplanted</th>
<th>Number of plants per line</th>
<th>% of population selected (approx.)</th>
<th>Activities</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>10-20 plants</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F2</td>
<td>2000-5000 plants</td>
<td>-</td>
<td>10%</td>
<td>Normally grown randomly</td>
<td></td>
</tr>
<tr>
<td>F3</td>
<td>200-500 lines</td>
<td>15-25 hills 1-2 rows</td>
<td>10-20% of lines 1-5 hills per line</td>
<td>Grow in lines only</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>100-300 lines</td>
<td>-as above-</td>
<td>-as above-</td>
<td>screening for stress conditions, drought, pest and disease resistance</td>
<td>Grow in lines or mini plots</td>
</tr>
<tr>
<td>F5</td>
<td>50 -100 lines</td>
<td>-as above-</td>
<td>-as above-</td>
<td>preliminary observations for yield trials if lines are relatively uniform</td>
<td>If nearly homogenous can be transferred to preliminary yield trial</td>
</tr>
<tr>
<td>F6</td>
<td>10-30 lines</td>
<td>-as above-</td>
<td>-as above-</td>
<td>Yield trials with or without replications</td>
<td></td>
</tr>
<tr>
<td>F7</td>
<td>10-15 lines</td>
<td>-as above-</td>
<td>-as above-</td>
<td>Compare with other varieties</td>
<td>Select uniform and high yielding lines for multi-location trials</td>
</tr>
<tr>
<td>F8</td>
<td>3 – 5 advanced selections</td>
<td>-as above-</td>
<td>-as above-</td>
<td>Multi-locational trials</td>
<td></td>
</tr>
<tr>
<td>F9-Fn</td>
<td>2-3 advanced selections</td>
<td>-as above-</td>
<td>-as above-</td>
<td>Start production of breeder seed for seed multiplication</td>
<td></td>
</tr>
</tbody>
</table>

8.3 Expanding farmer’s know-how on cross-pollinating crops

Cross-pollinating crops typically show more variability within varieties than self-pollinating crops. This is because plants within the population not only cross with each other, but also with plants in neighbouring fields. Natural outcrossing frequently occurs in small farmer communities where the small patches of land allow for a constant influx of new, desired and non-desired, genes into farmer’s varieties, increasing their variability. Hence, to keep the variety stable, farmers have to select more in cross-pollinating crops than in self-pollinating crops. At the same time, natural outcrossing opens perspectives for enhanced crossing and selection techniques. There is in principle, no need for emasculation and hand pollination in cross-pollinating crops as insect or wind pollination take automatically care of this. As a result of the heterogeneous nature of the population, the breeding cycle of cross-pollinating crops is different from that of self-pollinating crops. Three issues have a profound impact on how to handle cross-pollinating crops during selection: progeny testing, isolation and inbreeding.
Participants should understand these issues before proceeding with selection methods during the follow-up FFS-PPB. The purpose of this session is to familiarize participants with these topics.

**Progeny testing**
An important difference between breeding self-pollinating and cross-pollinating crops is found in the way the breeder evaluates his/her breeding material. In self-pollinating crops, in which an individual plant is mostly uniform and homozygous, the exact plant genotype is reproduced in the progeny (offspring) and may be evaluated by a pedigree test. In cross pollinating crops, individual plants are heterozygous, and when grown in the field, they are pollinated by other plants grown in the vicinity. Testing of the progeny of individual superior plants therefore only partially reflects the true potential of this plant, since some genetic properties are not expressed in traits.

**Isolation**
Breeders who wish to preserve the characteristics of a variety or population should prevent crossing with traits coming from other varieties, or in other words should isolate the crop from non-desired types of plants or varieties. In self-pollinating crops, farmers can still harvest from plants and retain the characteristics even though other varieties are planted nearby. In cross pollinating crops this is not possible, since pollination between the varieties will take place resulting in a mixture of different varieties. Breeders isolate crops in various ways: in space (distance), in time (different planting time), or physically (bagging, net house). Many farmers select seed from plants representing the true variety type for the next season.

**Inbreeding**
Inbreeding is the breeding using related plants within an isolated or a closed population. Inbreeding in cross-pollinated crops leads to a decline in vigour and productiveness: plants or fruits may become shorter/smaller, malformed, discoloured etc. (compare with humans or animals when two close relatives marry and get children). In cross-pollinated plant populations, inbreeding occurs when plants self-pollinate (forced or not), or it similarly happens when a population is re-produced and maintained from only a very few plants. To retain vigour and productiveness the breeder should allow for sufficient out-crossing, at least once every two seasons. The rate of inbreeding varies per crop and is, for instance, profound in maize, but hardly visible in some vegetables like loofah.

*Note:* In self-pollinating crops homozygosis is a desired condition at the end of the breeding cycle, because this implies that the population is stable and can be released as a new variety. In cross-pollinating crops, homozygosis is not really possible and not a desired condition, as this generally implies that the performance level has decreased because of inbreeding. On the other hand, breeders purposely make inbred lines to produce F1 hybrid varieties, a topic which is not further explained here.
Method

Time: 2-3 hours

Structure of presentation
• Discuss cross-pollinating versus self-pollinating crops
• Elaborate on progeny testing, isolation and inbreeding
• Focus on the crops under study
• Group activity
• Summary and conclusion

Group Activity
In this group exercise, participants discuss the various topics using some of the following questions:

1. Prepare a list of cultivated crops and ask participants which crops are self-pollinating and which are cross-pollinating. Indicate the vector involved in the outcrossing and the rate of outcrossing. Example: maize: 70-90% cross-pollinated by wind, eggplant: 2-8% cross-pollinated by insects, rice: 99% self, 1% cross-pollinated by wind).

2. By what means can farmers establish isolation between two varieties? Is forced self-pollination such as emasculation and bagging a method of isolation? For example: barriers can be: distance in space, distance in time, other crops interspaced, net house.

3. When a farmer chooses a superior plant at the centre and at the border of his maize field and harvests cobs from both plants, would he/she expects the progeny to be different or same?

4. Occasionally, participants in the FFS-PPB harvest seed of varieties from the variety evaluation study. When this is a cross-pollinated crops, do you think the plants retain the characteristics of the parent varieties and of he plants from which the seed is harvested? Give an explanation.

5. On the issue of inbreeding, do you know of examples of close family mating in animals? What happened in the offspring in terms of appearance, performance and vigour? What can you do to prevent inbreeding and restore vigour?

Suggestions for field studies
During the follow-up field studies, farmers further explore the issues:

1. Design an experiment to test the inbreeding theory by self-pollinating a cross-pollinated variety for one up to five generations. Take two crops, for example maize and bitter gourd. Note the performance in the offspring and compare this with the parent variety.

2. Plan a research activity to test how much distance is needed between two varieties in order to prevent outcrossing. Tip: use one variety with a visual trait (flower colour) to observe the rate of outcrossing. Preferably use a trait that is single-gene inherited (marker gene). If you are not sure about this, consult a breeder from a research institute.
8.4 Selection techniques in cross-pollinating crops

The two most commonly used artificial selection techniques in cross-pollinating crops are Mass Selection and Recurrent Selection. The purpose of this session is to familiarize participants with these two selection techniques.

Mass selection

The mass selection method is similar to the bulk selection method for self-pollinating crops (in the modified version of positive/negative bulk selection). Mass selection is also called population selection. Individual, well performing plants are selected, separately harvested, and bulked to grow the following generation. The mass selection method is close to traditional farmers’ practices. The selection method is based on phenotypic appearance of the plant in the field. However, since the seed is bulked, progeny testing at the plant level cannot be carried out.

The principle advantage of this method is its simplicity and the ease with which it can be carried out. Because of bulking of the population there is less risk of inbreeding. However, selection progress is slow. If primary selection is for yield, a characteristic with low heritability, mass selection will generally be ineffective.
Recurrent Selection

The main benefit of recurrent selection is the aspect of progeny testing. From a segregating population superior plants are selected, artificially emasculated, self-pollinated and separately harvested. Seed from each selected set of plants is planted in the next season in one or two rows. The progenies are used primarily for testing purposes. Once tested, retained seed of selected superior lines is then planted in the next generation and bulked. Bulking is required to prevent inbreeding. This selection procedure can be repeated, and continued until the population is stable enough for testing of yield and other traits and can be released as a new variety. Various modifications are used by breeders to improve the recurrent selection method, for example:

- If plant characteristics are visible before flowering (germination vigour, leaf shape), it is better to remove the poor performing plants from the field before flowering and bulk the remaining lines.

- If self-pollination is too laborious, farmers can harvest the selected plants (half-sibs) and sow the progeny in the next season for testing as above. In this method, however, selection progress is slower, since some degree of outcrossing occurs.
Table 8.3 Cross-pollinated crops - advantages and disadvantages of selection methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Mass selection  | • Easy to carry out  
• Little administration required  
• Less area needed  
• Makes use of natural selection processes | • No progeny testing possible  
• Weak selection pressure  
• Takes longer to create a stable variety  
• Generally no problem with inbreeding (provided sufficient – more than 50 - plants are harvested) |
| Recurrent selection | • Includes progeny testing  
• Selection progress is visible  
• Selection pressure is relatively high | • Without proper handling (bulking), inbreeding problems may occur  
• More area, labour and administration required |
Method

**Time: 2-3 hours**

*Structure for presentation*
- Discuss the selection techniques for cross pollinated crops
- Focus on the crops under study
- Group activity
- Summary and conclusion

*Group activity*
1. Small groups prepare two large sheets of paper and illustrate the selection techniques.
2. On completion of the selection diagrams, groups write down the strong and weak points of the selection methods.
3. Each group then presents their diagrams including the list of strong and weak points in the plenary for discussion.

*Topics for discussion*
- What are the potential problems in the mass selection method?
- What are the bottlenecks in the recurrent selection method?
- Which selection method requires most land and administration?

![Loofah F2 and F3 selections properly labeled](image)

### 8.5 Variety rehabilitation

The selection methods described above for self-pollinating and cross-pollinating crops can also be used to purify and rehabilitate a farmers’ variety. Farmers may complain about variety deterioration, indicating that a particular variety has lost its familiar characteristics, such as yield, taste, uniformity. Varieties may loose their traits or vigour by:

- accidental admixtures;
- outcrossing with off-type plants in the field;
- outcrossing with other varieties planted in neighbouring fields;
- inbreeding because of too small populations;
- mutation.

The follow-up field study on variety rehabilitation restores the original characteristics of the farmers’ variety through selection. The duration of this exercise takes usually two seasons.
Preparation
When farmers in the community complain about variety deterioration, the need for variety rehabilitation may first need to be checked. Often the problem can be resolved by surveying the neighbouring markets, seed shops and probing key farmers and other resource people, who may have better true-to-type seed available. However, when better seed cannot be found and a farming community attaches high value to particular traits of a farmers’ variety, rehabilitation is the only option available.

Method

*Time: 4-6 hours*

In this session farmers will explore the need for variety rehabilitation and determine whether they wish to conduct a follow-up variety rehabilitation activity for two seasons.

Session outline

1. Introduction to variety rehabilitation causes and solutions
2. Group activity - transect walk
3. Group activity - area survey (if needed)
4. Summary and conclusion

Ensure that live material of the farmer’s variety under study is available, and drawing materials are ready such as colour pen, paper and notebook.

Part 1: Introduction

1. Introduce the topic by discussing the various possible causes of variety deterioration.
2. Ask farmers to identify varieties that need rehabilitation and draw up a list of preferred traits, including a list of perceived “lost” traits. Also draw up a list of non-desired traits.
3. Discuss the lists in the plenary

Part 2: Transect walk

1. Conduct a transect walk with participants through the farmer fields. If more than one farmer variety was mentioned assign different groups to each study one variety. Choose, if possible, a time of the year just prior to harvest.
2. Groups start from the outer edge of the community’s farmland to the other end of the village and identify any standing crops of the particular farmers’ varieties noted.
3. While the group walks through the fields, one farmer notes down the group’s opinion on general performance, the presence of “lost” traits, and the variability of the varieties, by giving these criteria a field score.
4. Upon return to the plenary meeting, discuss the results.
Table 8.4: Example of a variety rehabilitation scoring table

<table>
<thead>
<tr>
<th>Field owner General</th>
<th>“Lost” desired Traits</th>
<th>Non-desired Traits</th>
<th>Variability score* (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Score: 1-5

Part 3: Survey of the area

This part can also be done as homework by the participants.

1. Participants prepare a list of potential sources of seed of the traditional variety in the neighbourhood, including local stores, markets, retailers, relatives and other known farmers. Farmers then split up and divide tasks. Part of the group visits other farming communities to verify availability and purity status of the variety. The other part will visit domestic markets and retail shops.

2. Upon return, discuss the findings in the plenary. Finally, again discuss the need for a follow-up activity on variety rehabilitation.

Topics for discussion:
- Did the transect walk and survey resulted in finding better seed of the variety? Is rehabilitation needed?
- Do you consider there is sufficient variability in the field to start selection?
- What benefits would rehabilitation bring to you? Discuss the issue in terms of productivity, increase of income, diversified markets, and household consumption

Field selection procedure

Once farmers have decided to start with variety rehabilitation, they will need to plan and prepare for the field exercise. In the first season, the allotment needed is about 500 m² per variety. The total area for the study will depend on the number of varieties under study. No replications are needed but the field should be divided into small separate plots for easier observation.

In self-pollinating crops the pedigree selection method is applied. The recurrent selection method is chosen for the selection in cross-pollinating crops.

For rice, progenies of selected hills are planted and tested in a field large enough to contain all selections. One progeny should contain a minimum of two rows of 25 hills. After performance testing, good performing rows are marked and 5-10 hills per row selected and bulked. This will be the source seed for the rehabilitated variety. For other crops, the approach is similar.

8.6 Village Genebank

A key problem for farmers in FFS-PPB programmes is to ensure the safe storage of the varieties and breeding lines introduced and generated by the programme. Local storage techniques by small farmers in humid tropical
areas are often inadequate to safeguard against seed loss as a result of insect damage and loss of viability. Difficulties also occur as a result of low quality packaging and inadequate identification and labelling, resulting in seed admixtures and accidental loss of seed lots. A village genebank facilitates access to the local varieties and breeding material generated by the FFS-PPB programme, and increases ownership by the farming community. This study is meant to elaborate the issue with participants.

Purpose
Village genebanks support the FFS-PPB programmes in different ways.

- They support the local breeding programme; farmers need to access the genebank more frequently and, therefore, they need to be established close to the farmers using its materials.
- In addition to local and exotic varieties, village genebanks may store seed of multiple breeding lines. In practice, a village genebank can have 100 or more different entries.
- A village genebank may also be called a village seed bank. A seed bank stresses the availability of sufficient seed volumes for the next season, whereas a genebank stores seed for more prolonged periods and not only of the varieties actually grown, but also additional materials of importance to the community. Here we use both terms without attaching the one or the other meaning in particular.

Type of storage
Conditions for seed storage at community level depend on the purpose and length of storage needed. Three types of storage can be distinguished:

- **Inter-seasonal storage**; This storage spans the period between two seasons, which can be 1 to 4 months.
- **Over-seasonal storage**; the purpose of this type of storage is to secure the availability of sufficient seed over a longer span of time, usually more than one season as mid-term backup.
- **Backup storage**; once collected, local varieties, especially the more exotic materials, should be stored as back-up for future use in local breeding programmes.

Storage adapted to local conditions
Community genebanks for PPB programmes are by definition small, accessible and low-tech. Examples of low-tech storage used by farmers are:

- Closed rat-proof aluminium cupboards – these are suitable for inter-seasonal storage of seed.
- Small air-tight plastic or tin containers – these are suggested for use in over-seasonal seed storage. Apply ash or silicagel for dehydration and grinded neem (Azadirachta indica) or dried marigold flowers (Tagetes spp.) as insect repellent.
- Small airtight mini glass bottles – these can be used for long-term seed storage of different varieties.
Record keeping and labelling
Farmers managing the village genebank should keep two types of record books: a *store book* and a *source book*.
- *Store book*; in this book the type and origin of the seed stored is retained, such as name of variety or breeding line, date of harvest, quantity stored and taken out.
- *Source book*, this contains information concerning the history and characteristics of the variety or breeding line. The purpose of the source book is to create a reference tool and to monitor the breeding progress.

Method

*Time: 2-3 hours*

*Structure of presentation*
- Discuss the need for a village genebank
- Elaborate on the different type of seed storage
- Discuss the need for proper record keeping and labelling
- Group activity
- Summary and conclusion

*Group activity*
1. Groups sit down to prepare an outline for a source book
2. Similarly the groups make an outline for a store book
3. In the plenary, discuss the topic and summarize

*Topics for discussion*
- Why do we need village genebanks?
- How many seed lots do you need to store, and for how long? List the number of breeding lines and varieties separately.
- How do you store the seed lots now and can you suggest improvements?
- Is the capacity in the community sufficient to run a village genebank over a long time?
8.7 Vegetable markets and crop diversification

Markets today increasingly dictate what farmers should grow, and therefore are a vital determinant, not only of the farmer’s income, but also of genetic diversity. This session is a short enhancement study and aims to explore the farmers’ market environment and study the linkage between markets and genetic diversity.

In PEDIGREA, a comprehensive enhancement study on market strategy development in farmers’ field schools is currently in preparation. The session described here may assist farmers to prepare for the FFS on market improvement.

![Trader on the vegetable market](image)

Method

*Time: 4 hours*

This exercise has five parts: apart from an introduction, it explores the community's market chain, pricing, market competition, and then continues with problem listing, and the farmer’s need for additional market information. Plan a break after 2 hours.

After a short introduction, split the participants in two or more groups and assign each group to a particular task or crop. Provide sheets of paper and pens to draw and write the results of discussion on the sheets. Facilitators should not read out the questions, but introduce them in a natural way during the discussions.

Marketing chain

1. Ask farmers to draw a marketing chain (see figure below for an example). Specify the different types of products (mature, immature fruit, flowers, leaves, etc) and the different types of consumers. Starting from the farmer, then ask to whom they are selling. List all types of intermediaries (household, neighbour, village collector, trader, wholesaler etc) between the farmers and the consumer.

2. Write down the proportion of produce going into each sub-chain.
Questions that can be used in the discussion are as follows:
1. What happens with the different harvested products in the different seasons?
2. Was the harvest sorted and graded (e.g. quality, size)?
3. What maximum amount would have been possible for you to sell?
4. How reproducibly can you provide such volumes?
5. What are the advantages and disadvantages of different selling destinations?
6. Are there any other possible selling destinations you know, but do not use?

Figure 8.6: Example of a market chain for vegetables in Cambodia

Pricing
Farmers may further elaborate on questions about pricing and pricing arrangements:
1. With respect to the sold produce, what kind of agreement do you have with the persons buying? When was the agreement made (before, during, after harvest). When was the price determined and how?
2. Which prices were received for the different products in the different seasons?
3. When was the money paid (in days before/after the harvest). What would have been your minimum price for the different products in the different seasons?

Ask groups to present and discuss the results.

Market competition
In the second time block, farmers elaborate on the matter of competition:
1. What strategies do you have to get a better price for your rice or vegetable produce?
2. Who are your biggest competitors in the different seasons?
3. What can you do to out-compete them?
4. How much do the prices fluctuate over the year?
5. What do you do with the harvest when the price is too low?
Listing of problems in marketing
Finally, ask farmers to name their problems experienced with rice and vegetable marketing. Farmers should first list the main problems (“what are your biggest problems”?). Then with each problem, they should list the reasons for this particular problem (“why does this problem exist?”) and write down the reason with an arrow to the constraint.

![Diagram of a market problem tree](image)

Figure 8.7: Example of a market problem tree

For each of the problems, farmers elaborate which possible solutions there are: “which solution can be used to deal with this constraint so that it becomes a “no problem”? The problem tree will then turn into a solution tree. Groups then present the results of their work in the plenary for discussion.

Market information
Wrap up by focusing on the different types of market information that farmers may need to determine or change their market strategies. Ask the following questions:
1. What market information would you like to have?
2. When would you like to have this information?
9. IDEAS FOR FARMER FIELD DAYS AND COMMUNITY MOBILISATION

Community mobilisation is essential to establish a sustainable FFS-PPB programme with outreach in the district or region. The Farmer Field Day at the end of the FFS course evidently is one of the most important tools to communicate the results of the FFS-PPB to other farmers and officials. But there are more ways to raise awareness in the community such as through news bulletins, farmer forums, and seed fairs.

9.1 Farmer Field Days

The farmer field day is an important event in the FFS-PPB. It is, par excellence, the occasion for the participants to show other people in the community what they have learned and to reveal the results of their achievements. This will build confidence and shared know-how amongst the participants and in the community. The farmer field day also serves as a platform for farmers to generate support for their activities on participatory plant breeding from dignitaries and officials. Farmer field days may be organised at the end of the start-up FFS-PPB course, but also at the end of the season of the follow-up field studies.

Farmers demonstrating the results of their studies

Preparation

Participants need to devote considerable time for the preparation and organization of the field day. Planning activities should start about three weeks ahead of the day. The couple of days before the field day are usually very busy, when they sent out invitations, prepare exhibition materials, and conduct rehearsals. This chapter lists some guidelines in order to assist facilitators and participants in the organisation of the farmer field day.
The field day may include a variety of activities such as:

- official speeches;
- field tour;
- exhibition;
- theatre;
- music;
- graduation ceremony.

Topics to discuss during the preparation are:

- How do we share the knowledge and skills learned in the FFS with other farmers and local officials?
- Are the results of field studies ready for presentation? What data still need to be compiled?
- Can we provide demonstrations in the field?
- Who should we invite for the field day?
- How do we ask to ensure involvement and commitment of local leaders in the community throughout the field day?

Necessary materials and a proper location for the farmer field day should be arranged, which includes a study field for the guided tour, an exhibition room or space and various utensils such as tape, paper and markers for signboards and labels. Participants may choose from the following list of ideas or develop their own.

Field visit
Activities in the field day can include the following:

- Guided tour around the farmer studies. Use signboards and displays to explain the methodologies used and what participants have learned from the results.
- A joint GEAN activity, comparing and scoring a number of varieties for one or two preferred characteristics.

Live demonstrations
Guests enjoy demonstrations and eagerly wait to practice themselves. Suggestions include:

- performing crossings, including emasculation and pollination, using plants in the field or in pots;
- cooking various varieties and evaluation of eating quality;
- organizing a seed fair displaying the crop genetic diversity in the community.

Exhibits & Displays
For each study, the following materials can be considered for presentation:

Tables and graphs:
- overview table on weekly GEAN observations;
- summary tables and graphs on the main criteria observed in comparing varieties (fruit colour, plant height, tillering, taste etc.);
- crop cuts and yield component analysis in advanced lines;
- tables with an overview of the crossings made.

Live or dried plant materials from different varieties:
- plants;
- panicles;
• flowers;
• fruits;
• seeds.

Present diagrams and illustrations such as:
• field study layout;
• diagrams of the selection methods;
• plant morphology and growth stages;
• drawings and pictures of the procedures employed in the cross breeding experiments.

Theatre and music
Theatre and music will provide for a welcome atmosphere during the farmer field day. Performances may focus, for example, on an appropriate theme in the community such as the sweetness of indigenous fruits, or the role of traditional rice in the life of farmers.

Training program
A summary report of information can be prepared on results of the training program focussing on:
• the baseline survey;
• the planning and preparation;
• the number and background of the participants;
• the field studies conducted;
• plans for follow up activities in the next season.

Awareness building
The field day also provides a platform for information to outsiders and officials to draw attention on on-farm conservation and crop improvement. A range of material may be prepared and activities planned by participants and facilitators focusing on advocacy.

Activities may include:
• Speeches from farmers, guests and officials
• Exchange of ideas between farmers and visitors on issues of genetic diversity

Farmer’s graduation
The field day is an excellent time to hold a graduation ceremony for the farmers who have participated in the field studies and FFS training sessions. Dignitary guests may be asked to issue the certificates and additional gifts (T-shirts).

9.2 News Bulletins and other types of communication
In the course of one or two years of follow-up field studies, the core team of facilitators and farmers may sit down to discuss how to communicate
information concerning the programme to neighbouring communities otherwise. This can be done in the form of:
Brochures
Simple brochures may provide information on the FFS-PPB programmes in the district, the type of crops, and the purpose, approach and achievements.

News bulletins
Similarly, farmers may issue a quarterly or annual news bulletin describing in more detail the different issues dealt with in the FFS-PPB programme, providing up-to-date highlights, larded with interviews and pictures of farmers participating. In these bulletins also issues related to farmers’ advocacy issues may be communicated.

Seed fairs
Seed fairs are excellent venues for sharing information concerning the FFS-PPB programme and for exchange of germplasm materials. Apart from local varieties farmer-breeders may present results of their work. Seed fairs may be combined with on-farm demonstration plots or farmer field days.

Farmer forums
Networks of farmer-breeders can exchange the results of the on-going FFS-PPB programmes and discuss planning of new FFS-PPB and problems in the implementation between them. Such forums may also act as a platform for communication with local officials.

A Farmer-breeder forum at village level

Seminars
Once the FFS-PPB programme is well on its way, the team may organise a district seminar to discuss the results of the breeding work with farmer-breeders, local officials, and other dignitaries, as well as to elaborate the scaling-up and mainstreaming of the programme in future.
10. TOOLS FOR PARTICIPATORY MONITORING AND EVALUATION

Monitoring and evaluation is carried out throughout the FFS-PPB programme. The question is what needs to be monitored, by whom, for what purpose, when and how? Good points in time for monitoring are the completion of the start-up FFS-PPB course, and the end of each season during the follow-up field studies. Monitoring and evaluation can be done at four different levels:

1. **Participatory processes**, which measure progress in terms of development of tools, methods and processes, such as the tools in this field guide.

2. **Outputs**, which describe the concrete and tangible products of the FFS-PPB, such as the number of participants in the FFS, acquired skills and know-how, and new varieties developed.

3. **Outcomes** or short-term effects, which describe the changes which occur within the community, for example in terms of leadership, local ability to solve problems and community self-esteem.

4. **Impacts** or mid-term to long-term effects, which form a measure for the overall changes in the community and may include the wider social and development goals.

This final chapter describes a few practical tools used in the monitoring and evaluation of FFS-PPB, especially at the level of participatory processes (level 1) and outputs (level 2). For further background information the reader is referred another PEDIGREA publication (Smolders et al. 2006).

![Farmers evaluating FFS-PPB using the picturing impact method](image)

10.1 Evaluation of participatory processes

Evaluations of tools, methods and resources are important in the FFS-PPB programme since it determines how participatory the FFS programme is performed and whether the tools are understood by the participants. This increases self-confidence and ownership amongst the participants.
T-chart
The T-chart is an evaluation method using a T-shape drawn on a large piece of paper with two columns for “good” and for “need to be improved”. Farmers may produce cards with activities and stick it in one of the columns. The cards in “need to be improved” should be discussed with the aim of finding solutions.

Piling up
In the Piling-up evaluation method farmers are split up in various groups and asked to make circles or drawings on a large piece of paper representing various activities of the FFS-PPB programme, such as:

- variety evaluation study;
- varietal crossing study;
- selection methods;
- germplasm used;
- group exercises;
- field days, etc.

Each person then should take ten seeds (pebbles or coins) and rate the activities by piling the seeds on top of the circles or drawings, with the highest number of seeds for the activity that was perceived best. Discuss the activities that have the least number piled-up with the aim to finding solutions for improvement.

Checklist
Checklists are generally used during farmer forums or training of trainer workshops when farmer-facilitators sit down to review the results of the FFS-PPB programme. The following checklist may be used in the evaluation:

1. Which methods and tools have worked well in the FFS-PPB? Why? What did they achieve?
2. Which methods and tools have been tried and did not prove particularly successful? Why not?
3. How can useful methods and tools be combined in processes which include all relevant stakeholders?
4. How does the success of methods and processes vary according to context (e.g. do some approaches work better in literate than in illiterate communities; similarly do they work better with wealthy farmers than with poor farmers, what about gender differences, and young and old farmers)?
5. What further work needs to be done?

Before- and after-tools
Facilitators conduct an end-of training evaluation to determine any changes required for the participatory processes, methods and tools used during the FFS-PPB course. A large piece of paper is divided vertically in a left and right column. On the left, facilitators list the weekly curriculum items of the FFS-PPB prepared before the course, including tools and exercises used. To the right they mention any improvement of methods and tools developed during the workshop or training.
10.2 Evaluation of outputs

Evaluation of outputs aims to monitor the results of the various activities in the FFS-PPB. This can involve the learning processes and the results of the different breeding studies, but also the level of participation and aspects measuring the quality of the FFS training programme.

The learning process – Ballot Box

At the end of the FFS course facilitators and participants want to know how much they have learned and whether their expectations were met. This is usually done with a ballot box questionnaire.

The Ballot box is a method that uses live specimens and field situations to test the participant’s know-how and management skills. The Ballot Box test should be given before and after training with the same level of difficulty. The questions in the test should be developed before the beginning of the season and relate to the core objectives of the FFS course, such as the priority crop and field studies undertaken. Questions should focus on:

- know-how concerning genetic resources management;
- recognition of reproductive parts and processes of a plant;
- selection methods;
- other areas covered in the course.

Facilitators should write the questions on a thick paper board and mount it on a signboard in the field. Questions should be multiple-choice and preferably placed next to a real condition or object that is being asked about in the question. Up to twenty questions should be prepared for the test. For each question, participants will tick the correct answer on the answer sheet. After everyone has taken the test, the facilitator walks the group through each question and discusses the correct answers.

Matrix tables

Results of the FFS-PPB courses may be compiled seasonally or annually in matrix tables to evaluate progress in the FFS-PPB programme. Usually, the matrix includes the following issues:

- Location of FFS-PPB courses and number of participants
- Crops and varieties evaluated in the study
- Varietal crosses made by participants
- Type and number of breeding lines selected
- Varieties released by farmers

Compile the data and review the results with participants. Use the matrix table to make a planning for the next season. The core facilitation team and local organization may use the matrix tables to monitor progress in the district programme, and to evaluate what can be done to improve the FFS-PPB programme.
Table 10.1: Suggestions for Ballot-Box Questions in FFS-PPB Vegetables

<table>
<thead>
<tr>
<th></th>
<th>1. What do you mean by vegetable breeding?</th>
<th>2. What is PPB?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) to produce more vegetables</td>
<td>a) Participatory Pest Breeding</td>
</tr>
<tr>
<td></td>
<td>b) to make the vegetables healthy</td>
<td>b) Participatory Plant Breeding</td>
</tr>
<tr>
<td></td>
<td>c) to improve the characteristics of</td>
<td>c) People’s Plant Breeding</td>
</tr>
<tr>
<td></td>
<td>vegetables</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>3. Which of these is male flower? (Choose from 3 specimen of flowers gathered earlier)</th>
<th>4. Which of these is the pollen? (Same methodology as # 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) female flower of squash</td>
<td>a) pollen</td>
</tr>
<tr>
<td></td>
<td>b) male flower of squash</td>
<td>b) stigma</td>
</tr>
<tr>
<td></td>
<td>c) flower of eggplant/ string beans</td>
<td>c) petals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5. Which of these is the female flower? (Choose from 3 specimen flowers which were gathered earlier)</th>
<th>6. Which of these is the anther? (Same methodology as # 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) female flower of squash</td>
<td>a) stigma</td>
</tr>
<tr>
<td></td>
<td>b) flower of eggplant/ string beans</td>
<td>b) anthers</td>
</tr>
<tr>
<td></td>
<td>c) male flower of squash</td>
<td>c) sepals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>7. Which of the following is a self-pollinated flower? (Same methodology as # 2 &amp; 3)</th>
<th>8. What is GEAn?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) Flower of eggplant/ string beans</td>
<td>a) General Ecosystem Analysis</td>
</tr>
<tr>
<td></td>
<td>b) Flower of squash</td>
<td>b) General Electric Analysis</td>
</tr>
<tr>
<td></td>
<td>c) Flower of bitter gourd</td>
<td>c) Genotype x Environment Analysis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>9. Which of the following flowers is cross-pollinated? (Same methodology as # 2 &amp; 3)</th>
<th>10. Which of the following is a pollinator of vegetables? (Choose from displayed specimen of the different insects and select crop)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) flower of okra</td>
<td>a) bee</td>
</tr>
<tr>
<td></td>
<td>b) flower of squash</td>
<td>b) lady beetle</td>
</tr>
<tr>
<td></td>
<td>c) flower of eggplant</td>
<td>c) flies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>11. Which of these is a complete flower? (Same methodology as # 2 &amp; 3)</th>
<th>12. Which of the following insects is considered as a pest to squash? (Same methodology as in # 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) eggplant flower</td>
<td>a) bee</td>
</tr>
<tr>
<td></td>
<td>b) squash flower</td>
<td>b) lady beetle</td>
</tr>
<tr>
<td></td>
<td>c) wax gourd flower</td>
<td>c) flies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>13. Which of these is an incomplete flower? (Same methodology as # 2 &amp; 3)</th>
<th>14. Which of the following insects is destructive to eggplant? (Same methodology as in # 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) eggplant flower</td>
<td>a) wasp</td>
</tr>
<tr>
<td></td>
<td>b) squash flower</td>
<td>b) beetle</td>
</tr>
<tr>
<td></td>
<td>c) string beans flower</td>
<td>c) borer (worm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>15. Which of these is the stigma? (Choices are from real specimen)</th>
<th>16. Which of these is a good soil? (Choose from a collection of different soil types)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) petals</td>
<td>a) loam</td>
</tr>
<tr>
<td></td>
<td>b) pollen</td>
<td>b) sand</td>
</tr>
<tr>
<td></td>
<td>c) stigma</td>
<td>c) sandy loam</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>17. Where did the eggplant originate?</th>
<th>18. What kind of weed is the most problematic when planting vegetables? (Choose from a collection of different weed types)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) India</td>
<td>a) sedges</td>
</tr>
<tr>
<td></td>
<td>b) Mexico</td>
<td>b) grass family</td>
</tr>
<tr>
<td></td>
<td>c) China</td>
<td>c) broadleaves</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>19. Where did squash originate?</th>
<th>20. Where did string beans originate?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) India</td>
<td>a) India</td>
</tr>
<tr>
<td></td>
<td>b) Mexico</td>
<td>b) Mexico</td>
</tr>
<tr>
<td></td>
<td>c) China</td>
<td>c) China</td>
</tr>
</tbody>
</table>

(Source: PPRDI, the Philippines)
Breeding progress

Breeding programmes take a long time to witness results. Farmers therefore need to assess the products of their breeding efforts from time to time. This will tell them whether they are making progress in their selection efforts, and whether the offspring is producing sufficient new material, or perhaps whether they should better focus on selection in the offspring of another cross.

To monitor breeding progress, ask farmers to plant the original parent varieties adjacent to the variety breeding plots derived from the crossings and to measure the differences. Especially recall the breeding objectives for this particular varietal cross. Farmers may use Table 10.2.

Table 10.2: Example of a table for monitoring breeding progress

<table>
<thead>
<tr>
<th>Breeding criteria</th>
<th>Parent A (Name of variety A)</th>
<th>Parent B (Name of variety B)</th>
<th>Performance level in breeding generation (F2, F3, F5, etc)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Height 100-120 cm</td>
<td>80 cm</td>
<td>120 cm</td>
<td>100-110 cm</td>
<td>Ok</td>
</tr>
<tr>
<td>No. of productive tillers &gt;20</td>
<td>30</td>
<td>12</td>
<td>12-18</td>
<td>No progress</td>
</tr>
<tr>
<td>Aroma (scale 1-5)</td>
<td>good</td>
<td>excellent</td>
<td>Excellent</td>
<td>OK</td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Picturing impact

This evaluation tool is a spontaneous event carried out by farmers in the community. In the picturing impact method, farmers report on the most significant changes (positive or negative, planned or unplanned) over the last period as a result of the FFS-PPB programme. In practice this mostly refers to outputs.

Selected farmers or farmer groups are provided with a photo camera and asked during a period of one week to visualize impacts generated by the FFS-PPB programme in the community. Photographs are then displayed and categorized. Discuss with participants the most significant changes in the community and review what can be done to improve the quality of outputs, outcomes and impact.

Case studies

Case studies are important as tools in the evaluation process, signifying sustainable changes in the farmer's management systems or farming community as a result of the FFS-PPB programme. Ask farmers to illustrate these changes by drawing or writing the active involvement of farmers and their community related to FFS-PPB, such as:

- selection approaches;
- adoption of varieties;
- conservation of genetic resources;
• farmer-to-farmer exchange of materials and information;
• marketing approaches;
• social awareness, gender and empowerment.

Case studies can be an extension of the picturing impact tool. After presentation, discuss the case study in the plenary by asking questions such as:

1. How significant is this case for the farming community?
2. Is this a positive or negative change?
3. What can we learn from this?
4. Can we change this into a tool for others to learn?
REFERENCES


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Smolders. H. 2006. Enhancing Farmers’ Role in Crop Development; Framework for Participatory Plant Breeding in Farmer Field Schools. PEDIGREA publication. Published by: CGN, the Netherlands. 53 p


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