PARTICIPATORY ENHANCEMENT OF
DIVERSITY OF GENETIC RESOURCES IN ASIA

RE-ESTABLISHING THE FARMER'S ROLE IN BREEDING; DEVELOPMENT OF FARMER FIELD SCHOOLS ON PARTICIPATORY PLANT BREEDING

A guide for farmer-trainers, agricultural extensionists and scientists on how to conduct and manage a farmer field school on the conservation and management of plant genetic resources

Details of author(s), institutes, address

RE-ESTABLISHING THE FARMER'S ROLE IN PLANT BREEDING; DEVELOPMENT OF FARMER FIELD SCHOOLS ON PARTICIPATORY PLANT BREEDING

A Guide for farmer-trainers, agricultural extensionists and scientists on how to develop and manage a Farmer Field School programme on the conservation and management of plant genetic resources

CONTENTS

PREFACE

Introduction

Over the last 10-15 years on-farm conservation and genetic resources management, more commonly known as Participatory Plant Breeding (PPB), has become from a little known approach to the vanguard and attention of many researchers, development workers and policy makers. This remarkable development was spurred by a growing realization that the world is rapidly loosing its agro-biodiversity, causing many traditional crops and varieties to the brink of extinction. The heritage of thousands of years of crop domestication by farmers, who has brought wild plants to generate crops that are able to feed entire communities and countries, is slowly disintegrating because of economic development, changes in climate and land use patterns, lack of knowledge and, sometimes, shear negligence. Experience and case studies from all over the world has provided evidence showing that Participatory Plant Breeding has great potential and is a viable alternative approach complementary to institutional plant breeding.

Overall, the 'science' of participatory plant breeding is an emerging discipline, which has made steady advances over the last decade, owing to the work of many dedicated researchers and development workers. Despite these efforts, few if any participatory plant breeding approaches have yet been able to grow beyond the pilot phase and appeal to researchers and farmers allowing wide spread institutionalisation of the approach. Expectations are rising and many people are waiting for applicable participatory plant breeding approach suitable to reach millions of farmers to preserve the world's agricultural heritage.

At the time when Participatory Plant Breeding emerged as a viable option, the Farmer Field School (FFS) model was making headway, mainly in Asia, where the approach was adopted by the FAO Inter-country programme as a new method for the transfer of know-how to farmers for the introduction of Integrated Pest Management. The success of the program led to replication and improvement of the FFS, first in other districts of Indonesia, and soon after in many other countries. Nowadays, FFS-IPM has been adopted by government research and extension agencies in many developing countries, including Asia, Africa and Latin America.

The success of the FFS model in IPM was instrument to diversify the approach to other cropping systems, to include not only rice but also rice -fish production systems, root crops, vegetables and plantation crops which led to a more integrated system of IPM called Community IPM. Also modules have been developed to cover other sciences. Over the years, developers joining with thousands of farmers have been involved in the formation, evolution and conceptualization of FFS activities. The development of the Farmer Field School approach for Participatory Plant Breeding is one of many, but nonetheless challenging attempt, using the Farmer Field School as vehicle for necessary transfer of know-how to farmers and for upscaling and mainstreaming of efforts.

This task is challenging because participatory plant breeding substantially differs from previous FFS learned topics in terms of investment, focus and benefit. Farmers may see immediate benefits in participating in IPM classes for instance through reduced costs on chemicals, but perceive benefits in participatory breeding programmes to be less as they take considerable more time to materialise. The ultimate question in building attractive curricula for Farmer Field Schools on Participatory Plant Breeding is how to build sufficient short-term benefit factors in the learning process of a FFS to retain the farmer's interest, in order to enable the management of genetic diversity in the long-term.

It is our sincere wish that this guide will significantly contribute to this development and will assist all the many workers who are engaged in developing participatory plant breeding approaches along similar lines.

The PEDIGREA Programme

The PEDIGREA programme (Participatory Enhancement of Diversity of Genetic Resources in Asia) was conceived in 2001, with the aim to develop institutional sustainable approaches for participatory plant breeding using the Farmer Field School. It aims to bring together farmers, extensionists and scientists from different disciplines to develop, upscale and mainstream Farmer Field Schools on Participatory Plant Breeding and to provide a scientific basis for the FFS-PPB approach.

Since 2002, learning spaces have been established in pilot programmes in Indonesia, Cambodia and the Philippines focusing on rice and indigenous vegetables. Additional experiences have come from training and participations in on-farm crop conservation and improvement programmes, both in Asia and Africa. PEDIGREA was much inspired by the work of BUCAP, which organisation works along similar lines in Vietnam and Laos, and by 2002 has published a first FFS manual on participatory plant breeding in rice. This approach was adopted in the first pilot FFS programmes and has been meanwhile been further developed. Indigenous vegetables have been added to the programme, using the same pilot communities, to study and develop FFS-PPB approaches in crops with a substantial commercial value.

Thus far most experience has been gained in formal-led approaches for PPB, illustrated by the numerous publications, which let farmers collaborate in institutional breeding but not give them decisive powers. The PEDIGREA programme embarks on the challenging task to develop farmer-led PPB approaches with the help of the Farmer Field School model framework. Considering the limited external capacities and funds available in many developing countries, PEDIGREA believes that farmer-led approaches provide a higher potential for sustainability and replicability. While emphasize is given to farmer-led PPB, PEDIGREA also realizes that considering the diversity in farming systems and communities, a flexible approach is needed. PEDIGREA therefore pursues and facilitates close collaboration with scientists and policy makers to benefit from the comparative advantages of both farmer- and institutional breeding systems.

PEDIGREA is not limited to any crop and aims to include also diversity management of animal genetic resources. Since 2004, PEDIGREA has become a foundation to offer a learning platform for organizations and institutions involved in participatory plant breeding.

How to Use This Guide

This Guide aims to compile numerous ideas, experiences and practices into one comprehensive volume in order to assist development workers, extensionists, and scientists on how to manage a Participatory Plant Breeding programme using the Farmer Field School approach.

The need for this guide was felt a few years ago when PEDIGREA partners started with the FFS-PPB approach in their respective communities. Despite numerous publications elaborating on the benefits of participatory plant breeding, astonishingly little information was available describing situations and approaches where farmers take the lead in breeding and selection. The only workable guide at the time was the BUCAP facilitation manual on rice FFS-PPB. It turned out that a lot of publications were written from a formal-led perspective rather than a farmer-led perspective.

The PEDIGREA programme therefore set out to develop the Guide in a step by step approach. A draft outline of a manual was developed (BUCAP manual was used) to facilitate the first FFS-PPB, which was adjusted by facilitators during their training and again with the help of farmers during the ensuing season-long FFS-PPB and follow up activities. Some tools and exercises worked, others did not work and new tools were added. Differences in cultural and educational background were noted demanding for regional adjustments. This development process ultimately led to the writing of this Guide, which is first of all, a 'State of the Art', a compilation of tools and exercises for implementation of FFS on PPB.

Realizing that not all readers are familiar with aspects of Participatory Plant Breeding, presenting tools and exercises would not be sufficient to entice such audience. It was decided therefore, in order to appeal to a wider audience, to write a more comprehensive guide describing the implementation of FFS-PPB as part of the broader context of Participatory Plant Breeding developments. For practical reasons this Guide has therefore two volumes:

Part I: explains the concepts of genetic erosion and the need for on-farm genetic resources management, what PPB is and the potentials and limitations of PPB. It also provides background information on the concept of Farmer Field Schools and how FFS-PPB differs from previous FFS approaches. It then leads the reader into explaining the key elements of FFS-PPB, followed by a detailed account of the various issues involved in the development and implementation of a FFS-PPB programme. It discusses topics like the conduct of baseline surveys, germplasm management, curriculum development, and implementation of season long and follow-up FFS courses. Finally, aspects are described to ensure continuation of PPB efforts at community level and how to secure sustainability and impact.

Part II: is a supplement to part I and describes various tools and exercises used in the preparation process and in the implementation of FFS-PPB. Tools are described for discussion of the concepts, the baseline study, Season-Long FFS-PPB and Follow-up activities. While most of the tools and exercises can be used interactively with other crops, most activities have written either for application in rice or vegetables. This is noted particularly in the description of tools on exercises on crop morphology and cultivation, and to some extent also in selection methods. Finally, some tools are described to evaluate and monitor progress of the FFS-PPB

Approaches, tools and exercises in FFS-PPB are very much part of an evolutionary process involving many people. We invite everyone who wishes to use these tools for their PPB programmes to further develop tools and make their own contributions which may lead to PPB becoming a practical approach but also a major scientific discipline.

This Guide is the product of the many partners engaged in the PEDIGREA programme: farmers, facilitators and scientists alike, which contributions are greatly acknowledged. It also encompasses the ideas of many other people who work along the lines. Without their contributions and enthusiasm it would not have been possible to compile this Guide.

SRER KHMER

CHAPTER 1: INTRODUCTION

1. The Importance Of Genetic Diversity

Seeds and other self-propagating materials are among the most vital inputs to agriculture. Grown into full plants they can feed people, provide medicines, produce fibres and building materials, and are able to satisfy the needs of entire communities and nations. However, it is the unique reproductive characteristic of these resources and the re-combining ability of its genes that enable farming communities to build and re-build their lives and to provide food for their households for generations. Despite rapid modernisation of agriculture, millions of farmers still rely on their own seed, selected from their last crop, to plant again in the next season.

Box: definitions

- Genetic diversity: the genetic variation present in a population or crop
- Gene: the functional unit of evolution, each gene is a section of DNA that codes for a specific biochemical function in a plant which single or together translate into traits
- Genetic erosion: the loss of diversity of crops in a farming system, and the loss of diversity within a crop.

Less than 200 years ago, all plant breeders were farmers. Plant breeding became a separate activity by scientists only during the 19th century, evolving into a major science by the second half of the 20th century. As we know, the science of crop breeding has been hugely successful, but builds largely on the store of genetic diversity present in crop plants accumulated by hundreds of generations. This was the work of farmers who observed, selected, multiplied, traded, and kept numerous variants of crop plants to retain and improve the characteristics of their crop. The result is a heritage of genetic resources that, today, is able to feed billions of humans.

Major primary sources of genetic diversity were created in the ancient world, with the help of emerging farming communities. Primary sources of diversity in rice lies for example in China and Southeast Asia, maize and pumpkin in Mexico, and barley in the Near East. The spread of agriculture in the ancient past to other parts of the world resulted to an increase in diversity of plant genetic resources not only in the centres of origin of the crops but to newer areas as well, creating secondary and sometimes tertiary centres of diversity. For instance, the horn of Africa (Ethiopia) is a major secondary centre of diversity for barley, wheat and sorghum, and also the diversity of bananas in Africa, originating from Southeast Asia, is a good example. Southeast Asia is now considered a centre of sweet potato diversity, a crop that comes from the Andes Mountains of South America. Many parts of Africa are now centres of diversity of cassava, a crop that comes from the Amazon region of South America. This spread and increase in diversity occurred in the early stages of agriculture, due to increasing trade from several thousands to about 200 years ago.

This heritage, however, is threatened by the rapidly changing conditions en environments in which farmers are expected to cultivate their crops. Farming systems today are subject to a substantial narrowing of the genetic basis which limits farmer options in the cultivation of crops and causing irreversible losses of traditional crops and varieties. Worldwide this genetic erosion is one of the main threats to sustainable crop production and mid-and long-term food security. Major causes of genetic erosion are:

- replacement of many diverse farmers' varieties by few modern varieties
- emerging markets and socio-economic conditions influencing consumption patterns favouring new farming systems and varieties
- changes in climatic patterns and habitat destruction like deforestation causing gradual or sudden shifts in agro-ecosystems
- reduction of diversity caused by calamities, such as major pest and diseases, drought spells, and civil war, making people to move from their homes
- centralization of plant breeding to few institutions and multinational corporations
- focus of modern agriculture on a few major crops and mono-cropping practices
- the loss of farmers' role as plant breeders

Despite advances in breeding, these trends in genetic erosion threaten to marginalise and impoverish entire farming population. Genetic diversity remains extremely important both to individual farmers and farming communities as well as to scientists and breeding institutions:

- Genetic diversity allows farmers to better manage uncertainties and sustain livelihood in marginal stress related production areas, spreading their risk of production over several genetic resources. The importance of PGR diversity to adapt to pests, diseases, adverse environments and food security is frequently not acknowledged.
- It enables farmers to grow crops under a range of varying conditions adverse environments
- Genetic diversity will continue to satisfy the diverse demand from households and consumers in diverse cultural settings, for instance taste, appearance, cooking quality, and by-products, to suite niche markets As source for food, medicine, fibers and other uses, the importance of PGR diversity is clear and obvious.
- It will assist both farmers and breeders to select and breed for better crops and varieties to satisfy present and future demands in production and consumer preferences.
- Finally, PGR diversity is the raw materials in plant breeding (parent materials), in improving crop varieties.

Four case studies of farmers and farming communities managing genetic diversity are presented to illustrate these issues. These case studies show how these changed environments can have an impact on the resilience of farming communities, and how they have and are able to cope under different circumstances using the available or exchanged genetic diversity.

Suggested case studies (need to be worked out):

1. Producing Barley in the Fertile Crescent

Many farmers in drought prone Fertile Crescent (land between Turkey and Iran), depend on the barley crop to sustain their lives. Barley seed and straw provide feed for small ruminants, primarily sheep. Palatability of straw and seed is an important attribute to most farmers including yield. This case focuses on breeding research in barley by ICARDA during the eighties and nineties. This research revealed major issues showing the importance of PPB in stress related environments. 1) to breed crops for difficult environments, selection (not only testing) must be conducted within the target environment and under the agronomic conditions of the local farmers to be successful 2) landraces grown by local farmers are a rich source of genetic diversity and very important for farmers under low-input/ risk-avoiding environments, strategies for on-farm conservation must therefore be introduced to preserve the evolutionary process of creating new genotypes and traits used to improve the living standards of present and future farmer generations 3) implementing a participatory plant breeding program where farmers select from a wide range of germplasm present in their own fields is a key factor in promoting their interest in conserving the original landrace, while adopting new lines and mixtures.
Source ICARDA, Ceccarelli & Grando, 1999

2. Maize Traditional Seed Systems in Mexico

This case study is about maize farming communities in Mexico, who are able to keep their maize varieties true to type despite farmers introducing lots of new local and exotic germplasm and farmers that grow maize in many small farmer plots. This is an excellent example of a meta population approach, whereby the entire community is engaged in the dynamic evolution of diversity, but also able to maintain varieties stable.
Source: Cimmyt, Dominique Louette 1999

3. Satisfying Consumer Demand

I suggest a case study from PEDIGREA, focusing on consumer demands in vegetables. Problem is that we have not yet eye catching impacts of farmers involved in managing diversity. We can only focus on the existing diversity and/or market potentials

4. Select and breed for better crops and varieties-farmer-led

I suggest to include a Rice case study from Vietnam (Bucap)

or else there is a good case study on beans comparing formal led breeding with farmer led PPB.

2. Key Role of Farmers in Genetic Diversity

Ancient civilisations have based their success largely on the progress achieved in agriculture and trading. Extensive selection of wild crops by different farming communities all over the world have altered their characteristics to adapt to the new environments, reshaping them to meet human needs and wants. This process of crop domestication which have taken thousands of years to evolve, have provided the basis of the major food crops as we know them today and are the foundation of today's food production. Great examples of domestication are the development of wild barley to two row barley and subsequently development into into six row barley types. (also tomato ...rice ...) . ...

Conscious selection of farmers together with the forces of nature in specific agro-ecosystem environments have been the key to this process of crop domestication. These evolutionary processes which were driven by the farmer's enhanced ability to observe, select, access and exchange genetic material in order to create better performing and more appealing varieties. This is a dynamic process that has generated new genetic diversity over and over again. Over the last 20 years, research has provided evidence that modern breeding and breeding institutions, despite significant advances, is not able to entirely copy or replaces these complex processes. As a result we need to go back and continue this dynamic process in order for agriculture to remain viable in future. In other words, we need to revive a process where farmers are breeders of their own crops.

An essential criterion for this evolutionary process to continue is genetic diversity. Without genetic diversity neither farmers nor breeders can create new crops or varieties. Farmers participate in this consciously or unconscious production cycle combining generation new genetic diversity with the use of genetic diversity for their own benefit. The driving force behind this dynamic process is footed on four interacting factors:

Agro-ecosystem management;
Each farming system consists of a specific agro-ecosystem, where natural selection and farmer's cultivation practices create a specific environment which exerts influence on the genetic diversity for their crops. The way farmers prepare their soils, plant their seeds, irrigate their crops, use inputs like fertilizers and pesticides may favour or disfavour certain types and varieties. External factors not controlled by farmers also influence genetic diversity, which is called *natural selection*. Farmers cultivate their crops within ecosystems composed of soils, climates, vegetation types, landforms, which environment can be prone to a-biotic stress such as drought, heat/cold, salinity, or biotic stress like weeds, pests and diseases. The characteristics of these agro-ecosystems can be very location specific, even so that no breeding institutions is interested to produce varieties for it, which results in that only local farmers can breed for better varieties.

Farmer Selection of plant characteristics;
Farmers use many different plant characteristics to identify and select their crop varieties, but these are mostly limited to what they can observe and sense. The characteristics farmer value in their varieties may relate to agronomy (e.g. yield, pest resistance, and drought tolerance), use (e.g. cooking or fodder quality) and markets

(colour, taste, appearance). Plant and seed selection practices, or *human selection*, are major factors in the maintenance of genetic diversity on-farm, such as selection in the field versus post-harvest and in-store, selection from a particular plot or designated area in a plot, and/or grain selection from the whole or part of a cob, fruit, panicle or pod used for seed. For maize in Indonesia, for example, the grains at the end of the cob generally are not used as seed. Specific cultivation techniques, such as high density in the seed hole, elimination of unwanted plants during growth or elimination of unwanted male flowering plants, may act as selecting forces. These practices may wield a selection force on the population or seed-lot, for or against certain characteristics, affecting the genetic base of the variety over time. Farmers may name varieties to identify the specific characteristics, the original source or indicate adaptation to particular environments. Such selection is essentially an individual activity practiced by many farmers within the same community and for these reasons capable to generate considerable diversity.

Farmer breeding systems;
Farmers, who cultivate crops like maize or pearl millet, may choose to plant their fields next to another variety, which may serve to boost production (hybridisation) or else to introduce new genes into the population. Farmers recognize that new diversity can be introduced into their varieties. They can encourage these processes, for example by using the natural crossing like above method, or discourage them through isolation in time or distance. By cultivating crops in their natural habitat, genes from wild relatives may also be introduced into the farmer variety. Using patterns of small and large fields grown with different varieties in the community farmers have been able to maintain the characteristics of certain crops and varieties. See for example the case study 2 in par. 1. Community based breeding systems or meta-populations are important in the conservation of traditional varieties and landraces. It also provides for a farmer breeding system which, similar but much slower than modern methods, generates diversity through conscious introduction of new genes and variability.

Seed systems;
Seed flows are one of the primary mechanisms through which new diversity enters farming systems. Contributing to this seed diffusion mechanism are for example neighbours, friends, relatives, local seed producing farmers, and grain markets. Exotic varieties may be introduced through visits to other markets, seed retail outlets, and development projects. The strength of the farmer to farmer seed networks or social seed systems can be an indication of the farming communities or individual farmer involvement in the conservation and breeding of crops.

The introduction of modern agriculture has brought with it a greater dependence of farmers on external technologies, including a dependency on know-how and inputs like fertilizers and seeds. Rather than using the creative potentials of farmers in selecting and breeding crops, there has been a tendency to denounce traditional know-how as inferior and linking local varieties with underdevelopment, low production and poverty. Because of this tendency, most transfer of know-how has focused on the application and adoption of modern technologies, resulting in a gradual loss of indigenous farmer knowledge. Technical options often proved not appropriate in the complex environment of farm households and lack of participation in the development and introduction of modern innovations to farm households has limited the transfer of know-how. However, new approaches are developing and gradually a consensus is building which is set to revive the role of farmers in on-farm management of genetic diversity.

3. Achievements of Institutional Breeding

Modern plant breeding stands among one of the great scientific and human success stories. Predictions in 1960's about forthcoming food shortages and famines due to explosive population growth in the world have been evaded largely because of the breeding efforts of international institutions and the many public and private breeding institutions worldwide. Plant breeding became a science only during the late 19th and early 20th century in Europe and the USA focusing on temperate and sub-tropical crops like potato, maize, wheat and soybean. Gradually, more research stations emerged in the second half of the 20^{th} century shifting the focus to include major staple crops like rice, groundnut and cassava.

International breeding institutes (12 in total, now combined under future harvest programmes) like IRRI in the Philippines for rice, ICRISAT in India for groundnut and semi-arid crops, CIAT in Colombia for cassava and AVRDC in Taiwan for vegetables have been established with international funding to conduct breeding and research for developing countries. In addition, almost every country in the world has established its own breeding programme. Scientist work in collaboration with the international institutes to improve and release new varieties for increasing production levels of the domestic farming systems. Also many private companies, in developing countries particularly in maize and vegetables, have emerged to satisfy the diverse demand of local farmers and industries for new varieties.

Most of the breeding research in the world was and still is conducted on research stations, in glasshouses and laboratories. Farmers are involved in this process mainly in the later stages of variety evaluation during multi-location trials. Breeding programmes make use of seed or propagated materials from genetic resources collected from the farmer's fields, and released materials, which are stored in low temperature conditions in so-called genebanks, for use in breeding programmes around the world. This method is called *ex-situ* conservation of genetic resources. This is different from *in-situ* conservation, which refers to the diverse genetic resources that are kept by farmers on their own farms. Together, these genebank hold a considerable number of the diversity available, for example for rice it holds 100.000 (?) different resources (excluding duplications), for maize 20.000 (?) and for wheat. 50.000 (?). Facilities are not sufficient to maintain all available genetic diversity in the world, especially minor crops, which have less international or commercial value.

Introduction of breeding technologies such as cross pollination and selection, and the introduction of single and double cross hybrids, has increased yield and other performance characteristics tremendously. For example, average yields of corn (maize) in the USA increased from around 2.5 t/ha in 1900 to about 9.4 t/ha in 2001. Similarly, worldwide average in wheat yields have increased from less than 1 t/ha in 1900 to more than 2.5 t/ha in 1990. Low yields are still prevalent in Africa but in France wheat yields have reached highs of over 8 t/ha. This is due to improvements in varieties as well as use of intensive farming techniques. Similar developments have been achieved in many other crops like rice, sorghum, and vegetables. Vegetable have been bred for use in off-seasons. ..

The green revolution in the 1960's/70's was a milestone in plant breeding, although the true merits have long been topic of discussion. Breeding for shorter and more photosensitive-efficient plant types in rice and wheat produced varieties with a significant higher yielding potential. This spurred the establishment of large scale intensification programmes in many developing countries to increase output at farm level. The invention of biotechnology, introduced some 25 years ago, has been another (equally controversial and much debated) achievement in modern breeding using laboratories rather than conventional field selection processes to accelerate the breeding and selection of crops for the creation of new varieties. This has lately culminated in the introduction of varieties produced by genetic modification (GMOs) using biotechnology approaches, generating considerable controversy worldwide because of assumed bio-unsafe procedures and issues involving intellectual property rights, threatening communities' self-help ability and food security systems.

Modern breeding and innovative technologies are expected to continue to make major headway in developing better crops and varieties. However, many farmers have been unable to reap the benefits from modern breeding because modern breeding primarily focus on major crops in favourable production areas and on crops with considerable commercial value.

What is Participatory Plant Breeding?

Fruits of major advances in agricultural science, such as those from the Green Revolution, have bypassed millions of farmers in developing countries, most of whom operate small farms under unstable and difficult growing conditions, grow crops with a lower commercial value and/or crops for specific environments and uses. Farmers often depend on these crops to sustain their livelihood. The adoption of new plant varieties by this group has been low, an issue that has challenged scientists, development workers, governments, and others with a stake in agricultural progress and in the fight against poverty.

To address these problems, a novel and promising breeding method known as decentralised Participatory Plant Breeding (PPB) has been developed. PPB promises a way of improving the service and delivery of crop improvement to these farming communities. The aims of PPB are:

- to develop locally adapted technologies for crop improvement and distribute them more effectively to and among farming communities
- to improve the conservation and use of crop genetic diversity
- to support local capacity development for generating such technologies contributing to 'empowerment' or 'self-help' of farmers and other actors

Each of these objectives marks some limitations or shortcomings in the present system of centralised breeding. PPB attempts to develop materials that are better adapted for the farmer's local environmental conditions or give more attention to diverse traits that farmers value other than yield, such as short maturity or market quality requirements.

PPB promises to conserve genetic resources *in-situ*, which means conservation is embedded in the dynamic on-farm environment. This is in contrast to –ex-situ conservation which preserves germplasm in cold stores or genebanks. *In-situ* conservation has the capability of preserving more of the available genetic diversity at a lower cost than *ex-situ* conservation in genebanks, and being part of the farmer's evolutionary environment, it ensures adding value to local diversity over time. Finally, as most of the know-how concerning crop improvement technologies have been confined to research institutions and organisations, PPB ensures that farmer's capacities to manage genetic diversity are improved. This seeks to provide farmers to gain more control of crop development and seed supply and enables them to pursue a different future than that which is currently offered by the institutional breeding.

Since PPB is implemented in and around the farmer household, it covers much more than technology development and transfer of know-how to farmers. It entails a system of mutual learning by farmers, facilitators and researchers in a move to merge farmer's indigenous practices and knowledge with modern breeding technologies. Active participation of farmers, including women, is important to make an impact and to ensure that the technologies are integrated in the farmers practices and owned by farmers. Participation of researchers is needed to make an impact on breeding technologies. Much more than institutional breeding, PPB makes a close link with other disciplines as well, such as social and economic, which add value to PPB approaches within the context of the farmer household and to established science.

In this guide we will use the term PPB to cover all activities concerned with on-farm genetic diversity management. This terminology is increasingly accepted in international circles. This means PPB includes crop genetic conservation, and PVS (Participatory Variety Selection), which is sometimes used separate from PPB to differentiate selection in stable lines from selection in unstable lines. PPB is also used synonymous with other terminologies commonly used including collaborative plant breeding (CPB), farmer participatory breeding (FPB) and participatory crop improvement (PCB).

3. Parallel Breeding Systems

Over the years, we have witnessed a rapidly growing interest in PPB. The PPB approach has appealed to both researchers and development workers for various reasons, which has resulted in a constant growth and expansion of the number of tools and programmes. PPB has gradually emerged as a viable system for genetic resources management at farm level, in parallel and complementary to conventional breeding systems at research stations. This has not yet developed into institutionalisation of the approach. Further work is needed to promote widespread introduction of PPB in farming communities.

It is crucial for both researchers and development workers to consider PPB not as a competing but as a complementary system, one that has significant comparative advantages to institutional breeding systems. In fact, PPB is not able to reach its full potential without the support from researchers in breeding institutions; similarly, breeding institutions can gain considerable advantage in working together with farmer communities through PPB.

For instance, limitations in the farmer's system are:
- the lack of (global) access to superior parent materials
- the production of variability from a high number of crosses and breeding lines
- breeding for broad adaptation
- lack of strategic goal setting processes
- systematic documentation and management of related information

It is in these functions that plant breeding institutions can and should play a role to support PPB. Institutional plant breeding also faces inherent weaknesses, such as:

- un-ability to capture real farmers' breeding objectives, needs and capacities
- short of location specific testing and adaptation
- limited capacity to manage large numbers of breeding lines
- limited number of varieties that can be released at a given time.

All of these weaknesses can be resolved by the farmers' genuine participation in plant breeding. Comparative advantages of the farmers' system of plant breeding that are difficult for institutional plant breeding to achieve are, for example:

- faster adoption of new varieties at local levels
- testing for local adaptation in many different agro-ecosystems
- direct participation of thousands of local farmers utilizing their creative powers in selection
- access to vast resources of know-how including diverse consumer demands
- lower cost of farmer breeding systems

To facilitate the discussion of these important concepts, some participatory exercises are added in chapter 8 to elaborate on the strengths, weaknesses and potential improvements of the two systems of breeding. In this chapter three different approaches are presented to facilitate discussion of this topic with participants of diverse backgrounds.

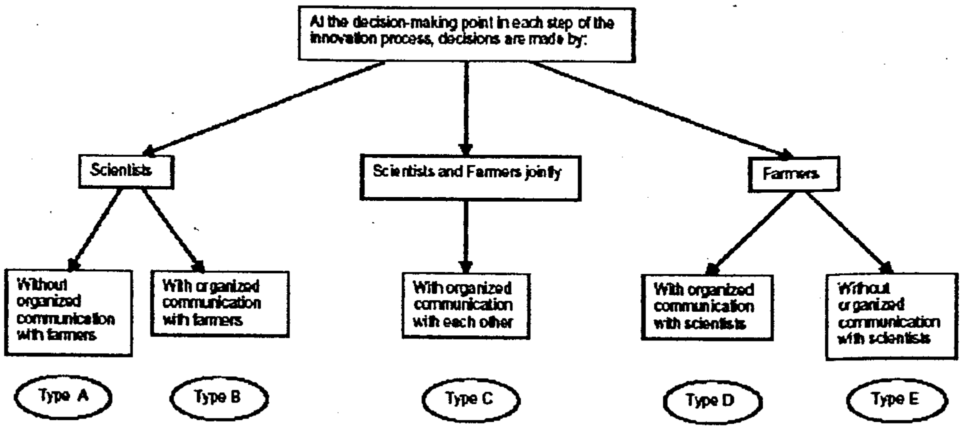
Obviously, a closer and genuine partnership between institutional plant breeding and farmers need to be developed. This should lead to a breeding system containing two parallel sub-systems of plant breeding: PPB and the institutional breeding system with numerous interactions. In developing these approaches, two classes of PPB must be distinguished:

- Formal- led PPB, where farmers participate and contribute to the breeding programme but researchers decide on the objectives and methodologies

- Farmer-led PPB, when researchers seek to support the farmer's own system of crop development; in this approach farmers decide on the objectives and methodologies.

The above indicates that in practice, the term 'participatory plant breeding' does not refer to a single, well-defined method for plant genetic improvement; rather, it refers to a set of breeding methods that are characterized by many different forms of interaction between farmers and breeders. Fig 1 depicts a framework involving, for instance, six different types of potential farmer-breeder interaction.

Figure 1: Types of Participatory Research Based on Locus of Decision-making



Apart from type A, which is entirely station oriented research without farmer interaction, the many forms of interaction have in common is that they are designed to shift the focus of plant genetic improvement research toward the local level by directly involving the end-user in the breeding process, and by doing this optimizing the approach. Varying degrees of interaction between farmers and scientists at different stages of the breeding process can be distinguished. Depending on the circumstances, the focus of breeding activity can vary in between entirely farmer-led PPB where farmers make the decisions, and the conventional 'scientific' breeding method, similar to type A above. Apart from these two extremes, approaches may range from a complete participatory breeding model in which farmers and scientists collaborate throughout the breeding process in various ways to 'participatory varietal selection' (PVS) in which the initial stages of the breeding process are performed by scientists and farmer participation is restricted to evaluating finished cultivars. But many other types of farmer-researcher collaboration are possible (fig 2). Overall, the breeding process substantially gains in strength by facilitating decision making by farmers and/or breeders in different stages of the breeding process.

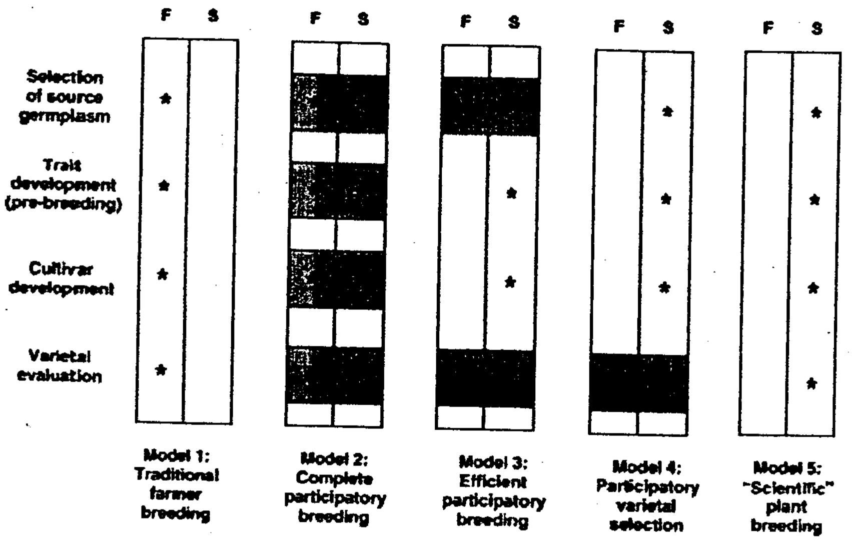


Fig 1. Collaborative approaches in participatory plant breeding (Moore & Bellon, 2004)

4. Prospects of Participatory Plant Breeding

The growing attention and enthusiasm for PPB approaches have led some to believe that PPB is suitable for all farming communities, crops and agricultural environments. Conventional scientists at the other end of the spectrum will argue that PPB is only suitable in centres of high genetic diversity for conservation purposes. PPB may not be suitable for all situations; however, this depends largely on the prevailing farming conditions and the objectives that researchers, development workers and farming communities have set themselves.

In general we might say that PPB is expected to benefit communities and to be of advantage in crops or geographic areas where conventional breeding efforts have been less successful or absent. These conditions are found in the following situations:

- Marginal agricultural areas, where environments are highly variable, such as in semi-arid rain-fed or mountainous areas. These conditions usually preclude the widespread adaptation of modern varieties.
- Rural areas with little or no formal seed supply mechanism and primarily subsistence-based farming
- Minor crops that are important in local areas but have not been the focus of plant breeding efforts

The above conditions would exclude crops and areas where institutional breeding have made quite a presence, such as for crops like wheat, rice and vegetables grown in relatively uniform fertile areas, with irrigated conditions, and where consumer preferences are relatively narrow and well defined, near major urban centres. This, however, would overstate the impact of modern breeding on agricultural production and grossly undervalue the prevailing diversity in farming systems and consumer preferences.

Institutional breeding sometimes terribly overlooks the demands of the target clients. Out of the thousands of varieties released over the last 50 years, only a fraction has been adopted by the farming community. Despite well performing varieties, seed supply mechanisms may not deliver the seed required by the farming community. Seed quality may be too low, the timing wrong or prices too high for farmers to acquire the variety. Especially varieties with build-in limitations for replication on-farm, such as hybrids, can be a major distracting factor for farmers. Even though farming communities have adopted modern varieties, many tend to keep their traditional cultivars, to cater for diverse consumer preferences at the household level and niche markets, or to retain a backup crop in case of casualties. Some communities deliberately include modern varieties to improve local landraces (see for example case study 2). All these provide reasons for not adopting modern varieties and would argue in favour of PPB. In more general terms, we might therefore say that conditions become more suitable for PPB when circumstances render the supply and/or adoption of modern varieties impossible or less likely (product or market deficiency/failure). In addition to the above conditions, this may be particular so in situations where:

- Consumers demand very specific traits that are not catered for by modern breeding; for example for use in special dishes, cultural ceremonies, or preferred use of secondary products like long straw for animal feed, flowers for vegetable soups etc.
- Specific agronomic conditions where modern varieties have little impact, such as in mixed cropping systems and organic farming
- Conditions of dramatic change; civil war and natural disaster.

However, social and justice effects can be also be a driving motive to establish a PPB programme. Community empowerment or the need to provide explicit attention to the role of women and poor farmers are proponents of this objective. In PPB programmes where this is the main objective the site location for PPB is less critical, but so are the criteria for success. Empowerment, however, always is a strong motive force for PPB, as to be successful in PPB, it is important for communities to re-establish the role of farmers over the breeding process.

Some argue that participatory plant breeding is likely to have negative impacts on diversity, especially of landraces, because it intends to change local crop population structure, and replace it with higher yielding or better performing varieties. There is little evidence yet to support this theory as PPB aims farmers to manage crop genetic diversity through a dynamic process integrated in their local farming systems rather than preserve a static portfolio of crops. Only in cases where this dynamic process is reduced by overly enforcing farmers to adopt varieties and technologies, through market forces, or in case communities have become reliant on compensation, usually through payment, PPB programmes may lead to a loss of local diversity. In the development and implementation of PPB programmes this aspect should be well monitored to ensure that PPB indeed facilitates crop genetic diversity.

CHAPTER 2 FARMER FIELD SCHOOL CONCEPT

1.1 The Rise of Farmer Field Schools

The Farmer Field School (FFS) concept was conceived in the 1980's at a time when Green Revolution type of intensification programmes where in its final stages. This type of projects, sometimes very large and country wide, aimed to boost agricultural production of the main staple crops rice, wheat and maize, to keep track with population growth, especially in developing countries. These programmes principally were driven by the philosophy that productivity could be raised if only farmers would have better access to certain inputs like seeds, irrigation, fertilizer, and agro-chemicals, and used them according to a set of prescribed instructions, so-called extension packages. Most of these large scale projects involved the building of irrigation systems, the establishment of supply mechanisms for seed of improved high- yielding varieties, and the provision for fertilizers and agro-chemicals. Agricultural extension systems were developed to conduct training and promote the adoption of the extension packages by farmers. Many farmers, especially those located in well-irrigated areas with good soils, responded positively to the opportunities, resulting in a doubling of the average yield for main crops in Asia between 1960 and the 1990's.

However, helping farmers to build sustainable, productive agricultural systems proved more difficult than originally supposed. The top-down systems to deliver input packages and information to farmers proved not appropriate to suit the diverse agricultural environments and although this approach succeeded in introducing small farmers to the new technologies, new problems quickly emerged:

- Uniform high yielding varieties that were introduced to boost production soon resulted in a rapid loss genetic diversity, causing traditional varieties and minor crops to vanish.
- Routine pesticide applications caused severe ecological disorders, resulting in the rise of new pest infestation, and in pest resistance
- External pressure on farmers was tremendous. Farmers were expected to be progressive and adopt new technologies; this however resulted in the taking away of farmer skills to adapt new technologies to their local needs and requirements

Rather than reducing the risk of production for farmers and increasing income, in many areas the approach gradually brought new threats to the sustainable production and profitability of agriculture.

It was soon realized that a radical new approach was needed to sustain and improve agricultural production systems. Early work and research with small farmers in the Philippines by FAO proved the feasibility of action-learning approaches with farmer groups, teaching farmers to apply what they had learned and use this again to develop new initiatives to gain greater control over local conditions. In response to growing problems with pest management problems, particularly brown plant hoppers in Indonesia, the training concept was adapted to introduce farmers to methods of Integrated Pest Management in rice. In 1988, this approach, which was dubbed the Farmer Field School model for Integrated Pest Management (FFS-IPM), was implemented in Indonesia, first at district level, later at regional level and soon country-wide. By mid 1990, over 50.000 farmers had participated in the first set of field schools in Indonesia and was on its way to become a very effective model for farmer education.

FFS soon became the approach for IPM training in Asia and many countries of Africa and Latin America, and is currently applied in a wide range of crops, including vegetables and plantation crops. Most of these countries also have adopted national policies supporting FFS-IPM.

After the success of the FFS-IPM, it was just a matter of time to see the FFS approach being applied to agricultural subjects other than IPM. The universal learning concept applied in FFS makes the FFS suitable for virtually any topic. Presently, FFS models have been developed for use, for instance, in community education, protection of human health, soil management, natural resources management, and in the conservation of biodiversity.

2.2 Principals of Farmer Field Schools

All Farmer Field Schools use the 'Learning Cycle' as the basic concept for learning. This method, which is well known among people who teach adults, uses experience for reflection and conceptualization, and experimentation for observation and analysis, again adding to experience and further learning. For example, in FFS-PPB, the participants go to the field early morning to collect data (experience) and return to the meeting place to analyse the data (reflection). Farmers would then make use of the data to prepare a presentation regarding field conditions and differences between varieties, and then propose decisions for actions and observations (conceptualize). This decision is then implemented over the following week (experimentation) and the cycle begins again.

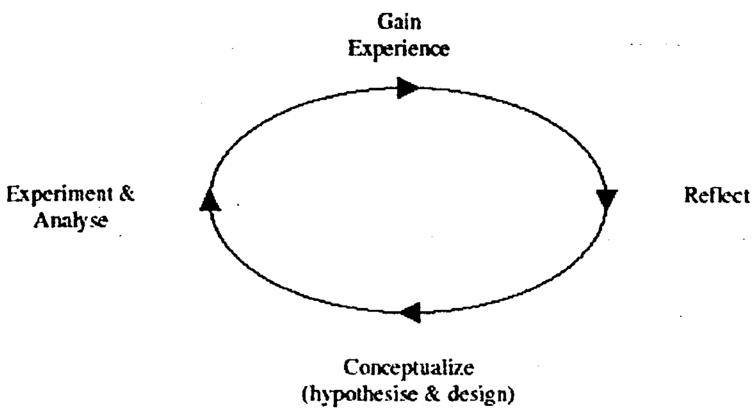


Fig 3: The Learning Cycle

The Learning Cycle applied in the FFS model is principally different from the top-down system of farmer teaching employed by agricultural extension agencies in the past. In chapter 8 an excellent exercise is presented for discussion with extension agents and researchers who wish to get a better understanding of the FFS concepts.

In practice, basic concepts of FFS translate into the following:

Farmers becoming experts; FFS does not apply a 'packaged technology' that should be 'adopted' by farmers, but a process of decision making in which farmers gradually improve on their knowledge, experience and observation skills. The key is that farmers conduct their own field studies. Their training is based on comparison studies (of different treatments) and field studies that they themselves design and conduct, and not the extension or research staff.. In so doing they become *experts* on the particular practice they are investigating.

The Field is the primary learning floor; Skills and concepts are best learned, practiced, and debated in the field. The field is the best teacher. Classroom lectures and presentations are not effective. Working in small sub-groups collecting data in the field, and use these data for action decisions are the best way for farmers to learn.

Facilitators not Teachers. Trainers must not lecture, but should facilitate a process of learning. Trainers do not convince farmers, but rather provide structured experiences so that farmers can test methods and convince themselves about which are useful and which are not. Presentations during meetings are the work of the farmers and not the trainer. The extension worker may take part in the subsequent discussion sessions but as a contributor, rather than leader, in arriving at an agreed consensus on what action needs to be taken at that time.

Season-long training courses. Training should be related to the seasonal cycle of the practice being investigated. For annual crops this would extend from land preparation to harvesting. For fodder production this would include the dry season to evaluate the quantity and quality at a time of year when livestock feeds are commonly in short supply. For tree production training would need to continue over several years for farmers to be able to see for themselves the full range of costs and benefits. FFS-PPB offers both short-term and long-term benefits to farmers.

Regular group meetings; Farmers must be allowed to actively participate and share their experiences at agreed regular intervals during training to achieve maximum interest and effectiveness. For annual crops such meetings may be every 1 or 2 weeks during the cropping season. For other farm management practices the time between each meeting would depend on what specific activities need to be done, or be related to critical periods of the year when there are key issues to observe and discuss in the field.

Group dynamics and team building; Training includes communication skill building, problem solving, leadership, and discussion methods. Farmers require these skills. Successful activities at the community level require that farmers can apply effective leadership skills and have the ability to communicate their findings to others.

Learning materials are learner generated; Farmers generate their own learning materials, from drawings of what they observe, to the field trials themselves. These materials are consistent with local conditions, are less expensive to develop, are controlled by the learners and thus can be discussed by the learners (and used by farmer-trainers) to teach others. Learners know the meaning of the materials because they have created the materials and/or reflect local cultures and environments.

2.3 Transition from FFS-IPM to FFS-PPB

The success of the IPM -FFS has opened up potential for the development of other FFS with different subjects and themes in support of farmer livelihood systems, including Farmer Field Schools on Participatory Plant Breeding (FFS-PPB). Over the last 20 years, numerous people have been involved in the evolution and conceptualization of FFS activities, which have provided an excellent basis for the formation of FFS-PPB. Already, in many countries a strong cadre of facilitators, including researchers, extension workers and farmers-who have become trainers are available, while hundreds of thousands of farmers have participated in FFS-IPM courses. This has been instrumental to developing a critical mass of skilled people, and numerous tools and exercises, developed for farmers to gather, systematize and expand local knowledge. Programmes on FFS-PPB, like PEDIGREA, tremendously may benefit from this critical mass. Experiences, however, have learnt that the FFS-IPM model cannot be automatically transferred into FFS-PPB, because of some fundamentally different concepts:

Agro-biodiversity versus Agro-ecosystem;

In FFS-IPM farmers learn to apply ecological principles to better manage their crops within their own specific agro-ecosystems. Farmers learn to achieve greater control over the conditions that they face every day in their field by counting harmful insects and predators and assess environmental conditions, crop responses and spraying of chemicals, to achieve higher economic returns while sustaining stable agro-ecosystems. Agro-biodiversity is an inseparable part of the existing agro-ecosystem. However, the effect of farmers managing genetic diversity on the stability of agro-ecosystems is considerably less than that of farmer's crop management practices such as pesticide applications. Rapid changes in farming systems causing the destruction of agro-ecosystems is not the result of a loss in genetic diversity, rather it is the result of a range many different factors concerned in the 'modernization' of agriculture production. Genetic diversity is important for environmental stability in the long-term, unless the diversity drops to exceptionally low levels causing widespread pest and disease outbreak.[1] Since most farmers have no experience with this type of disasters, and application of ecological principals does not visibly alter the genetic structure of their crops (natural selection is a very slow process), the focus of FFS-PPB must be different from the ecosystem management principals applied in FFS-IPM. In stead, FFS-PPB focuses on the genetic structures of plant populations, observing genetic expression of attributes in itself, and in interaction with the environment, such as in the study of varieties and populations. Proven concepts like AESA (Agro-ecosystem analysis) are replaced by GENSYS (Genotype-environment system analysis)

Duration of FFS-PPB;

In IPM all plant, insect and environment interaction as well as management practices can be studied and learnt in one season. For annual crops like rice, FFS-IPM takes 3-4 months or 12-14 weeks to complete; in plantation crops the FFS-IPM may take a bit longer. After this season long study, farmers are expected to apply the learned concepts in their field and to act upon their own initiative and analysis, or renew experiences by conducting their own local IPM programmes with few if any external inputs. The concept of community IPM has been developed to promote the farmer self-organisation and self-development at community level. In FFS-PPB, concepts involved in the management of genetic diversity, in principal, can be learned in one season, but usually involves more seasons. The first season long FFS-PPB is usually sufficient to teach farmers the basic principals of collection, field observation and selection. Experience has learned that many farmers are eager to continue activities and learn more about the breeding and selection of their crops. As a result, a range of follow-up activities have been developed to fill this demand, including cross breeding, more advanced selection methods, and market explorations. After the start-up FFS-PPB, farmers may

---

[1] The potato crop failure in Ireland in the 19th century due to Phytophtora infestation was due to a very narrow diversity of the potato crop causing the reduction of the Irish population by one fourth through deaths and migration. The rice crop failure in Asia due to one virus, tungro, destroyed all rice areas planted to only one variety, IR8, in the early 1970s is another example of crop failure due to lack of genetic diversity.

internationally recognized to sustain agricultural production and food security. Social justice has close links with empowerment as well but also with the growing awareness and attention to developer(s) obtaining an equal share of the benefits of genetic resources. Genetic resources, after all, represent a value, which, if appropriately used, may provide significant revenues to the producer and breeder, including farmers. Systems for benefit sharing with farmers have not yet been established, but the FFS may be a potential instrument to create necessary awareness to farmer and become active members in discussion forums and in advocacy meetings in future.

SRER KHMER

Chapter 3 Key Elements of FFS-PPB

1. The Learning Matrix

Farmer Field Schools on Participatory Plant Breeding aim to support the local skills and capacity of farmers in genetic resource management. Farmers expect to learn various skills during the FFS allowing them to preserve or initiate a change in the current crop genetic diversity. A FFS-PPB facilitates a process whereby local skills and capacities are integrated and strengthened with technologies adapted from 'modern' breeding science but not enforced.

In order to do this, FFS-PPB curricula are based on a learning matrix containing four farmer learning goals:

1. Seek better varieties	2. Seek diverse markets
3. Conserve and manage diversity	4. Farmers become experts

These learning actions provide farmers a variety of challenges in a step by step approach to increase skills in breeding and management of genetic diversity. A season-long FFS –PPB programme brings farmers to a basic level (1), which follows up with post FFS programmes in market diversification (2), and in germplasm management and cross breeding (3), reaching finally more advanced levels of managing PPB programmes and advocacy. Once completed, this will lead farmers to become farmer-experts.

Seek better varieties

Basic skills are needed to make farmers aware of the potentials of genetic diversity management, make better decisions and test more and more diverse germplasm at the same time.

- Group interactions will assist farmers in strategic goal setting processes helping them to translate individual needs into farmer community needs.
- From a range of different sources, farmers learn to select germplasm containing desired characteristics that fit local conditions. Variety testing is the learning floor to acquire skills in better decision making.
- Through experimentation, observation and analysis, farmers learn to test a large number of varieties for performance.
- Knowing how the plant grows and how it reproduces will help farmers to determine differences between self and cross pollinating crops, which will assist

them in conserving local varieties and in the making of parental crosses for breeding purpose.

- Farmers furthermore obtain a broad overview of the scope of participatory plant breeding and are introduced to various aspects involved in the on-farm breeding process.

Seek diverse markets

Few farmer communities nowadays operate in isolation from markets. Markets increasingly determine what farmers should plant and more and more control on-farm genetic diversity. Farmers need skills to understand and tap market potentials and necessary tools to integrate gained know-how in their breeding goals.

- Exploring product diversity and consumer demand at home and in their village or city markets is a crucial first step for farmers towards better understanding of (niche) markets.
- By using various group exercises farmers learn to assess their strengths, weaknesses, opportunities and risks, allowing them to decide upon a strategic plan to increase household income while diversifying production systems.
- Strategies must be action oriented. Some are short-term, others are mid or long-term. Farmers will translate goals and strategies into action plans for implementation for changes in production systems, community organisation and breeding goals.
- By adjusting breeding goals farmers will also learn to translate these into a set of actions on how to improve their crops by introducing germplasm with desired characteristics in order to tap and use the market potentials.

Conserve and manage diversity

Knowing how to manage available genetic diversity will help farmers to better preserve what they have and develop what they need. These learning actions are meant to provide farmers tools to truly take their future in their own hands.

- Increased access to and exchange of suitable germplasm is the basis for crop improvement. Using different tools, farmers learn to identify barriers and potentials in existing seed systems, and develop strategies to improve and act on it.
- Seed displays, variety characterisation and storage are needed to increase farmer's access to germplasm. Farmers learn to use these methodologies and integrate these into their own local seed systems.
- Cross breeding is an advanced tool for crop improvement; it tremendously increases germplasm variability, needing superior skills to manage them. After having learnt how to make crosses in 1), farmers learn to manage the newly generated variability by applying different selection methods. Using the field as learning floor, they will study the breeding cycle, selection methods for self and cross pollinating crops, and various other tools and techniques to improve their crops.

Farmers become experts

Farmers as breeding experts are needed to make a leap forward to developing mature participatory breeding programmes and expand these to other communities. Not all farmers and farming communities would qualify for this, some will hold on to different priorities, but others may find the motivation and time to invest in breeding activities.

- Farmers as experts work increasingly collaborate with scientists in a variety of different ways, forming stable breeding alliances.
- Farmer experts learn how to build on previously learned experiences, and know how to develop own experiments.
- They acquire expert skills to cross breeding, selection in segregating lines, and other breeding technologies, including advocacy.

The emphasize in this learning action is placed on the ability of farmers to make better decisions, increase efficiency, innovation, and become better managers of their own genetic diversity.

2. The Breeding Cycle

Successful breeding programmes have features that lead the breeders quickly through different stages of the breeding cycle, a guided process that aims to produce better performing varieties. Each cycle is expected to produce at least one or more new varieties. This breeding process is the same for both farmers and scientists, and consists of three main ingredients:

- Generating variability
- Narrowing down variability through selection
- Testing of new varieties

As indicated in chapter 1, without genetic diversity (or variability), farmers and scientists cannot select for new varieties. Variability therefore increases the chance to find better performing varieties. Breeders generate variability either through introduction of new germplasm or through cross breeding, the latter is a method to re-combine desired characteristics, which were anchored before the crossing in two separate varieties. After the new variability is generated, a selection process is started among thousands of plants to select the lines with the highest potential performance, usually in the order of 5-10 seed lots. During this process the quantity of material is slowly build up to allow for more thorough testing. Finally, the potential varieties are tested for productivity under a range of different growing conditions, and acceptability for a range of different characteristics like taste, appearance, cooking quality.

One of the main limitations of farmers' system of breeding system is that the rate of development of new varieties is slow, because farmers lack the methodologies to quickly generate variability and again handle the created variability through selection to produce new varieties. Most farmers only generate variability by introducing germplasm from neighbouring farmers, or from relatives in other districts, but do not have the tools to pursue other options like increased access to germplasm, and cross breeding. In the FFS-PPB farmers learn to work with these more advanced methodologies to improve their own systems of crop breeding.

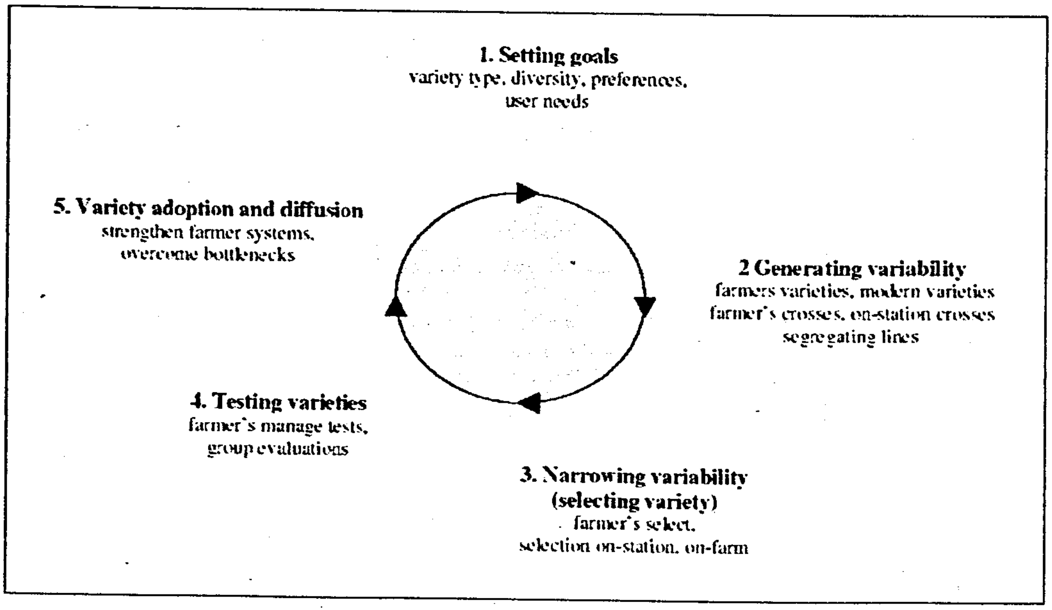
To be truly successful, two more features should be added to the breeding cycle:

- Setting goals
- variety adoption and diffusion

A breeder should plan ahead of time what characteristics he wants to have in a new variety, and then starts to search and generate the variability from which he expects to select the new variety from. The success of the breeding programme often depends on how good he is at defining these goals. This is major limitation in the farmer breeding system, as farmers have a set of preferred characteristics in their mind, but rarely work together to set well-defined goals and objectives for their breeding programme. Goal setting is a major element of the FFS-PPB, which will be addressed and re-addressed throughout the curriculum.

Once a breeder has produced the new variety, he would like to see that the variety is adopted and disseminated to as many farmer end-users as possible. In the institutional sector of most developing countries systems are in place for the release of the variety and the distribution of the material through multiplication and supply mechanisms using seed retailers to sell to farmers. New varieties produced by the farmer breeding system are diffused through farmer-to farmer exchange mechanism, however, these systems may be considerably improved. In the FFS-PPB, farmers will study the existing systems of variety conservation, multiplication and diffusion in their communities and are set to the task to find ways to improve these systems.

Fig 5: The breeding cycle (from Weltzien et al, 2003)



The similarity and compatibility of the two breeding systems open up potential for many types of collaboration between farmers and scientists. For example, scientists may help farmers in generating variability by supplying core sets of varieties for e,g. pest resistance, stored in genebanks, or produced from pre-breeding programmes. They may also supply segregating populations for further selection by farmers, for instance supplying F2 or F4 populations in rice (the second respectively fourth generation after making a cross between two parent varieties). Farmers may assist scientists in the testing of advanced selections before releasing, and by contributing to the selection warranting broader diffusion and adaptation. Such type of collaboration, using the decisive powers of both systems, significantly contributes to the quality and strength of the breeding cycle.

3. FFS Training Components

Participatory Plant Breeding programmes are implemented by farmers and thus require emphasize on the farmer's skills and knowledge. Similarly, the PPB programme provides an action learning environment with farmer participants expecting to find solutions to existing constraints in the farming system and improvements in the pool of varieties cultivated by them. To a large extent this pool of varieties determine their food security and household income. The ultimate aim of the FFS-PPB programme is:

- to improve the existing pool of farmer's varieties in the community or farming system while maintaining or increasing genetic diversity
- to improve farmer's skills and knowledge so that they become managers of their own genetic diversity ensuring increased food production and food security in future

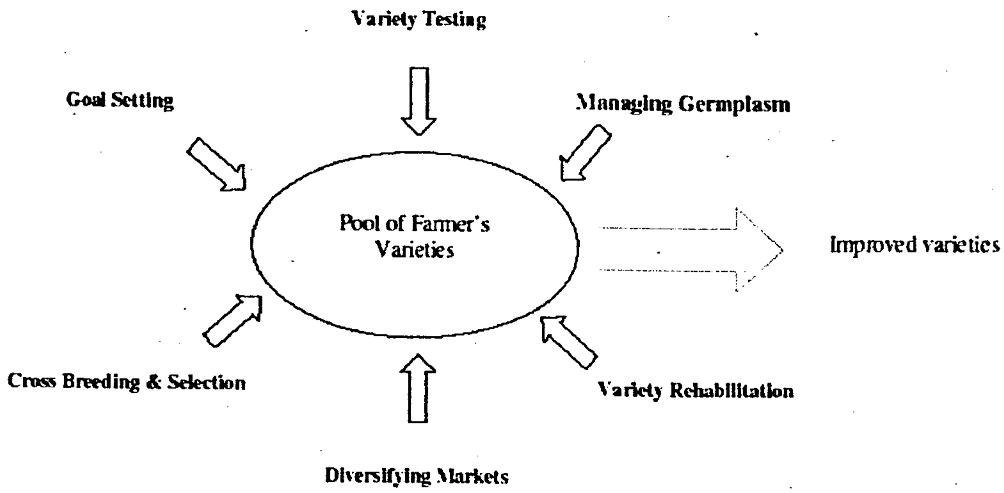
Each FFS-PPB programme consists of six key learning elements, which single or together will contribute to achieve the above purposes. Each learning element teaches various skills:

- Setting goals
- Managing germplasm
- Evaluating varieties
- Rehabilitating varieties
- Crossbreeding and selection
- Diversifying Markets

These elements are integrated in a season-long farmer field school programme or in separate follow-up training topics studies. They all use the field as the main working floor.

In most cases farmers will start their regular sessions by going to the field to conduct observations, collect data, and perform visual evaluations, while carrying out various types of experiments. Farmers will then go to their meeting place and use the newly gained experiences, skills and data for further analysis, presentation, and group deliberation, to plan for new activities and experiments in the weeks ahead. All FFS sessions will start with an expectation setting to review what has been planned for the day, and make changes where necessary. The sessions will end with a time for evaluation to recapture what has been learned (or not learned), and to make a planning for the next session. This action learning environment will ensure active participation of farmers in the planning process, and secure that the learning topics address the gaps in know-how of farmers.

Training programmes are interconnected through field studies and closely follow the patterns identified in the breeding cycle. The local varieties are the main reference point for the studies as farmers are familiar with the specific strength and weaknesses of their varieties. The study on market diversification is interconnected with all the other training programmes. It is an instrument to provide both increased short term household income while at the same time ensuring impact through goal setting in breeding, thereby influencing future production and household economy. It thus assists farmers in field experimentation, selection and evaluation processes through refining goal setting. More types of special studies are discussed in chapter 6.



In the next section a short description is provided of the weight of these elements in the various training programmes

Learning action	1	2	3	4
Training programme	Season Long	Follow-up	Follow-up	Follow-up
Focus	Basic skills development	Market diversity	Conserve & Manage Diversity	Organisation, communication & advocacy
Setting Goals				
Managing Germplasm				
Evaluating varieties				
Rehabilitating varieties				
Crossing and advanced selection				
Diversifying markets				

Setting goals for the PPB programme
Well defined goals and clear breeding objectives have a tremendous impact on the success of a FFS-PPB as it shapes the entire design of the farmer's breeding and research programme. Once clear goals are set, it determines the type of participants

involved in the programme, the crop focus and type of germplasm to be introduced and used, the kind of studies, experiments, and selection procedures to apply.

At farmer community level goal setting must be holistic, flexible and cannot be limited to breeding alone. It should depart from identifying the main constraints at community level to go down to problems of farmer households in particular with limiting factors in the farmer crop production, seed and marketing systems. Subsequently, farmers may focus on the strength and weaknesses of their own pool of varieties, identifying preferred agronomic and consumer preferences and setting objectives for breeding and selection.

Two facets in the goal setting at FFS-PPB are important:

- *Goal setting is a group activity.* Individual farmers may have their own set of goals and preferences, however, in the FFS-PPB, farmers work together to find solutions which are for the benefit of the entire farming community, thus requiring a certain level of generalisation. Most exercises in the FFS-PPB are group-centred, but designed to take account of individual preferences by making use of, for example, ballot box, card ranking, hand voting and other participatory tools.

- *Goal setting is a recurring activity,* going from broad-based to more specific, gradually closing the gap between what farmers need and want, and what is possible within the limited space and time of the FFS-PPB. For example, initially, farmer goals may reflect a wide range of criteria, including yield and yield stability, use for animal feed, kitchen quality, shape and colour, maturity time, low fertilizer need, pest and disease resistance, and off-season production. Gradually farmers may realize that they only can make progress in a few of these criteria during the FFS-PPB, but may realize that continuation of the PPB programme is needed to achieve the other objectives.

In the FFS-PPB, goal setting is addressed at different stages:

- *Before the FFS-PPB;* during a participatory baseline survey designed to identify the existing farming system constraints and strengths and weaknesses in the pool of farmer varieties and determine the breeding objectives. The baseline survey also aims to create community awareness on genetic diversity. Details about the conduct of a village baseline survey on plant genetic resources are presented in chapter 4.
- *At the beginning of each FFS-PPB activiy* ; when the initial breeding objectives set during the baseline survey will be re-addressed and refined for use during the FFS-PPB.
- *At the end of the end of each FFS-PPB activity*; to determine the achievements of the FFS-PPB and narrow down the objectives for activities during the subsequent seasons (if farmers want to continue the PPB programme)

Managing Germplasm

Farmers may have limited access or exposure to existing genetic diversity through local seed systems, which can limit their capability to attain their goals in crop development. This FFS programme provides farmers the skills to assess existing genetic diversity, both in the vicinity and elsewhere, identify ways to obtain access to it, and stimulates them to collect genetic materials for evaluation and use in the FFS-PPB programme. It also offers scope for farmers to elaborate on how to document information of collected and used germplasm, and to seek options for seed storage, including seed banks, and improve multiplication and diffusion systems. Issues related to this topic are presented in chapter 5.

Variety Testing
One of the elementary steps in the FFS program involves performance comparison of a number of introduced varieties with existing cultivars that are planted by the farmers in the community. Variety evaluation is a relatively straightforward process compared with other breeding activities and has the ability to obtain results within a short span of time span, if performed correctly. Variety testing is therefore ideal to teach farmers the skills of performance analysis, testing more germplasm than they are used to, while at the same time introducing them to the other aspects of PPB and motivating them to continue with PPB. Variety testing provides a solid preparation for goal setting before starting with a cross breeding and selection programme. Each variety trial usually contains between 10-20 different varieties and is performed using simple designs with partial or full replications, depending on the capability of farmers to analyse and absorb the results. Further explanation follows in chapter 5 while tools are described in chapter 10.

Variety Rehabilitation
Varieties tend to deteriorate because of accidental admixtures, natural selection, cross pollination with non-desired plant types or varieties, and sometimes mutation. This causes varieties to loose one or more of its preferred characteristics such as yield, appearance or resistance. In the absence of alternative sources of quality supply, farmers need skills to improve and restore their varieties. They will learn this during this field study, which is detailed in chapter 6.

Crossbreeding and selection
For farmers to become experts in breeding they will need to learn advanced techniques, including the making of crosses between different varieties, and various selection techniques such as bulk, pedigree and single seed selection. Other skills include differentiating between self and cross pollinating crops, isolation and emasculation techniques, and recurrent selection processes. Farmers as experts shall make their own decisions on breeding goals based on solid analysis and elaboration of the farming system situation, and work together in groups of 4-5 farmers on the same crop and breeding goal. Close collaboration with scientists is vital for an effective breeding programme; best results will be achieved if similar programs are conducted both on-station and on-farm. This training programme is detailed in chapter 6.

Market Diversification
Most of today's farming systems link with markets, which increasingly determine what varieties farmers should plant. Usually farmers are at the end of the market chain and can elicit little influence on the market chain or consumer preference. However, distinct differences between consumer preferences in the domestic market, including own household consumption, and those in the wholesale markets are crucial for the goal setting in the PPB programme. Farmers should ask themselves where they expect

to get the highest benefit with the lowest risk, what value is attached to each crop, value differences in primary and secondary products, and which market chain provides best options for the future. This is crucial in determining priorities in the breeding and selection programme. This training programme on markets is designed to assist farmers in identifying products, (niche) markets, consumer preferences and market constraints, which together helps farmers to prepare and implement a market strategy to improve household food security using PPB. Details of this training programme are described in chapter 7.

4. Genotype Environment Analysis (GENSYS)

One of the key elements in the FFS-PPB course is to enhance the farmer's observation skills, which becomes increasingly important when they increase the genetic variability for selection purposes. Farmers need to *get an eye* for specific plant characteristics, assessing what this characteristic will do to increase plant performance, to what extent the characteristic is *heritable* ; assess what human, biotic or a-biotic factors may have influenced the expression.

In FFS-PPB we use the method of *Genotype Environment Analysis (GENSYS)* to facilitate farmers' skills in observation, analysis and decision making. The importance of GENSYS in FFS-PPB corresponds with the importance of agro-ecosystem analysis (AESA) in FFS-IPM. The GENSY method is a weekly field activity in which farmers will conduct a sequence of observations on plant genotype and environment, data are presented and analysed using specific tools in a general meeting. This method will help farmers to make the right decisions concerning field management practices and plant and variety selection.

Farmers may want to know, for example, when testing varieties, whether observed performance characteristics, such as yield or taste, are stable enough to suit their farming systems or whether the performance is influenced by pest or diseases, or weather. Similarly, it is important for farmers in their breeding and selection programmes to make the right decisions on what plants to select and to know the distinction between performance characteristics determined by genes alone and the extent of environmental interaction. This distinction is crucial in breeding, because of a factor known as heritability, which means that farmers can only select and carry over to the next generation characteristics that are determined by genes, and not those determined by environmental factors in the agro-ecosystem.

There are numerous factors in the farmer's agro-ecosystem that can influence the performance of a plant, variety or genotype and effect the phenotypic expression. For example, rice varieties with the same genotype may yield more when the soil is nicely puddled and levelled, while rat damage will reduce the yield. Both environmental factors influence the expression of genes but do not effect the genes themselves. Two seed lots harvested from the same variety grown under different environmental circumstances will produce equally well when grown in the same field in the next season. This relationship between genotype and environment is found in any farmer's field and can be depicted like in fig 6:

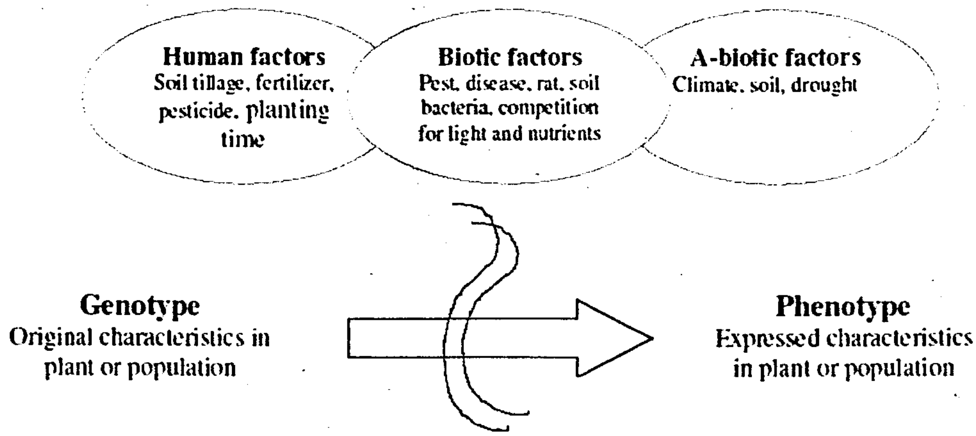


Fig 6: Genotype- environment factors

GENSYS is integrated in all FFS-PPB training programmes teaching farmers to observe and analyse genotype- environment interactions and enables them to act upon observed interactions intuitively.

> Box: **about genes and genotypes**
> Any single plant is carrier of a set of genes with specific characteristics, which are heritable, meaning they can be reproduced to the next season. Each gene or a set of genes expresses a certain plant characteristic, for example, fruit colour or pest resistance. Together all genes in the plant determine how the plant looks, feels, tastes, which feature is called genotype. Genes are the *fingerprints* of biology, a unique set of heritable characteristics. Genotypes influenced by different environmental factors, can result in different phenotypes, which are the expression of the genotypic characteristics.

In the above paragraphs key principles and elements of FFS-PPB have been discussed. In the next chapters these key elements will be further explained when we will discuss the development and implementation of the FFS-PPB at community level.

CHAPTER 4 DEVELOPING THE FFS-PPB PROGRAMME

1. Overview: steps in the development of FFS-PPB

Developing an FFS-PPB programme in a specific district or region requires several steps in order to build the necessary know-how, links with researchers, cadre of trainers, resource materials and political/policy support. The following steps are deemed necessary for establishing a successful, and ensuring a sustainable FFS-PPB programme.

Step 1: Pre-select crops and areas
Step 2: Establish contacts with scientists and research stations
Step 3: Recruit and train core group of FFS facilitators
Step 4: Conduct village baseline surveys
Step 5: Arrange and manage germplasm for use in FFS
Step 6: Train local farmer trainers and develop FFS curriculum
Step 7: Implement Farmer Field Schools
Step 8: Develop and implement follow-up activities
Step 9: Ensure sustainability of FFS-PPB
Step 10: Build political/policy support

The first five steps in the programme consist of preparatory elements that are essential to build the foundation upon which the FFS-PPB programme is established. These aspects are explained in the current chapter. Steps 6 and 7 relate to the implementation of the Farmer Field Schools and how to put together a season-long curriculum, which topics will be discussed in chapter 5. Step 8 is ensures the continuation of the PPB programme in the community after the season-long FFS-PPB, which is explained in chapter 6. Finally, it is crucial to build support for the FFS-PPB and to take care of upscaling and mainstreaming of the FFS-PPB approach. Steps 9 and 10 are discussed in chapter 7.

2. Pre-selection of crops and areas

The highest benefits from FFS-PPB programmes are expected to be achieved in areas where market deficiencies or failures prevent modern varieties to reach farmers. As explained in chapter 1, there are many more situations where PPB can be successful and looking at the range of cases of PPB worldwide, the above conditions are certainly not the only successful ones. Social and socio economic circumstances also may enhance the success of PPB, especially when farmers seek to re-establish their role in crop improvement.

Any FFS-PPB programme should start with identifying a range of potential crops and areas. A common approach to support this selection is to conduct a survey investigating farming system patterns in the region by using secondary data from national statistics or from research and extension agencies. This will indicate the major staple and minor crops grown by farmers in the region and the location of the major production areas. Strategies for selection may depend on the focus of the programme:

- marginal production areas are identified when the focus is on breeding for stress related conditions
- locations with high genetic diversity should be selected if the primary focus is on conservation

- intensive production areas close to markets should be selected if breeding research is undertaken to suit specific consumer preferences, and when the aim is to increase genetic diversity
- Pilot programmes in one crop, such as vegetables, may be established near successful on-going FFS-PPB programmes of another crop, like rice, to take advantage of learned skills and experiences in the community

Whichever choice is made, validation is required at community level to confirm the importance of the selected crop(s) in the farming system during a participatory baseline survey. Experience has learned that each location is unique, and that specific information concerning farming and seed systems, as well as local participation, disclosed during the survey, can be a major factor in the selection process to choose a particular village for establishing a FFS-PPB.

In Asia rice, wheat and maize are staple crops that are of primary importance to small scale farmers. In Africa, crops like maize, sorghum and millet are important. Implementation of PPB in these crops potentially allows for widespread upscaling and replication. Minor crops, such as indigenous vegetables like pumpkin and loofah, or finger millet, can be of significant local importance to farmers in some regions, which may be reason to especially start a programme in these areas. In some situations, it is not clear what crops are most valuable for farmers; the baseline survey should be decisive after selection of the area.

3. Village Baseline Survey

A validation survey is required to assess the possible impact of a PPB programme on the selected farming community and farming systems. The best occasion to do this is during a baseline survey. In reality, however, it is quite difficult to engage a community into a survey, while still keeping all options open. Verification of impact parameters on farming systems should be conducted as much as possible before the baseline survey.

Development workers, researchers and/or facilitator(s) should visit a selected target community at least once to discuss with elders and community members the prospect of starting up a FFS-PPB. During this discussion, a broad impression of PPB should be elaborated: what farmers will learn, the timeline and expected tangible outputs, whereas it is important for facilitators to obtain a general idea about the production environment, market infrastructure and priority crops at community level. A village may be selected when there is sufficient evidence that selected crop varieties are maintained on-farm (and not purchased from elsewhere), and significantly contributes to the community's livelihood.

The village baseline survey can then be conducted, which should prepare and sensitise the community on genetic diversity management, while obtaining necessary information concerning the status of genetic diversity and major production constraints. More specifically, the survey, which is usually conducted over a period of 2-3 days, aims to:

1. Increase the level of understanding on the local status of genetic diversity and the dynamic forces that drive them, which information is necessary for farmer decision making
    - Understand the amount and distribution of genetic diversity by farmers over time and space, both at species (crop) and subspecies (variety) level, if applicable
    - Understand who maintains diversity
    - Understand the processes used to maintain genetic diversity on-farm

- Understand the internal and external factors (such as markets, seed availability etc.) that influence farmer's decision to maintain diversity

2. Generate awareness among farmers concerning their role in on-farm crop improvement
   - farmers to understand the strength and weaknesses of institutional breeding and the complementary role of farmer breeding in conservation and crop improvement
   - Identify gaps in farmer's knowledge and skills in PGR management

3. Lay the foundation for the establishment of the FFS-PPB
   - Prioritize crops (if applicable) based on local popularity, profitability for farmers, and breeding potential
   - Identify desired traits (breeding objectives) within selected priority crops

The baseline survey uses group dynamic processes to allow farmer participants to self-discover the status of local genetic diversity, constraints in the farming system environment, and determine potentials of on-farm crop improvement. This is important to build their confidence concerning own roles in this process. In addition to group dynamic process, semi-structured interviews of focus groups are conducted, which will complement and fill-in gaps of information collected during the group exercises.

Farmers with hands-on experience in the production of selected crop(s) should participate in the survey, as well a good variety of small and big producers. Participation may also be required of both male and female farmers, and several generations of farmers, which prevent a certain bias in the survey. The experience is that by involving different levels of society the baseline survey will gain in depth and scope of information, which will help farmers in making the right decisions.

Tools for the conduct of a participatory village baseline survey on plant genetic resources are detailed in chapter 9. Many of these methodologies have been developed and tested over a period of time in different cultural and environmental settings of Asia and Africa. The sequence of the baseline survey involves 6 steps:

1. *Farm Production systems*; farmers will list crops that play a major role in the farming systems and identify the main agronomic and socio economic constraints
2. *Genetic diversity*; participants will identify the existing varieties, characterise the performance and the preferred and non-preferred traits, and assess changes in genetic diversity over time, describe selection strategies to maintain genetic diversity
3. *Access to germplasm*; participants will analyse the existing seed systems within and between communities
4. *Crop and variety markets*; farmers will list markets and market channels for selected crops and varieties, and thus assess impacts of markets on genetic diversity
5. *Goal setting process*; they will finally identify and prioritise desired traits in crops and varieties, which are subsequently translated into breeding goals for the FFS-PPB
6. *Selection of priority crop*(s) for FFS-PPB; using a systematised approach farmers will discuss priority crops during various stages of the baseline survey

In most cases, tools for selection of priority crops are not needed. In vegetables, however, these tools have been proven to be very effective, as they allow villagers to make step-wise decisions on the most important crops, which listing sometimes may include more than 100 different species.

A simple reporting format can be used to document the results of the group work and interviews in each step of the baseline survey. This will help the community and facilitators to re-visit the breeding objectives during the FFS-PPB and the reasons that lead them to these decisions.

The baseline survey is foremost a farmer-driven and not a research -driven activity, although researchers usually can extract a substantial amount of information on local genetic diversity, farmer selection practices and consumer preferences. The pace and depth of the survey should be directed by the time farmers can invest in the survey and the ability of the community to decide upon their own goals. This may take longer than the 2-3 days set apart for the survey and, in some instance may take several weeks. A well founded goal setting process will significantly contribute to the enthusiasm and involvement of farmers in the FFS-PPB.

3. Establishing Links with Research[1]

Forming links with individual scientists and research institutions is a deliberate strategy to enhance the establishment and sustainability of the FFS-PPB, while strengthening the researchers and research stations by introducing viable new approaches to plant breeding. This is a mutual learning process based on the comparative strengths and weaknesses of both breeding systems; farmer and institutional breeding. Links with researchers are established either on an individual basis or through a kind of agreement, for example by a Memorandum of Understanding (MOU), describing the concept and involvement of researchers in the FFS-PPB programme, and the potential role and contribution farmers can provide to formal research programmes.

The success of establishing a research link varies per country and whether research institutions have already implemented PPB initiatives, in response to international agreements. In practice, links with researchers may be established initially on individual basis to lay the foundation for further collaboration and MOU.

Main benefits for FFS-PPB in linking up with research are:

- Access to germplasm
- Skill support
- Political/policy support

Farmers are limited in their access to genetic diversity, for example, they have no direct access to the rich resources stored in national and international genebanks. In addition, they do not have access to segregating materials, such as F2 or F4, available to select from. Collaborating scientists can assist the FFS-PPB in obtaining the necessary germplasm and create the needed variability in accordance with the community breeding goals. Scientists may engage in various aspects of the FFS programme including breeding, variety testing or seed production and may offer farmers new skills, or seek to extend best local practices. Their involvement in capacity development should particularly focus on the core facilitators, and in

[1] This paragraph pre-supposes that FFS-PPB programmes are implemented by non-research based agencies, such as NGOs, project offices or extension agencies. Implementation directly by a research institute has clear advantages in terms of scientific input, but programme often lack the experience in participatory bottom-up approaches mastered by NGOs.

the development of follow-up FFS-PPB activities and experiments for participating farming communities. These experiences should culminate in research papers, publications, and elaboration of PPB approaches with policy makers, which are expected to bring a more scientific approach to FFS-PPB, and increased political and policy support.

Researchers may benefit from FFS-PPB by:

- 'free' testing of varieties and selection of breeding lines by farmers in diverse farming environments
- selection for stress related conditions in marginal areas
- a structured way to obtain information concerning diverse agronomic and consumer preferences, using farmer's knowledge
- contribute to the use of participatory approaches in science

Farmers and researchers both have to work out the method of collaboration in the FFS-PPB programme. Potential options for collaboration, indicating the various responsibilities and roles of farmers and researchers in PPB are presented for reflection in fig 10 (adapted from Morris & Bellon, 2004).

Table 1. Modes of participation in participatory plant breeding (PPB)

Mode of participation	Role of plant breeders	Role of farmers	Comments
Farmers are given finished varieties developed by plant breeders	• Set breeding objectives • Select source germplasm • Identify traits for improvement • Determine breeding methodology • Establish testing procedures • Evaluate finished cultivars on station	• Decide only whether or not to adopt the product	• Traditional breeding • Little direct interaction between farmers and breeders • Breeders knowledge of what farmers' want is not based on organized and direct interaction with farmers
Farmers provide source germplasm on which breeding process is based	• Collect and characterize source germplasm • Identify traits for improvement • Determine breeding methodology • Establish testing procedures • Evaluate finished cultivars on station • Basis for developing new varieties	• Provide source germplasm • Part of target population	• Source germplasm comes from farmers in target population, rather than gene bank • Well adapted material, hopefully with many traits farmers value • Tenuous relationship between farmers and breeders • Breeding process solely in the hands of breeders
Farmers identify traits to be improved and suggest selection criteria	• Set breeding objectives • Select source germplasm • Determine breeding methodology • Establish testing procedures • Evaluate finished cultivars on station	• Identify traits for improvement	• Better targeted varieties • Varieties more likely to respond to farmers' needs and constraints
Farmers evaluate finished varieties on station or in scientists-managed on-farm trials and help select varieties to distribute	• Set breeding objectives • Select source germplasm • Identify traits for improvement • Determine breeding methodology • Establish testing procedures • Finished cultivars evaluated on station or in farmers' fields but under breeders' management	• Actively participate in testing procedures • Identify finished or near finished varieties that are interesting to them	• Farmers may be able to select for traits that they cannot easily describe in words • Decision-making and responsibility for selection of germplasm shared between breeders and farmers • If varieties are planted on-farm in several different locations, breeders and farmers can evaluate them under a range of biophysical conditions

Table 3. Continued

Mode of participation	Role of plant breeders	Role of farmers	Comments
Farmers evaluate unfinished materials (lines, families, landraces) on station or in scientists-managed on-farm trials and select materials for further improvement	• Help set breeding objectives • May select source germplasm • Help identify traits for improvement • Determine breeding methodology • Establish testing procedures • Finished cultivars evaluated on station or in farmers' fields	• Identify interesting materials that still show a high degree of genetic variability for further improvement • Help to set the breeding objectives • Identify traits for improvement	• May lead to more diverse set of materials to be improved • Provides good idea of genotype-by-environment interactions if done in farmers' fields
Farmers conduct germplasm evaluation trials in their own fields and using their own management practices	• Help set breeding objectives • May select source germplasm • Help identify which traits will be targeted for improvement • Determine breeding methodology	• Farmers actively participate in testing procedures • Testing is done in farmers' fields and under their management • Identify near or finished varieties or interesting materials that still show a high degree of genetic variability for further improvement • Help to set breeding objectives • Identify traits for improvement	• Materials could be finished varieties or unfinished materials in different stages of improvement • Provides a very good idea of genotype-by-environment interactions • Explicitly incorporates farmers' needs, interests, and constraints • Strong organized interaction between breeders and farmers • Sharing of decision-making, responsibilities, and activities
Farmers are trained in 'scientific' breeding methods	• Train farmers in scientific breeding methods so they can: (1) maintain valued traits in their varieties, (2) modify existing traits, and/or (3) introduce new traits.	• Set breeding objectives • Select source germplasm • Identify traits for improvement • Determine breeding methodology • Establish testing procedures • Testing done on farmers' fields	• Trained farmers are able to carry out breeding process on their own, possibly with help from scientists

Source: Authors.

4. Recruitment and training of FFS facilitators

The first step towards establishing the FFS-PPB programme is the training of a core group of trainers and facilitators by experienced development workers and researchers. Once trained, this core group of facilitators will be responsible for most aspects of training developments and the management of the FFS-PPB in their region. Recruitment of this core group often comes from IPM programmes, which has the advantage that they already master FFS concepts, including methods and theories of non-formal adult education, leadership and FFS management. Firstly, core facilitators should be farmers and know how to grow crops in the sense that they are familiar with all processes from land preparation to harvest. Secondly, they must be ready to become experts in PPB methods. The career path to the development of a core facilitator is as follows:

- Farmer or FFS-IPM facilitator
- Participates in TOT and becomes FFS-PPB facilitator
- Facilitates in one or more season-long FFS-PPB and becomes Trainer of trainer
- Trainer/Manager of FFS-PPB programmes
- Resource person

Core trainers eventually become senior facilitators and resource persons, however, they must be able to spend a large amount of time in fields with trainees and farmers. They should be ready to meet frequently to assist in planning work plans, budgets and strategies for improving the PPB programme, and should provide full time input for at least five or more seasons.

Once a core team of FFS facilitators is developed, they should be able to conduct training of trainers to develop new farmer-facilitators and to prepare them for the conduct of season-long FFS-PPB. Each TOT typically lasts about 2 weeks and has 10 to 15 participants. Different resource persons, including researchers and guest trainers from other FFS-PPB programmes should contribute to the TOT and provide live examples of how PPB can be implemented. At the end of the TOT, farmer-facilitators should be able to:

- Know how to organise the season long FFS-PPB training programme, including arranging and managing germplasm, variety testing and crossing
- Facilitate the farmer field studies and apply tools and exercises
- Prepare a Farmer Field School curriculum
- Prepare a budget

5. Arrange and Manage Germplasm

The fifth step in the development of FFS-PPB programmes involves arranging for necessary germplasm to increase variability and options for selection. This is both a preparatory as well as a continuous activity supporting the development of the FFS-PPB programme. This activity entails setting up mechanisms for:

- germplasm collection
- characterisation
- storage
- multiplication and diffusion

Sweet potato		
Pearl millet		
Maize		

Collection of germplasm from local markets may be easy but should be avoided as much as possible, as it does not allow to assess and describe the variety in the field or to collect sufficient material. If a lot of material nevertheless is collected from local markets, a pre-screening test must be organised to preview the suitability and/or to multiply the source for use at FFS-PPB level.

Characterisation;
Knowledge of local varieties is rarely documented in farmer communities, as it is a collected part of the farmers' minds and transferred by visual observation or word of mouth. Accessing this information by farmers outside the community and by researchers, for example to establish a new FFS-PPB, however, may be very cumbersome and time consuming, unless there is some documentation available. Also, preserving the varieties within the community for later use in the PPB programme, for example as parent material in crosses, may be prone to error without a description of the variety or line attached to the seed lot. Characterisation therefore significantly can contribute to the successful implementation of the FFS-PPB programme.

The primary objective of characterisation is to describe local and introduced varieties to facilitate the access and use of varieties or lines by farmers and researchers. A single variety may have many different characteristics, but only few of these are important for farmers. Comprehensive descriptor lists such as those used by scientists in genebanks are far too complex, and are not needed in the farmer's case. Farmers need to elaborate a set of main characteristics that they are familiar with and are essential or can improve production, household consumption and/or local markets. They can add other characteristics, either positive or negative, later on if they feel so needed for smooth implementation of the programme. For documentation, farmers may use a simple booklet to document the information and use codes and labels to identify the seed lots.

Characterisation of germplasm is done in different stages, in each stage the information may be validated and updated:

- During collection missions
- During testing of varieties
- During selection using the variety as parent material

This is a sample of a first characterisation list compiled by farmers in Indonesia for vegetables:

Date of collection:	Production cycle (in days) ....
Name of collector:	Appearance of fruit ....
Address of farmer-producer:	Pest & disease resistance ....
Source of seed:	Production capacity ....

General description: ....
....
Strengths: ....
....
Weaknesses ....
....

Development workers or researchers may provide additional support by filing back-up information and germplasm. For each crop, farmers may elaborate a different set of characteristics. As farmers are not familiar with this type of activity, facilitation and support by development workers or researchers may be needed. Support can be extended by providing a back-up facility for germplasm storage and keeping a database with information collected by farmers and/or other sources. Whereas testing of varieties are a standard training programme in the FFS-PPB, collection missions are usually optional, and may need additional logistical support in terms of transportation, guidance and bags for collection.

Storage;
Varieties that have proven to be of value to farmers after introduction and testing must be stored for use in the PPB programme later on. The number of varieties or lines expected to be stored is usually more than 50, sometimes over 100, thus requiring special low-tech storage techniques. Techniques may vary depending on the crop and quantity. Rice seed, for example, may be stored as panicles or in bags, while the best storage for pumpkin seed is in the fruit. Low-cost seed banks, like on shelves in a separate well-insulated room of a farm house, for example, belonging to one of the farmer-facilitators, is usually sufficient to store the seed and transfer it from one season to the other. As indicated above, it is important to label the bags with appropriate description of the name, origin and date of harvest.

Farmers may establish community seed banks to store tens of different varieties for later use by farmers for production or testing purposes. Community seed banks are valuable devices in the conservation of varieties but have proven to be not very sustainable over time and require constant external input. Alternatively, a concept of de-centralised community seed banks may be tried, where a number of farmers are responsible each to maintain a few varieties.

Multiplication;
To maintain suitable varieties requires not only good storage, but also occasional multiplication. This may be easy for strictly self pollinating crops like rice or beans, as farmers can harvest seed from the variety trial for planting in the next season. However, multiplication is more difficult to achieve in cross pollinating crops, like maize, bitter gourd and pearl millet, for which crops usually a proper isolation is required. If the multiplication field is too small or too close (less than 500 meter) to another variety, chances are that the typical variety characteristics are not retained to the next season. When multiplication is needed, farmers should prepare the location of the field and the time of planting well ahead of time. For development FFS-PPB programmes to larger areas, additional multiplication support may be extended by support organisations.

Diffusion;
The diffusion of varieties applies both to the introduction of new germplasm to the FFS-PPB (downstream flow) as well as the spread of varieties to other FFS-PPB programmes (upstream flow). Both systems are highly dependent on the effectiveness of the farmer-to-farmer network in spreading information, which depends on:

- Key farmers
- Word of mouth
- Observation
- Documented information
- Distance

SRER KHMER

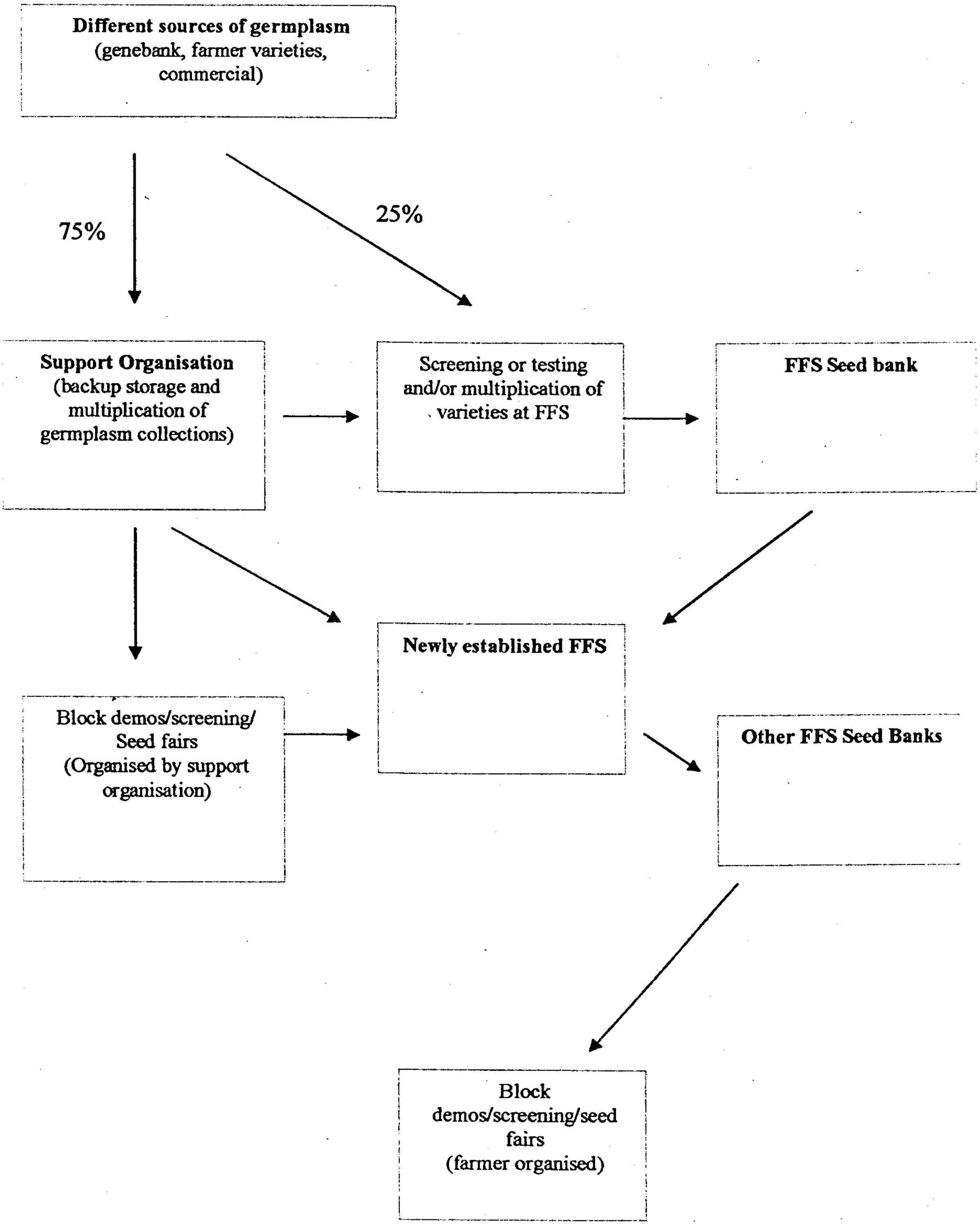
In most communities, key farmers who specialise in variety multiplication and supply of seed, also ensure the effective diffusion of varieties within and among communities. Names of key farmers (or nodal farmers) in the community may be disclosed during the baseline survey. They are often also ensuring the spread of information concerning specific varieties, hence participation of key farmers in the FFS-PPB can assist the development of the FFS-PPB programme both ways: by dissemination germplasm and information thereof. Characterisation of varieties as described above significantly can help in the dissemination of varieties and can be used for reference once it is documented. Various media such as local radio or newspapers can also make use of this information. In addition, seed fairs may be organised by farmers to display their varieties and facilitate the diffusion of germplasm.

Role of support organisations in germplasm management
Skills of farmers to manage germplasm initially may not be enough to carry the FFS-PPB programme substantially forward, especially when the distance between FFS communities is a disincentive to effective dissemination of germplasm. External support then may be needed to keep activities going. Research institutions, extension agencies and NGOs can facilitate such support in various ways:

- Back-up storage of germplasm (short and long-term)
- Multiplication of varieties in isolated areas
- Back-up documentation of variety characterisations
- Organisation of screening trials and regional seed fairs
- More effective use of media, including FFS forums

Materials and equipment to assist in this support such as seed storage bins, bags, simple drying equipment and transportation should be available. Fig X proposes a strategy for the effective germplasm management involving both FFS-PPB communities and supporting organisations. Discussion of this topic may be facilitated using exercise xx in chapter 10

Fig X: Assuring the effective introduction and dissemination of suitable varieties for FFS-PPB programmes



CHAPTER 5 IMPLEMENTATION OF SEASON-LONG FFS-PPB

1. Introduction

All Farmer Field Schools on PPB starts with offering farmers a chance to acquire basic skills in genetic resources management. This is covered by the first learning goal in the Learning Matrix: 'Seek Better Varieties'. By the end of this course, farmer participants should be able to carry out the following activities:

- Observe and evaluate a large number of varieties using variety trials
- Identify, acquire and store germplasm
- Understand flower morphology and pollination processes
- Conduct parental crosses in priority crops

In order to achieve this goal, the FFS will implement season-long field studies emphasizing on:

- variety evaluation
- plant reproductive morphology

The season-long variety evaluation trial allows farmers to strengthen their skills in comparing a number of varieties for performance, in particular in the evaluation of the own pool of varieties against introduced germplasm. Through field exercises and collective group work, farmers will strengthen their ability to make collective decisions on variety performance by learning the skills of goal setting, field observation, and by applying various tools for scoring and evaluation.

The training on reproductive morphology aims to strengthen farmer's understanding of the plant biological processes involved in the re-production of plants. Practical exercises in the field, such as study of flowers, fruits, pollination processes, and the making of crosses between two selected parent varieties, will allow farmers to understand the potential of plant reproductive processes in generating genetic variability and needed follow up action for selection. This topic introduces farmers to the subject of cross breeding and can be followed up with selection in segregating lines in the season following the FFS course.

In rice, it has been quite common to additionally include field studies on selection in segregating populations, such as F2, F4 and F6, because of availability of suitable crossing materials from nearby research stations. This provides benefits to farmers as they are able to select for local adapted varieties in a relatively short period of time. At the same time, it gives farmers an idea of what they might expect to see after conducting parental crosses and planting of the progeny from crosses in the field. The approach, however, is feasible in rice, and perhaps a few other major crops, because of the limited space needed in a farmer's field and the numerous formal rice breeding programmes, but may not be feasible for other crops. Pedagogical concerns also have been expressed as it might lead to overflow of information for participants. This training component on cross breeding and selection in segregating lines, including for rice, will be further discussed in chapter 6.

Depending on the crop, the length of the curriculum and the interest of the participants, more training components can be included in the curriculum, such as variety rehabilitation, cross breeding/selection and market diversity. Discussion of these 'special' topics, however, is usually limited to one or two sessions and few field exercises during the course, and may be left over to guest teachers. In this chapter we will discuss in more detail the implementation of the Season-Long Farmer Field Schools on Participatory Plant Breeding.

2. Farmer Field School Planning

Each Season-Long Farmer Field School is carried out by a facilitation team consisting of two FFS facilitator. One trainer is the local extension staff who usually works in the field with the local farmers, the other trainer is the farmer-facilitator.

Facilitators receive training during a TOT on PPB which aims to:

- prepare participants to become trainers in the FFS-PPB
- prepare and discuss the detailed planning of the FFS-PPB

The TOT should be held at least 2 months prior to the first farmer session at the FFS, and just before or after the conduct of the village baseline survey, to allow time to arrange for necessary germplasm and to make needed preparations. Each facilitation team should prepare for a planning of the Farmer Field School, which should include details of:

- Expectations setting and learning goals
- Discussion of required germplasm and approaches how to access and make it available
- Participant selection, analysis of gaps in the skills and know-how
- Field preparations and management
- Setting of FFS-curriculum including contents of weekly sessions
- Guest trainers for special topics
- Setting date of the FFS and (if applicable) village baseline survey
- Overall budget preparation

A detailed plan for the FFS is prepared and elaborated with other participants at the end of the TOT.

One facilitation team can be responsible for more than one FFS-PPB, up-to a total of four in the same area, which will allow for effective exchange of views and experiences. The FFSs can all be established at the same time or in different seasons. Preferably the FFS have established PPB programmes on the same crop which helps to synchronise the plantings and exchanges. The two trainers can visit all the FFS in four days time, whereas the remaining day(s) may be used for the trainers to work together to organize training for the next week.

3. Organisation

A FFS 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 criteria[1]:

[1] Exclusion of farmers who are not eligible to these criteria still can participate in the results; there can be frequent informal exchanges within the community, they may learn during the Farmer Field Day at the end of the FFS, and obtain seed of well-performing varieties.

- Have farmland in the immediate village neighbourhood
- Be an active farmers with a keen interest in variety multiplication and crop selection
- Have experience in the cultivation of selected priority crop(s)
- Is in good health, between 18 and 60 years old, preferably with some basic schooling
- Committed to attend the full duration of the Season-Long FFS-PPB

The list of participants should include male and female, young and old farmers. Some persuasion may be needed to get female farmers to participate in the FFS, especially in some cultures. Discussion of this topic, using exercise....in chapter 10 may be helpful to convince community members for females to participate.

Participants in the FFS will work together in groups of 4-5 farmers, each with a specific task in the observation and analysis of field studies. This will provide for effective interaction and discussion within and between groups. Groups are formed by the facilitators at the start of the FFS-PPB.

Farmers in the FFS-PPB meet on a regular, most often weekly, basis to keep the momentum and follow up on all the topics and field exercises needed to complete the course. Course duration for annul crops is usually between 14-16 weeks. The course will be in the morning for about 4-5 hours, which usually starts with expectation setting and field work. Participants will then meet again to analyse and discuss findings, continue with common or special topics, and finish the day at noon with an evaluation.

At the end of the course, successful farmers will receive a graduation certificate. Evaluation of skills acquired by individual farmers can be conducted with the help of the 'ballot box' method, which is conducted on the first and last day of the course. This method is used also to evaluate the overall FFS-PPB course.

4. FFS Preparations

There are numerous preparations that must be done at different times prior to the course initiation. Usually this will require one trainer to be in contact with the community well before the training begins:

- Arranging and collecting varieties for the variety trial. This can be done 2 to 3 weeks before the planting of the trial, provided that the varieties and sources have been identified and seed is available. If this is not the case, farmers may need more time to collect the seed. A collection mission may be organised at least 1 month before the initiation of the FFS, involving farmers and/or facilitators, to allow for the seed to be collected. For each variety, also a simple characterisation is required. See for discussion of germplasm management chapter 4.

- Selection of study field. It is suggested that the studies all be set-up in one field, close to the village location, to facilitate weekly observations, experimentation and learning. The field site can be a privately-owned land or communal owned land. Usually, some form of compensation may be required, either in cash or in kind, which may be provided by the community or project. The study field should be representative of the local agro-ecosystem, away from houses and big trees, within walking distance from the village, and strategically located where other people can see the experiments. Sometimes it may be needed to fence the study fields to protect it against grazing animals.

- Field preparation such as ploughing should be done 2-3 weeks before direct sowing or transplanting

- Planning for sowing need to be thoroughly discussed with participants. Sowing of a variety trial may include up-until 15 different varieties, which all need to be kept separate and labelled during seed/nursery and during transplanting to avoid admixture. Nurseries need to be protected with a cage against birds and other animals.

- The study field lay-out should be discussed thoroughly and mapped out well by the participants to be ready for transplanting or direct sowing. Besides signs and markers in the field, participants should also draw a map of the trial, which will assist in identification should a field sign be removed.

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

- Materials for training should be listed and bought before training. Field signs and labels, fertilizer and manures should be ready on the first day of training. Other training materials such as paper, markers, should also be purchased beforehand.

5. Field Studies

The main field study in the Season-Long FFS-PPB is the variety testing and evaluation. The field study on reproductive morphology only requires a small number of plants to be available. These plants usually can be taken from border plants of the variety trial, however, if more is required a small field plot may be added. For the variety trial to succeed, it is important to take notice of a number of issues:

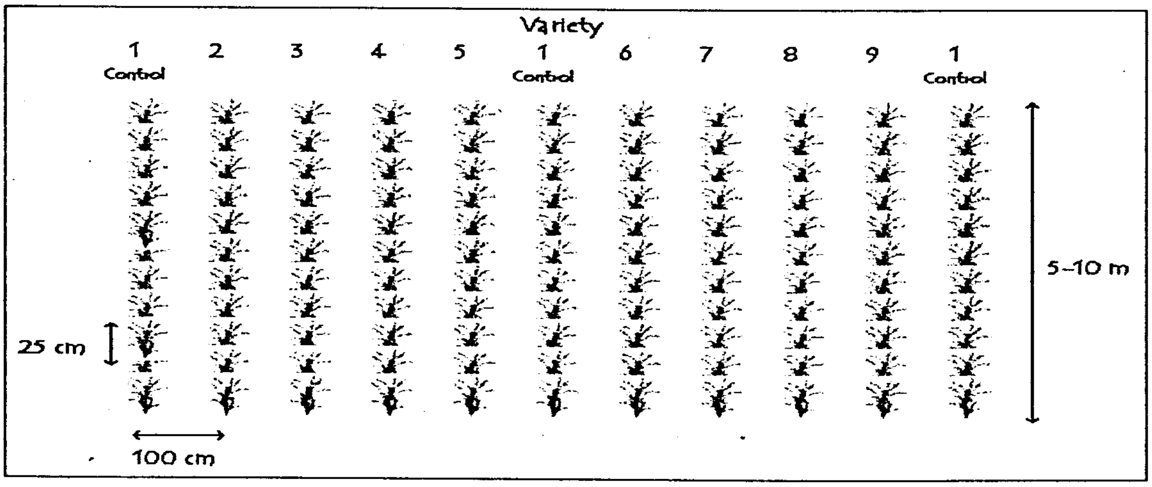
Number of varieties; ten to fifteen varieties is ideal for farmers to gain knowledge and skills. However, the range of varieties may vary widely, as we have seen FFS communities conducting trials with more than 30 varieties in the case of rice, and others with only 8 varieties or less, in the case of pumpkin. The number of varieties largely depends on the plot size, planting density, skills of participants and type of trial and number of replications.

Control variety; one of the local cultivars chosen by farmers should serve as the 'standard' or control variety for comparison, although other local varieties may be included as well. The control variety should be the variety most promising or most commonly planted by farmers in the village. The remaining varieties may be obtained from the village neighbourhood, from farmers elsewhere in the region, or acquired from commercial sources. Exotic germplasm from government agencies, genebanks or from extension officers or researchers, from other regions and countries, recommended by the help of supporting agencies, may be included, if required, which should be arranged with

Size of field; the size of the field depends on the number of varieties that farmers may wish to include in the study, and the number of replicates in the trial. Usually, total size of the field does not exceed 2000 m2.

Type of design; the design of the trial may vary dependent on the skills of the participants. As farmers have difficulties in using research tools like statistical analysis (ANOVA) because of the scientific complexities, specially adapted participatory tools have been shown to serve similar output and allows to include up-to two or three replications. These tools are further discussed in chapter 10 and in the paragraph on GENSYS below. The most common design used in the FFS-PPB, is the partial replicated variety trial, in which only the control variety is replicated, once every four varieties. For comparison, replicates of identical trials may be conducted in other nearby FFS-PPB villages, which adds value to the comparison. The latter design also adds value to researchers, who can use data for more sophisticated analysis.

Fig x: Example of a partial replicated variety trial



Soil tillage and fertilizer applica tion; Local soil tillage and fertilizer practices will be used. The kind of soil tillage and fertilizer application used should be discussed with the farmer group during the pre-season discussion. It is important to apply soil tillage and fertilizer (organic or an-organic) in strictly uniform quantities as this may influence the variety performance and comparison.

Agro-chemicals and weeding; No pesticides should be used to allow comparison of resistance to insect pests and diseases, unless the infection threatens to wipe out the field study. The usual weeding practices should be applied.

6. Common topics

During the course farmers will study a number of different topics that will guide them to acquire basic skills in genetic resources management. As skills and concepts are best learned, practiced, and debated in the field, farmers will learn by working in small sub-groups collecting data in the field and use these data for action decisions. As such, most of the topics discussed in this section use the field as the main teaching floor and are carried out in small groups. They contain experimental outlines, which farmers can use to learn and develop their own approaches in order to make founded decisions. A detailed outline of the topic exercises and guidelines for facilitators is provided in chapter 10. In this paragraph a general outline of the exercise is given.

Re-visiting the breeding objectives; The FFS participants may not be the same as the people who participated in the baseline survey, it is therefore necessary at the beginning of the FFS course to re-view the goal setting process again. Facilitators can walk the participants through the process, but also re-conduct the exercises, in particular focusing on 1) listing of strength and weaknesses of cultivated varieties and 2) prioritization of preferred variety characteristics. This exercise directs the way field observations in the FFS are conducted, therefore some details are needed in the goal setting process to proceed with the next topics. However, sufficient flexibility must be provided, as goals (breeding objectives) and observations may change over time, when for example farmers come to realize that other characteristics are more important.

Setting observations and scoring methods; this exercise will ensure that farmers observe characteristics in the field that are linked with breeding objectives and are carried out in a way that farmers can handle and understand. Collecting too many data and too specific details will only confuse farmers. In this exercise farmers will elaborate on the type of observations, the scoring technique, and the time of field observation in the course of the growth season. Not all farmers may be ready to discuss this topic in detail at the beginning of the FFS. Facilitators should follow a gradual approach and work from broad observations at the beginning of the FFS towards more detailed observations and scoring when farmers start with data collection in the field. Once observations are set, they are compiled and integrated with the weekly observations in GENSYS.

Table X: Sample table for observation setting

Goal or Breeding objectives	Observations	Scoring method	Time of observations

Plant morphology and plant growth stages; This exercise will provide farmers a general idea of the morphology and growth stages of the crop under study. They will study and draw the different parts of the plants. Growth stages include all critical phases of the plant development including seedling stage, vegetative stage, flowering stage, fruiting stage, seed filling stage up-to harvest and crop maturity. The exercise is meant to assist farmers to determine the best timing for observations of the criteria in the field, and serves as preparation for the study on flower morphology.

Flower morphology; In this exercise farmers work in small groups to study flowers and reproduction. They will study flowers collected in the vicinity by drawings, identifying different flower parts like petals, stigma and stamina, pollen etc in an effort to resolve questions like: what is the most (in)complete flower? This is followed up with short lectures on flower morphology focusing on priority crop(s). Subsequently, farmers will study the pollination process and identify factors that inhibit or facilitate pollination and fertilization, By identifying the insect, wind, water and other factors involved in the pollination process, they will discuss the need for isolation and resolve questions like: what flower is cross/self pollinating?

Bee exercise; this is a field exercise meant to allow farmers to study insect behaviour and their role in the pollination process. This exercise is excellent for many cucurbits (pumpkin, Loofah) and leguminous crops (bean, cowpea) but less suitable for wind pollinated crops like rice and maize. In sub-groups of 4 farmers, participants will count the various types of insects visiting flowers in the field during a period of 10 minutes. By repeating this exercise on different times of the day, and on other days, they will determine the influence of environmental factors like rain/sunshine, temperature, time and other factors on insect behaviour.

Making crosses; Farmers are led to discuss the benefits of creating variability by making crosses, resolving issues like: when do we need to make crosses for selection? In farmer sub groups they will identify varieties for use as parent lines in crosses. Farmers also study patterns in flower development from buds to wilting, and determine the best time for emasculation, pollination and bagging. Short demonstrations with live plants will show participants how to conduct the crosses, by emasculating, bagging, pollinating, and proper labelling. Farmers will then master the technique of making crosses in a series of field sessions and monitor their success.

Eating qualities; Cooking quality and taste are among the most important traits farmer may prefer in a variety. This exercise is meant to guide farmers in the process of evaluating varieties for eating quality. Farmers will first discuss desired and non-desired traits related to taste, texture, cooking, and appearance after cooking. They then proceed to discuss the process of scoring and evaluation, the timing and the number of participants. Following this preparation, a full session is usually dedicated to allow individual and farmer groups to evaluate eating qualities.

Harvest and storage; this exercise is conducted just before the harvest, and leads farmers to discuss and prepare for harvest, threshing and storage of the various varieties in the trial. They will focus on the danger of admixtures, out-crossing, need for tags, bags, and places for storage.

7. Special topics

This paragraph describes five additional topics which help to increase skills and understanding of farmers on the various contents of PPB. Depending on the crop, time availability during the FFS course and the interest of the participants, one or more special session may be included in the curriculum Guest facilitators or researchers may present these sessions. Farmers may be interested to include other issues as well which should be suggested at the start of the FFS.

About genes and genotypes; farmers are not familiar with various terminologies used in selection and breeding. By using live examples of segregating materials, such as animals, plants and seeds, this exercise aims to introduce farmers to topics like genes, genotype, genetic segregation, and genotype –environment interactions.

Variety rehabilitation; this topic let farmers discuss the causes of variety deterioration and ways to restore the original variety. The exercise starts with a transect walk in the village to identify deteriorated varieties. Farmers will then discuss their practices in obtaining new seed, in selection, trying to preserve the variety characteristics. This exercise is meant to investigate the need in the farming community to start a follow-up activity on variety rehabilitation.

Selection techniques – self-pollinating crops; this exercise introduces farmers to the topic of selection methods in segregating lines. The session explains, depending on the background of the participants in simple or more complicated terms, methodologies in the selection of self-pollinating crops, discussing different generations, like F1, F2 until F8, and selection methods used by farmer and breeders, such as bulk selection, pedigree selection, line selection, need for yield trials etc. It also makes a links with efforts in variety rehabilitation.

Selection techniques – cross pollinating crops; this exercise is similar to the previous one and is offered to FFS participants in case the priority crop is cross pollinating. The sessions let farmers discuss their selection methods and explain the methodologies in the selection of cross pollinating crops. Methods like bulk selection and various types of recurrent selection are explained. Typical problems in the selection process are discussed like the need for isolation and recombination of genes to avoid inbreeding. Similar to the previous exercise, topics are discussed in simple or more complex terms depending on the background of the participants.

Market diversification; this topic will lead farmers to discuss to varying detail the present market products, domestic and wholesale markets, key stakeholders, and the role of diverse varieties in this market. It then focuses on what can be done to improve the market, reduce risks, diversify products and discover niche markets. This topic is meant to sensitise participants for the follow up activity on market diversification and strategy development.

8. Genotype Environment Analysis

Genotype - Environment Analysis, or in short GENSYS, is a weekly activity conducted throughout the season-long FFS-PPB course. The purpose of GENSYS is to guide farmers in the analysis of collected results from field observations. GENSYS recognizes two types of field observations:

- *G-observations* are observations on variety characteristics defined by farmers at the start of the FFS course and are closely linked with breeding objectives. Data are collected at different times during the cropping season, depending on the attribute. Characteristics are determined by the genetic composition (genotype) of the variety.

- *E-observations* are observations on environmental factors in the study field, caused by a-biotic factors, biotic factors or the farmer himself. These factors may influence the genetic expression (genotype) of the variety resulting in altered expression (phenotype). See chapter 4 for explanation of this phenomenon.

After data collection in the field, farmers come together at the meeting place to analyze the data and whatever they have seen in the field using drawings, tables, graphical presentation and group discussion. At the end of the activity, farmers should wrap-up by 1) make a conclusion on variety performance in the field, by indicating what variety has performed best on the particular characteristic discussed, and 2) make a decision about any actions required in the field during the next week.

In order to reach this decision, the GENSYS analysis focuses on three issues:

G-analysis ; some characteristics are observed at the beginning of the season, others at the end, and some throughout the season. As there are many different characteristics involved in the variety trial, the facilitators should select every week one or two characteristics for farmers to observe and discuss. For example, fruit shape of bitter gourds is collected during one or two weeks after the varieties have started to produce fruits, and results can then be discussed immediately after this exercise, however fruit yield is observed throughout the season and can be analysed only after final harvest. Similarly, plant height in rice can be observed and analyzed immediate after tillering is completed. In the F-analyses farmers make use of summary tables, graphs, and drawings wherever possible. Conclusions concerning best performing varieties should be made based on:

- Visual comparison
- Pair-wise comparison
- Scoring card comparison

For an explanation of these methodologies see chapter 10.

E analysis; are recorded on weekly basis. Analysis can be done by preparing a big chart with the weeks on the X-axis and incidence on the Y-axis.

- Biotic factors involve for example harmful insect populations, rats and weeds which can be monitored by indicating: few insects: one drawing, many insects: many drawings.
- A-biotic factors include rainfall and sunshine, and irrigation; data may be recorded on a chart indicating: mostly sunny: add a sun, mostly rainy: add a cloud, etc.
- Human factors include fertilizer applications, pesticide spraying etc. Analysis may be on a chart depicting: fertilization: picture of hand,

GE analysis; The purpose of this analysis is to obtain a true picture of the variety performances without interference of environmental factors. For example, variety yield in the trial may be influenced by irrigation patterns, soil types or fertilizer application. GE analysis will help in removing these interactions from the data to provide a more realistic picture enabling farmers to compare varieties based on real expressed characteristics. GE -analysis makes farmers aware of these issues. However, removal of environmental interactions on the data in the FFS-PPB is limited which is because of the trial design. If full replications are used in stead of partial replication this would allow for better analysis. GE analysis is generally obtained through:

- Visual observation; farmers observe the trial and record possible interacting factors; they make drawings of the trial or variety plot indicating possible disturbing factors on the variety performance
- Simple graphical analysis; by using the replicated data of the control variety, the environmental error (or bandwidth) can be depicted and varieties with significant higher or lower performance identified

9. Farmer Field day

When all varieties have been harvested, or when most data have been collected, it is time to wrap-up the season's FFS-PPB training course. Preparations must be made for organizing a farmer's field day to report back to the whole community on the lessons learned and progress made. The farmer's field day is a celebration. It is carried out to share the results of the studies to other farmers in the community, to relatives and officials. The farmer's Field day also serves as a platform for farmers to generate support for their activities to dignitaries and officials.

It is important to well prepare the Farmer's Field Day. The time ahead of the farmer field day are usually full of activities: evaluations must be finalized, graphs and tables prepared, performances rehearsed and exhibition rooms arranged. The weekly GE analysis is helpful to compile the necessary data, thus when the Farmer Field Days is held, most data are already available. Some suggestions for exhibitions during the Farmer Field Days are presented in chapter 14.

10. Final evaluation & planning

Towards the end of the training season, it is time to measure changes in know-how and field skills of individual participants between the beginning and the end of the training, and to evaluate the training and plan for the next season.

- Evaluation of individual participant progress in gaining field skills and know-how involve changes that are assumed to have taken place as a result of the training activities during the season's training course. Evaluation usually takes place using the 'ballot box' method, which method uses multiple choice questionnaires and field situations to test the farmer's know-how and skills. Questions used in the ballot box should be developed before the season.

- General evaluation of the training course should reveals lessons learned. It aims at making facilitators grow into better facilitators. There are always lessons to be learned, methods to improve and approaches to be adjusted. Various evaluation tools are available. Commonly used methods are the T-chart and the Piling up method.

- Evaluation of training impact is the most difficult factor to measure, since results of PPB training are not likely to produce immediate tangible results. Usually tangible results relate to the farmer's benefit and income, the environment or the community organizations. During this evaluation session, participants may indicate how many wish to plant and adopt the newly introduced varieties. The number of farmers interested to continue with PPB and follow-up FFS-PPB activities may give an indication of the potential impact.

On completion of the training course evaluation, participants together with the facilitators should discuss the planning for the following season. It must be mentioned that not all participants need to continue with PPB. However, usually a number of farmers may decide to go ahead with follow-up courses, or to repeat the trial with a different set of varieties. Questions that need to be discussed during this planning session include:

- What kind of field studies and follow-up activities will we conduct in the next season?

- Who will participate in these activities
- Who will be responsible for seed storage during the off-season?,
- When is the time to conduct a more detailed pre-season planning meeting?
- What will be the follow up activities during the next season?

Upon completion of the evaluation and planning session, the results should be summarized. These will be used to determine what kind of support will be needed during the next season.

11. FFS curriculum

The following weekly schedule is a sample of a FFS on PPB conducted on a vegetable crop. In general it will be necessary to adjust the content and schedule to the priority crop, local conditions, and farmer interests.

Table XX: sample of 14 week FFS curriculum To be further worked out – Field Indonesia?

Box: A day in the Farmer Field School on PPB to be further worked out – Field Indonesia?

CHAPTER 6 ENSURING CONTINUATION

Introduction

The Season-Long FFS on PPB signifies the introductory course on genetic resources management. Farmers learn the basic skills of conducting variety testing, acquiring germplasm and making crosses in order to increase variability. However, there is much more to learn and explore beyond this basic program.

The purpose of follow-up activities is to challenge farmers to further upgrade their skills and become 'experts' in genetic diversity management, while at the same ensure continuity of PPB. Any such effort takes place synchronous with the community's crop improvement and diversification programme.

The challenge for any PPB programme is to offer activities that are of immediate interest to farmers. Only this will ensure continuation of the programme beyond the Season-Long FFS-PPB. All efforts in the FFS-PPB, including crop and site selection, selection of participants, field practice and other training sessions are meant to pave the way for a continuation of the PPB programme and thus ensuring impact on the farming community.

Experience, however, teaches that multiple-season PPB is not a viable option for all farming communities at all site. Some communities and farmers remain with variety evaluation only (PVS), some engage in developing crop marketing strategies for value added diversification, while others may explore the additional options of crossbreeding in PPB programmes.

2. Follow-up activities

The learning matrix, presented in chapter 3, provides farmers with three other learning goals beyond the basic goal 'seek better varieties', leading farmers to levels of 'seek diversified markets', 'conserve and manage diversity', to reach the level of 'farmers become experts'. In line with this matrix, six follow-up activities have been identified in PPB:

1. Crop market strategy development for value added diversification
2. Crossbreeding; selection in segregating lines of self-pollinating crops
3. Crossbreeding; selection in segregating lines of cross-pollinating crops
4. Variety rehabilitation
5. Farmer-to-farmer diffusion and management of genetic resources
6. Community organisation in PPB

In the PEDIGREA programme thus far only activities 1 through 4 have been worked out. It is expected that the activities 5 and 6 will be available in near future. Modules were developed particularly for rice and vegetables, whereas most experience was gained in rice. Modules can be adjusted to accommodate FFS-PPB in other crops.

3. Crop market strategies for value added diversification

to be completed
LEI: Siebe, Gerdien and Sebastian

Suggested Outline:

Purpose and approach (crops, market survey, swot, strategy development)
Organisation (stakeholders selection, approach)
Preparation (materials, logistics)
Implementation (description of participatory tools, details in part II)
Evaluation and monitoring

(perhaps a separate chapter?)

4. Crop breeding: selection methods for self pollinating crops

Introduction

Like modern breeding, farmers often generate new possibilities for selection through recombination of genes by, for example, by deliberately mixing of varieties. However, the low rate of out-crossing in self pollinating crops produces fairly uniform varieties and offer little options for farmers to select in. In practice, most farmer selection in self pollinating crops is limited to off-type roguing.

When farmers cross two parent varieties and plant the ensuing generations, they suddenly encounter considerable more variability than they are used to. This new variability opens up potential for selection of better performing varieties. However, the potential will not be available, unless farmers know how to handle this high amount of variability. The purpose of this activity is to teach farmer the skills of selection in segregating populations for self pollinating crops. By the end of this course, farmers should be able to:

- Understand the role of genes in creating homozygous and heterozygous plant types
- Explain the breeding cycle for self-pollinating crops
- Describe and apply selection in the field by using the three types of selection methods in self pollinating crops

Most cereals and grain legumes belong to the group of strictly self-pollinating crops, including some vegetables. Some other crops are predominantly self-pollinating which allow similar selection techniques to apply.

Table X: Strictly and Pre-dominantly Self pollinating crops (less than 3% resp. 10% out-crossing)

	Cereal crops	Leguminous crops	Other crops
Strictly self pollinating	Rice	Bean	Tomato
	Wheat	Chickpea	Potato
	Barley	Soybean	
	Finger millet	Cowpea	
		Yard-long bean	
		Groundnut	
		Lentil	
Pre-dominantly self-pollinating	Sorghum	Bambara groundnut	Eggplant

Breeders cleverly use strategic goal setting and selection methods to direct the selection work and to develop new and better performing varieties. The breeding cycle in self pollinating crops is usually well defined; populations with high variability are generated by crosses, which is subsequently again narrowed by selection and reproduction. After a number of generations the population has developed again into a stable line or variety.

Breeding cycle for self-pollinating crops

The breeding cycle of self pollinating crops usually starts with the making of a cross between two selected stable parent varieties (parental cross), or between a line and a parent variety (e.g. backcross). This is how variability is generated, or genes are re-combined. However, this variability does not show in the first generation (F1), but only in the second generation (F2). Whereas the parent varieties were uniformly homozygous (AA or aa), the F1 will be uniformly heterozygous (Aa), and the F2 will be the first segregating population (AA, Aa and aa). For each of the subsequent generations, there will be more segregation occurring producing more and more homozygous plants. After 8 or 10 generations, the population again has become almost entirely homozygous and stable.

Considering that the offspring in the F2 and F3 consists of thousands of segregating plants, no field will be big enough to contain all these plants and diversity. It is therefore necessary to plant as many offspring plants as possible since there is a good chance that the desired plant type (genotype) is lost because of the sampling procedure. Selection must take place to ensure that the right plants are taken to the next generation and the wrong plants are rejected. Selection starts in the F2 and ends normally in the F8. If the (farmer) breeder has a good eye and selection is done well, he will succeed in producing a new variety with outstanding performance. Meanwhile, new breeding cycles may be started up by parent crossing. It is this continued selection process, set by specific breeding goals, that makes the breeding work challenging.

Selection methods

The three most commonly used selection methods in the breeding cycle of self-pollinating crops are:

- *Bulk selection (or negative mass selection)*; this is very similar to off-type roguing practice by farmers: all the off-types are removed and the remaining plants are harvested in bulk

- *Modified bulk selection(or positive mass selection)*; this is like bulk selection but reversed: in this method the best plants are tagged, harvested and bulked, while the rest of the field is rejected

- *Pedigree selection*; this is unlike bulk selection. Each good plant is selected and tagged in the field, and harvested separately, which seed is planted in single rows during the next season for performance comparison and further selection.

Each method has its advantages and disadvantages. Usually, breeders use a combination of methodologies to make best use of the comparative advantages. For example, they may apply bulk methods in the early F2 and F3 generations to save space and retain as many plants as possible, and pedigree selection in the F4 and F5 generations. Comparison of selected lines for yield usually starts in the F5, when the individual selections are planted in small plots. Selection methods applied in segregating populations may also be applied in variety rehabilitation (see later).

Farmer motivation

This activity is primarily capacity development training as it offers short-term benefits to farmers only in terms of skills and know-how, but is scarce on economic benefits. The breeding cycle promises benefits only after 8 to 10 seasons of intense selection and testing (in the humid tropics this translates to 4 to 5 years). Will farmers be interested to participate and invest time in this activity? In principal, this follow-up activity is not for the everyday farmer.

It is designed specifically for those farmers who are able to look beyond the horizon of short-term planning, who seek to satisfy their curiosity, are eager to learn, and for those who aim at some sense of social justice and community empowerment.

Even then, it may not be expected that training incentives are enough to motivate farmers to continue with PPB over several seasons. Creative options must ensure that farmers stick with the breeding programme.

- **Make crosses at research institutes and introduce F2, F4 or F6 to the PPB programme.** This option is a viable approach especially for major staple crops like rice that can benefit from the many national research institutes' breeding programmes. Rice is a strategic crop in most countries of Asia and Africa and breeding programmes are ongoing at many places. Collaboration with research institutes should ensure that such material is available for selection by farmers. This then short-cuts the breeding cycle significantly, promising benefits to farmers in a significant shorter period of time. However, this approach is less viable for minor crops like indigenous vegetables.

- **Conduct part of selection at farm-level, part of at research level**; Many different types of collaboration between farmers and researchers are possible. Farmers, for example, may select in the F2/F3 generations to ensure local adaptability, then the researcher may select in the F4/F5 to select for specific characteristics like plant type, where after farmers can conduct the final selection for yield performance. See other examples of farmer-breeder collaboration in chapter 1 and 4.

- **Development of community PPB**; the best way for continuation of the PPB programme is to ensure that the programme is carried by the community. Training of farmer trainers and Farmer to farmer FFS are examples of how PPB can become more part of the community and less an externally driven activity. To some extent also the concept of meta population can be used in self-pollinating crops (see next paragraph). For further discussion of this issue see chapter 7.

In rice, the above approaches offer significant added value especially in the collaboration with researchers and in benefits to farmers. Because of this proven concept, PEDIGREA develops regular links with rice breeders and research stations, and offers farmers standard F2, F4 and F6 populations already during the Season-Long FFS-PPB course, which seed lots are planted next to the variety evaluation trial. Farmers have reacted positively to this opportunity and the hands-on approach has shown farmers to learn quickly, although they may not (yet) fully understand the concept of genes and segregation. When they go through the follow up course on selection methods they will understand quickly.

Organisation

For non-rice crops farmers may best opt for this activity when the F2 plot is planted after successfully completing the parental crosses. This is usually in the 2nd season after the Season-Long FFS-PPB. F1 seeds should be planted and harvested in the off- season. In rice, it is slightly different; farmers may opt for this activity when they continue selection in the F3, F5 and F7 generations immediately after the Season-Long FFS-PPB during the first major rice season

A facilitation team consisting of one farmer-trainer and one extension worker should guide farmers through the field selection processes in the F2 through F8. The team may invite researchers or senior facilitators to elaborate with participants on the complex topics of genetics and selection methods. Farmers may be divided in groups of 4-5 people who are given the task of selection in one or more segregating plots. The facilitation team should prepare the FFS curriculum well ahead of time specifying needed preparations and timing of the FFS field activities. Usually 5 meetings during the season are sufficient:

- Preparation meeting/planting
- Selection round 1
- Selection round 2
- Harvest and storage
- Wrap-up meeting or Farmer Field Day

Field Preparations

To enable this activity to be successful, some preparations are needed:

- Germplasm management; F2 seed harvested from parental crosses and regeneration of the F1 plot (non-segregating), should be available 2-3 weeks before direct sowing or transplanting of the crop. Other generations like F3 through F8, if any, must be available in time for planting as well. Contacts with breeders from national research stations should ensure that segregating lines become available on time for the season's planting.

- Selection of study field. All plots should be preferably planted in one field, close to the village location to facilitate observations and learning. The field should be representative of the local agro-ecosystem, away from houses and big trees, within walking distance from the village, and strategically located where other people can see the experiments.

- Field preparation should be done 2-3 weeks before direct sowing or transplanting.

- Planning for sowing need to be thoroughly discussed with participants. Sowing of segregating lines may include many plots which all need to be kept separate and labelled during seed/nursery and transplanting to avoid admixture. Nurseries need to be protected with a cage against birds and other animals.

- The layout of the study field varies per crop, but should be discussed thoroughly and mapped out well by the participants to be ready before planting. Parent varieties used in the crossings may be planted in the borders as controls and to verify progress in the selection process.

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

- Materials for training should be listed and bought before the training. Field signs and labels, fertilizer and manures should be ready on the first day of training. Other training materials such as paper, markers, should also be purchased beforehand.

Field studies
Farmers will study a number of different topics that will guide them to learn and acquire skills in line selection. This study is primarily action oriented: small sub-groups conduct work in the field, collect data and use these data for action decisions. A detailed outline of the topic exercises and guidelines is provided in chapter XX.

Goal setting, observation and selection; facilitators and participants should walk through the process of goal setting described in the earlier sections (see tools in chapter 4, 10) to refine objectives and scoring methods of desired variety characteristics. At the end of this session, farmers should make a decision on the priority criteria for selection.

Selection methods; using the field as primary learning floor, farmers learn the processes involved in the breeding cycle, bulk selection, modified bulk and pedigree selection. Advantages and disadvantages are explained. At the end of the session, farmers should be able to make a drawing of the breeding cycle using different selection methods, and should be able to decide what selection method to apply in the field.

Harvest and storage; this exercise is conducted just before the harvest, and leads farmers to discuss and prepare for harvest, threshing and storage of the various plots and individually selected plants. By the end of this session farmers will be able prevent admixtures, use proper tags, bags and to store seed for next season planting.

Genotype environment analysis; during the selection rounds, farmers should be aware of interactions between genotype and environment. This is a refresher session for farmers: farmers will design their own set of genotypic criteria to collect from the field, as well as environmental aspects, and analyse possible interactions. See further suggestions in chapter 4.

Wrap-up meeting / Farmer Field Day; by the end of the season, farmers should enjoy a final session of evaluation and planning of the next season. Data recorded during the season can be summarised. A Farmer Field Day is organised to let the whole community and dignitaries share the results and progress made during the selection process.

5. Crop breeding: selection methods for cross pollinating crops

Introduction

Cross pollinated crops typically show much more variation within varieties than self-pollinated crops. Farmers traditionally have more options in cross pollinated crops to create variability for crop selection and improvement than in self-pollinated crops. A relatively high rate of out-crossing makes it easier for farmers to manipulate crop variability: some apply clever selection techniques, plant their field near other varieties and/or harvest from field margins to select new types. Keeping the variety true-to-type, however, is also more difficult in cross pollinating crops. The purpose of this activity is to teach farmer the skills of selecting in populations of cross pollinating crops. By the end of this course, farmers should be able to:

- Understand the role of genes in creating homozygous and heterozygous plant types
- Explain the breeding cycle for cross -pollinating crops
- Describe and apply selection in the field by using the selection methods in cross pollinating crops

Many staple and cash crops belong to the group of cross pollinating crops. Few crops are strictly out crossing, most crops are partial cross pollinating and partial self pollinating in which the rate of cross pollination is determined by factors affecting the pollination, such as insects or wind.

Table X: Some typical cross and semi-cross pollinating crops

Cereal crops	Leguminous crops	Vegetable crops	Other crops
Maize	Broad bean	Cabbage	Sunflower
Pearl millet	Pigeon pea	Bitter gourd	Mustard
Rye		Pumpkin	Sesame
		Wax gourd	
		Okra	
		Onion	
		Loofah	
		Cucumber	
		Carrot	

Inbreeding and isolation

Three issues in cross pollinating crops have a profound impact on how to handle crops during selection. Farmers should understand these features before proceeding with selection methods.

Progeny testing; in self pollinating crops, the progeny (or offspring, which is the seed harvested and replanted from a given plant) is exactly the same as the parent plant from which the seed was taken. In cross pollinating crops, plants will largely be pollinated by pollen from plants in the vicinity, depending on the rate of out-crossing. Testing of the progeny of a plant in a cross -pollinating crop only partially reflect the true performance of this plant, for the other part reflects the performance of the plants in the vicinity. Breeders use the terms *testing for combining ability* to point at this effect.

Inbreeding; occurs when cross pollinated plants are (forced to) self pollinate, or similarly happen when a population is re-produced from a few plants only. Inbreeding in cross-pollinated crops leads to a decline in vigour and productiveness: plants or fruits may become shorter, malformed, discoloured etc. (compare with humans or animals when two close relatives marry and get children) 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 the vegetable loofah.

Isolation; breeders who wish to preserve a variety or population true-to-type should prevent out-crossing, or in other words isolate the crop from non-desired types. In self pollinating crops, when different lines or plots are planted next to each other like in a variety trial or F2, farmers can still harvest these crops for replanting in the next season. For cross pollinating crops this would not be possible, as the harvested seed will be mixed with the other varieties or lines. Breeders can isolate crops in various ways: in space (distance), in time (different planting time), or physically (bagging, net house).

The key difference is that in the breeding of self pollinated crops the homozygous nature of the plants is stressed. In the breeding of cross pollinated crops the heterozygous nature of the individual plant is stressed. In a field of maize, each plant will contain a mix of both homozygous and heterozygous loci (set of genes), but without the heterozygous loci, the characteristics of the population is not fully expressed.

Breeding cycle
The breeding cycle in cross pollinating crops is less well defined than in self pollinating crops. Usually, breeders work in a series of short cycles of one to three seasons in order to make progress. Increasing variability by making parent crosses is similar to self-pollinating crops, but the use of natural crossing is preferred over hand crossing, as this allows handling of larger populations and retains better vigour and heterozygosis.

Selection methods
The three most commonly used selection methods in the breeding cycle of cross -pollinating crops are:

- *Mass (or bulk) selection*; this method is very close to the farmer's own selection system: individual plants with desirable traits are chosen and the seed harvested from them is bulked to grow the following generation.

- *Plant -to row selection* (ear to row selection); seed of individual plants with desirable traits are grown in individual plots in order to determine their performance. Best performing plots are bulked. When the trait is visible only after pollination, such as planting time to maturity, it is better to bulk retained seed of the original plants, an then to bulk the rows. This process may be repeated in several cycles.

- *Recurrent selection*; individually selected plants are self pollinated (or whole populations are selfed using net houses), while harvested seed is grown in individual rows or plots to determine performance. Best performing plots are allowed to cross in all possible combinations (bulking). This process may be repeated in several cycles. Also use of retained seed is recommended in case of traits that are visible after pollination has taken place.

Like in self-pollinating crops, each method has its advantages and disadvantages, and a combination of methodologies is often used to make best use of the comparative advantages of each selection method. The above selection methods may also be used in variety rehabilitation.

Meta-populations

In small farmer communities, where most PPB takes place, it is virtually impossible to find a plot that can accommodate all the populations for selection and breeding, and equally take care of proper isolation. Breeding of cross pollinating crops in this situation should not attempt to make farmers adapt to the breeder's environments. Rather breeders should adapt to the farmer situation. Hence, the concept of meta-populations for farmer field schools was developed for PPB in cross pollinating crops.

Meta-populations are decentralized field units that are managed by individual farmers or a small group of 4-5 farmers who are responsible for planting, selection, harvest, storage and also for isolation. One population may be handled by one group or a number of farmer groups at the same time, which interact and discuss among each other the breeding goals, selection methods and share the achievements in crop improvement.

Meta-populations can resolve some of the most tricky aspects of PPB at community level:

- Decentralization prevents that all PPB management is shouldered on a few hard working farmers or farmer-facilitators. All farmers work together for the same purpose increasing sustainability of the programme
- Farmer to farmer interaction is stimulated because the equal tasks and competitive elements stimulates interaction; each farmer group is responsible for more or less the same activities
- Successful breeding programmes use a lot of space, a central field is usually not available at community level and also may incur high cost for the community in reimbursing one farmer to the use of his field. Decentralized fields may be just the answer.
- Meta-populations have been described as functional units in maize in a small farmer community in Mexico (see case study 2, chapter 1). It reflects much better the farmer situation.

Meta population are an important aspect of FFS becoming community PPB. Monitoring systems, however, need to be adapted to accommodate PPB based on meta-populations.

Organisation

To be further worked out

Preparation
Germplasm management
Site selection
Materials
Controls
Field lay-out

Topics

Goal setting and observation
Bulk selection method
Simple recurrent selection methods
Isolation and inbreeding
Harvest and storage
Variety rehabilitation – land races
GEnsys

Evaluation and planning

7. Variety Rehabilitation

Introduction

Farming communities sometimes complain of variety deterioration, indicating that a particular variety has lost one or more familiar characteristics ascribed to the original introduced variety. Variety rehabilitation is a methodology that offers to restore the original characteristics of the particular variety. The method is sometimes mentioned synonymous with variety purification; however, on-farm conditions do not allow this term to be entirely valid, as farmers rather focus on the performance of a particular variety and less on uniformity and distinguish-ability, like in modern breeding systems.

For example, many farmers in marginal production areas tend to cultivate land races, which is a mix of different genotypes. Research has indicated that many of these land races, often the result of hundreds of years of farmer selection, may not give maximum yield under all circumstances, but provide output even under the harshest conditions, under which conditions modern varieties cannot produce. Farmers in these environments are risk-avoiding and stable performance is why they prefer local non-uniform varieties.

In other cases, however, uniformity may be desired by farmers, such as in rice and vegetables cultivated primarily for domestic marketing or for the processing industry. A critical level of uniformity is often required because of consumer demand or because it provides higher marketable output.

Many farmers consciously select in their crops, either through roughing or post harvest seed selection. Some farmers are expert in selection and are known in the community to supply quality seed of a particular variety. For modern varieties, farmers often can buy new seed of the same variety from the bazaar or market place to replace their own seed. With domestic market economies growing in importance, both the local and market options supply most of the replacement seed required in the community. Hence, the community may complaint of variety deterioration, but in discussions it is often found that the problem can be frequently resolved by surveying the neighbouring sources, rather than starting a variety rehabilitation activity. However, in certain situations, especially when the community attaches extraordinary high values to a particular traditional variety, rehabilitation may be the only option available to restore the variety.

By the end of this activity, farmers have learned to:

- identify the causes of variety deterioration
- use tools to describe the desired and non desired characteristics
- apply appropriate selection techniques to restore the variety

Organisation

This activity is usually carried out by a group of 4-5 farmers and involves interventions two times during the season. Evaluation of selection results are conducted in seasons following the follow-up activity. For teaching purposes, depending on the farmer interest, it may desirable to arrange for two or three separate groups of 4-5 farmers who will work on one variety each in different fields or different parts of the field. This introduces a sense of group competition, stimulating participants to improve their skills. Farmers should be selected from among people who have successfully completed the Season-Long FFS-PPB.

The traditional variety must be identified during the Season-Long FFS-PPB course. Farmers should have indicated strong preferences of consumers and farmers alike to use and cultivate the variety once it is rehabilitated.

The curriculum typically involves four sessions, spread over two planting seasons:

- preparation meeting
- mid season selection
- pre or post harvest selection
- observation of results in 2nd/3rd season

Preparation

For this activity to succeed a number of preparations are required:

- Prior to planting one of the facilitators should discuss with farmers how to conduct the activity

- Farmers should choose the 'best' seed lot of the variety available in the community, meaning that which is considered the least 'deteriorated' or providing the best option for selection. In case of doubt, two or three seed lots or fields should be planted.

- Selection of study field should be done 2-3 weeks before planting and preferably located not too far from the village location. Size of the study field should not exceed 2000 m2, but this may depend on the type of crop.

- Field preparation should be done 2-3 weeks before direct sowing or transplanting. To enable individual plant selection, seeds or seedlings should be planted one plants per hill. Management of the field should be in accordance with normal practice.

- Materials for training should be listed and bought before training like field signs and labels, fertilizers, field markers, writing and paper materials.

Field studies

Tools used in this activity are primarily field based. Details are found in part II.

Village transect walk; this exercise is meant to start discussion on the various causes of variety deterioration. Farmers walk trough different standing fields or to various places where seed or material is dried or stored and identify factors that might cause deterioration: admixture, cross pollination, birds, mutation etc.

Variety characterisation; it is important that the positive and negative characteristics of the variety are described, to subsequently describe the desired traits. Use same tools as described in the baseline survey.

Selection methods; Farmers with facilitators review the appropriate selection methods and apply these in the field using tags to identify desired genotypes. Selection methods vary depending on the type of crop. Methods described in paragraph 3 and 4 of this chapter can be used.
Harvest and storage; farmers will discuss, prepare and practice harvest and storage of seed or propagated material for planting in the next season. Handling of this material depends on the crop and type of selection method. This session can also be used for planning the next planting season.

Evaluation

Farmers can measure the selection progress during the 2nd or 3rd season after harvest of the study field. Evaluation of the plot usually takes place by visual observation. However, farmers may decide to do a more rigorous evaluation by counting both the study field and the progenies:

- No of off-type plants
- No of plants with identified negative characteristics
- No. of plants with identified positive characteristics

See further questions for discussion of variety rehabilitation with farmer participants.

Note on selection in landraces

Rehabilitation of a landrace may occasionally result in a higher yield or better performance, especially in more favourable conditions, but probably will not result in higher stability in yield or performance. Therefore, it must be handled with care. Usually, this is done only in collaboration with a researcher. When farmers identify a traditional cultivar as a single variety, how do we distinguish between a common deteriorated variety and a landrace?

- Firstly, most land races occur today in marginal production areas, classified by stress conditions such as semi arid, rain-fed, or saline growth conditions, varying altitudes, and cultivated in areas that have not been touched by modern varieties.

- Secondly, we may determine landraces by using the ear to row method and compare the progeny of a large number of individual plants. As landraces consist of many different homogenous lines, data recorded from these progenies should indicate at various classes of varieties.

Landraces may offer potential for crop improvement by direct ear to row selection in the field. Some researchers have been able to separate individual lines of landrace and then re-combine the best performing lines to re-supply the seed to the local farming community. This would be a perfect platform for collaboration between researchers and farmers, as researchers could assist in the separation of lines, while farmers could be helpful in identifying the valued traits and recombination to produce the improved landrace.

The role of farmer facilitators is not only important for the development of FFS-PPB programmes in their own communities, which tend to extend over several years, but also for the initiation of farmer-to farmer FFS. Farmer-to farmer FFS have been one of the key elements in the development of FFS-IPM over large areas.

Basically, farmer to farmer FFS-PPB can be implemented in the same way as other FFS-PPB, except that the FFS is entirely managed by farmers, although senior facilitators provide technical backstopping. The other advantage is that cost and funding of such FFS will most likely be less due to lower travel and honorarium cost required by the trainers, providing for better efficiency.

Experiences in formal-led and farmer-led PPB have to be further developed and adapted to fit the Farmer Field School approach, which means focuses on the farmers' creativity and experimentation, the use of indigenous know-how, and on providing farmers skills in making own decisions, rather than teaching just a package of technology and know-how. Follow up activities need to be worked out like on: farmer-to farmer seed systems and on farmer organisation and advocacy. Much creativity and experience is needed also in developing innovative approaches in PPB such as meta-populations: applying selection methods in cross pollinating crops. FFS approaches need to be developed for other crops as well, such as for cereals other than rice, different types of vegetables and leguminous crops. Emphasize need to be made on providing short term benefits to farmers in terms of improvement of household economies or preferences, while preserving the genetic diversity in the long term.

Forums held at the village, district or regional level enable farmers to interact and discuss various issues related to PPB. Farmers belonging to neighbouring communities can meet to share the results of their field studies, or keep each other informed on developments following the season-long FFS-PPB. If farmers are organizing new FFS-PPB, they can share plans and ideas. Initially these meetings may be held in conjunction with follow-up training courses, however, over time these may be self organized. This will increase the ownership of the rural communities contributing to the promotion of sustainable rural livelihoods.

1. Political and policy support

A lot of research on formal-led and farmer-led approaches on PPB is taking place worldwide, especially in developing countries. Ironically, most of this research is conducted by or through international institutions, but few by the countries' national research institutions. This is remarkable because these institutions might benefit most of this development. An increasing number of countries have actively supported approaches to in-situ management of crop genetic diversity as an alternative to ex-situ conservation and conventional plant breeding. This is a recent development; as such the countries would need time to review their policies. Institutionalization of PPB therefore is imminent and probably just a matter of time.

There is a need for some institutional changes within research institutes to enable researchers to effectively participate in PPB activities.

- Germplasm held at research stations should become easier accessible for farmers; this applies to collected germplasm held at genebanks, pre-breeding material as well as F2, F4 and F6 material. Without necessary backing of the research institutes, farmers will be able to get only access to redundant material. It would be better if breeders would be active in developing material especially for selection on-farm, particularly since breeding for local adaptation is markedly different from conventional breeding strategies for broad adaptation. Some breeders, mainly of international institutes, have already started programmes to establish pre-breeding programmes containing populations with a core set of available genetic diversity, and make this available for farmers to select. Others have supplied F2, F4 or F6 populations.

- National seed laws and laws on intellectual property rights (breeder rights) must be reviewed on aspects that are counter productive to PPB. For example, some national seed laws may contain restrictions to the functioning of informal seed systems, which would limit farmers access to local germplasm, and diffusion of farmer varieties to other communities. Quarantine policies may restrict access to foreign germplasm. Similarly, intellectual property rights may prevent farmers to use certain protected germplasm material in their breeding programmes.

- Research and development outputs from FFS-PPB must be recognized as product innovations; Researchers cannot be expected to invest time and effort into programmes that do not deliver outputs in the form of scientific publications or released varieties. Without institutional backing, they will do so only for hobby purposes. Farmers who breed varieties use those varieties for their own benefit, but breeders and research institutes provide services and need national or international recognition to sustain them, or sell their produce to recover cost. Institutionalization of PPB would need to include systems whereby cultivars resulting from PPB recognize the institution as source of material. This can be, for example, part of the MOU.

- National policies should recognize PPB as a 'science' discipline, functioning as part of the national breeding programme, in parallel to other disciplines. The science of PPB extends beyond plant breeding. Research will need more experts with various background such as sociologists, economists, and anthropologists, in recognition of the fact that development also has a human side. Breeding therefore becomes more holistic. In particular there is a need for research institutes to explore, develop, test and improve protocols of partnerships with farmers; develop new research tools for farmers' use; adjust scientific and technological systems to farmers' capacities; review plant breeding strategies as they serve the needs of small farmers.

Institutionalisation of the FFS-PPB approach will not replace conventional breeding but will initiate and establish new programmes to enable those farmers who have been previously not reached by formal breeding efforts, to make better use of available genetic resources and improve their livelihood.

4. Monitoring and Evaluation

The purpose of monitoring and evaluation is to provide the leaders of activities with information that they need for making necessary decisions. Most of the evaluations these days are conducted in a participatory way, where gathered information is used for learning purposes and for empowerment of participants. Evaluation should never be used to subdue and control people.

FFS activity level
At the end of an FFS activity the facilitator and participants may want to measure how much they have learned as a result of the training activity. Also, they may evaluate the methodologies applied, the materials and environment, and the role of the facilitators and participants in the learning process. Evaluation in the FFS is a continuous participatory process, starting with expectation setting and level setting at the beginning of the course (ballot box), followed by weekly planning and evaluation, which process is finished by the end of the course. The purpose of this participatory evaluation is to contribute to empowerment (farmer can be proud their learned capacities) and to learn from the positive and negative experiences during the course for planning of the next activity.

Community level
More important than measuring skills and know-how is to measure impact. In PPB impacts can be measured only after one or two season but usually it takes more time to measure the true impact of a PPB programme. Farmers may improve their basic skills and knowledge, and have followed many different training, but may still not be able to resolve their main problems. Unlike know-how and skills, impacts rather measure tangible benefits, for example the adoption of new varieties and the extent to how these varieties improve the farmer's income. However, PPB can also have an impact on the environment, or on the community organization and self-funding activities, which also should be measured.

Measuring of impact allows leaders to take decisions on necessary actions to make corrections in the programme. Impact evaluation is primarily done in a participatory approach, which enables everyone, facilitators, farmers and community leaders alike to learn. At community level the impact of a PPB programme may be measured and monitored by:

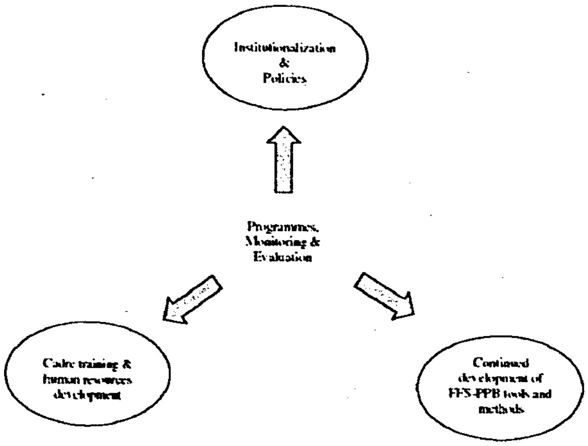
- The rate and area of adoption of new varieties by farmers
- Changes in the range of genetic diversity
- Crop farm-gate price per unit area
- Number of farmers participating in post-FFS (self-financed) activities
- Engagement of farmers in FFS-PPB related forums
- Examples of special 'Success Cases'

Impact measurement can be done annually and preferably carried out during celebrations marking the end of the (main) FFS-PPB season.

National / regional level
Any organisation that intends to develop and implement FFS-PPB for a larger area should also think about evaluation of other elements, such as establishment of institutional linkages, facilitation of necessary policy support, and human resources development.

Development of a cadre of facilitators and support staff is an important element in the development of FFS-PPB. Training of trainers should be conducted to facilitate continued needs of skills and know-how at different levels. Different forums and seminars should be organised and open for facilitators to obtain more exposure. Researchers should actively participate in the TOTs. Impacts may be measure by total number of active FFS-PPB, forums and seminars, and diversity of facilitators

Fig XX. Monitoring aspects at national and regional level



Impacts at the level of institutionalisation and seed policies are more difficult to measure. A good level of understanding is required with regard to the national research framework and established policies for promotion and remuneration of scientists. Also there is expertise needed to understand the working of seed regulatory frameworks and intellectual property rights. Evaluation at this level should be conducted by specialists who have a thorough understanding of the policies involved.

Policy makers should be aware of the potentials of PPB, using farmer forums, and field visits. Relevant policy makers, senior researcher and breeders, as well as senior farmer facilitators should discuss and identify the bottlenecks that inhibit institutionalization of PPB, and subsequently determine indicators (verifiable measures), whereby progress is measured. This type of participatory meetings should be conducted annually to monitor progress.

Fig X: Measuring impact at regional./national level

CHAPTER 8 CONCEPTUAL TOOLS

1. Two Systems of Plant Breeding

For Farmer Field Schools on Participatory Plant Breeding to be truly successful, strategic alliances with researchers at breeding institutes must be made to make optimal use of the comparative advantages of breeding systems existing at farmer level and that at institutional level. Many types of collaboration are possible, some of which have been described in part I.

Acting on these strategic alliances frequently requires a paradigm shift. Traditionally, farmers take part in the breeding process only in the conventional way being evaluators and users of the final varieties. Many breeders and scientists are not aware of the full potential and benefit of on-farm crop breeding, and few thusfar have taken the initiative to build breeding alliances in which farmers have a more pronounced role in crop breeding. Farmers also may be reluctant to cooperate with breeders on a more equal basis and get more involved into breeding and selection, as they may feel indoctrinated and overwhelmed by the terms and methodologies involved, in trial designs and the handling of multiple data, as often required by breeders.

Lack of facilitating policies supporting on-farm approaches often provide major obstacles to developing farmer-breeder alliances, especially policies that regulate research priorities, determine incentives to and provide recognition for breeders, and regulate the flow of money to conduct breeding. In the discussions needed to prepare for FFS-PPB, the participation of all stakeholders are very much needed, not only breeders, researchers, extension workers and farmers, but also policy makers.

The following exercises attempt to address these issues for discussion with stakeholders with diverse backgrounds.

Exercise 1.1: The Farmer's Dream

This tool will be implemented at village level with farmers and uses drawings to explore the historic trend in genetic diversity in the farming community. The exercise will identify how farmers think about genetic diversity management, and how they perceive their involvement in breeding and selection.

Participants are asked to divide in groups of 4-5 people and firstly to prepare two drawings, one that expresses the genetic diversity in their community in the past (20-30 years ago), and another how they perceive it to be now. Subsequently they are asked to make another drawing in which they should present how they perceive it to be in the future. Details should be provided especially with regard to (examples in brackets):

- changes in the village and in the environment (inhabitants, climate)
- the extent of genetic diversity (crops, varieties)
- problems facing genetic diversity (environment, markets)
- tools for managing diversity (storage, small plots, seed banks)

- After completion of the drawings, the different groups should compare and discuss the results

Note: Before starting this exercise it is important that participants are aware of the use and need for genetic diversity by farming communities. Also, it may be necessary to describe the achievements of breeding institution and the way how farmers can benefit from it, both from a conventional point of view through introduction of new varieties, as well as from the point of view in a farmer-breeder alliance in on-farm crop genetic improvement. The facilitator should take time to introduce the subject and verify whether participants have understood the issues concerned.

Exercise 1.2: SWOT analysis of the two breeding systems: de-mystifying the science of breeding

This exercise attempts to identify the strengths and limitations of farmers' management of plant genetic resources, as well as the strengths and weaknesses of the institutional system. By doing so, the participants will realise that the two systems are complimentary in many ways. In the areas where one system is weak, they also identify the areas where the other system is strong. Each plant breeding system thus has comparative advantages and disadvantages. To meet the needs for crop improvement and base broadening, both for subsistence and for intensive and market oriented production, the two systems of plant breeding; the institutional and the farmer community systems, are both needed. The exercises will assist participants in determining what should be done to improve the system and to make optimal use of the comparative advantages of the two breeding systems.

Discussions can be held in two or more groups using table 1. Each group elaborates on what is meant by the breeding components, and then discusses and decides the strengths and weaknesses of the farmer breeding system and the institutional breeding system. 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, on the potential improvements in the farmer's system, and subsequently on how to support and promote the institutional breeding system. Findings should be discussed and compiled in the plenary. A detailed table is printed at the end of this chapter for use by facilitators.

Table 1: SWOT analysis of the two breeding systems

Breeding Component	**Farmer**		**Government/ Institution**		**How to Improve**
	Strength	Weakness	Strength	Weakness	
Conservation					
Breeding objective					
Access to parent materials					
Breeding techniques					
Selection techniques					
Genetic progress					
Varietal trials multi location					
Decision making					

Ownership					

This tool is ideally suited as an introduction and starter for discussion at training sessions, workshops and seminars. The extent of this elaboration may depend on the participating parties.

When conducted with farmers and farmer-trainers, it may be advisable to focus on the participant's experiences with farmer's breeding system only and explain the rest of the table in the plenary. Also facilitators may need to expand more on the terminologies and the breeding components to enable participants to fully understand the discussions. This exercise is ideally conducted during the training or trainers and at the start of the farmer field school, and can be additionally used to identify gaps in knowledge and skills of the participants. Used at FFS level, the exercise is a great empowerment tool and helps in de-mystifying the science of breeding, as it teaches farmers the comparative advantages of farmer breeding over institutional breeding, and how to overcome certain disadvantages in their systems by collaborating with breeders and researchers.

If the meeting is conducted with agricultural extension staff and lower NGO staff, one may leave the discussion after completing the first table or limit the discussion to the question what should be done to support and promote participatory plant breeding in the local farming communities. Particular reference can be made to increasing:

- number of varieties released/adopted
- resistance to pest and disease
- tolerance to specific stress conditions (drought/heat/salinity)
- adaptation to areas with variable environments

However, if policy makers and senior researchers partake in the discussion, one may further attempt to consolidate the discussion, and focus on important short-term and long-term objectives, policy development and resources allocation as outlined in table 2.

Table 2: Facilitating Policies

COMPONENT	**Current situation**	**Desired Situation**	**Short term objective**	**Long-term objective**	**Resources**
Facilitating policies					
Priorities in plant breeding					
Conservation					
Crop focus					
Farmer – Researcher Alliances					
Funding					

2. Principles of Adult Learning

The following two exercises are ideal to start a discussion on the concepts and principles of adult learning. The first exercise elaborates on the process of learning, how adults learn, and what conditions are important for adult learning. The second exercise will assist in defining adult non-formal education and explain some concepts and principles of adult learning.

Exercise 2.1: the process of Learning

Ask participants to think of the most important thing each of them learned outside of school which affected their lives. Write this on paper. Discuss how these lessons were learned by asking these questions:

- How important and decisive was the lesson?
- Who helped you to learn it?
- What was the relationship between you and the person who helped you in the learning?
- What was the situation in which you learned it?
- In what way did you learn it?
- What made the learning easier or more difficult?

Encourage the participants to discuss the questions and their answers and summarise this on poster paper using the table below:

Content/Lesson (What they learned)	Situation (What helped them to learn)	Method (how they learned)	People (Who helped them to learn)
1.			
2.			
3.			
4.			

Encourage the participants to dialogue among each other using the following observations in the discussion:

- Adults have wide experiences but learned most from their peers.
- They learn quickly of relevant things to their lives.
- Adults have a sense of personal dignity
- The power of observation and reasoning grows stronger in adults while memory may weaken

Exercise 2.2: Concepts and Principles of Adult-learning

Arrange nine groups by asking participants to count-off from 1 to 9, and assign each group to discuss one adult learning principle mentioned in the table below. Each small group discuss the principles in 15 to 20 minutes. Outcomes should be presented on paper and reported in the plenary for discussion.

1. Learning is an experience that occurs inside the learner and is activated by the learner
   - Learning is controlled by the learner
   - Changes in perception and behaviour are mere products of human meaning and perceiving, not from forces exerted upon the person
   - It flourishes in a situation in which teaching is seen as a facilitating process that assist people to explore and discover the personal meaning of events for them
   - No one directly teaches anyone anything of significance
   - People learn what they want to learn; they see and hear what they want to see and hear
   - No learning takes place without personal involvement and meaning for the learner.

2. Learning is the discovery of the personal meaning and relevance of ideas
   - People internalize ideas and concepts relevant to their needs and problems
   - Learning needs exploration of ideas in relation to self and community
   - With pragmatic boundaries, what is relevant and meaningful is decided by the learner ad discovered by the learner.

3. Learning and behavioural change is a result of experience
   - People become able when they experience success
   - People become responsible when they assume responsibility
   - People become independent when they experience independent behaviour

4. Learning is a co-operative and collaborative process
   - Co-operative approaches are enabling
   - Peoples' own identities become more defined in collaborative efforts – it induces more creativity
   - It builds human communities and empowers individuals, in particular, together with the empowerment of the community

5. Learning is an evolutionary process
   - Behavioural changes need time/patience, and rapid learning demand structured procedures that will not result in lasting learning;
   - Real learning is characterised by free, open communications, confrontation, acceptance, respect, right to make mistakes, self realization, cooperation and collaboration, ambiguity, freedom from threat, trust and active personal involvement

6. Learning is sometimes painful
   - Behavioural changes calls for giving up the old and comfortable ways of believing, thinking and valuing
   - It is uncomfortable to share one's self and ideas under a microscope of a group, and to genuinely confront people. Pain is necessary, but this is followed by appreciation and pleasure in the discovery of new ideas or in changing one's self

7. One of the richest resources for learning is the learner his/herself
    - Each individual has accumulated experiences, ideas, feelings, and attitudes, which can be a resource for problem solving and learning
    - Learning process must draw these resources

8. The process is both intellectual and emotional
    - When feelings and thoughts are in harmony, learning is maximized
    - Thus, people come first before objectives; nothing is achieved if people are not open, if people are confused, tense and threatened

9. The process of problem solving and learning are highly unique and individual
    - Each one has his/her own style of learning and problem solving
    - We need to assist people to define and make explicitly to themselves the methods they use so they can improve them and to appreciate alternative methods

3. Principals of Farmer Action Research

In a sense, "participatory action research" is the practical application of the principles of "learning cycle". Participatory action research is a universal process engaging the learner in a sequence of activities, as explained in chapter 2. The following exercise will help in discussing the principles of farmer action research.

Exercise 3.1: The Action-Research Process

This exercise is ideally suited for extension workers and breeders who have some previous experience in working with farmers and wish to learn the principles of farmer action research to improve their engagement with farmers. It may be necessary to start with a group dynamics or game (energizer) that will relax and prepare participants to start to critique their earlier work style.

Let small groups discuss and analyze their past research and extension experiences.
Split up in small groups and let them discuss and analyze their past research and extension experiences. Each small group should discuss the following points:

- In your experience with formal survey forms in conducting research, what were the strong and weak responses and attitudes of local farmers?
- Were they enthusiastic, bored, uninterested, did they answer seriously or were they not thinking well about their responses, were discussions encouraged, did farmers enjoyed it or were they running away from it ?
- What was the role of the farmers in the research? Mention the source of information or active collectors of data? Who analyzed the data? Were the results of the research discussed with farmers? If discussed, what were the farmers' reactions? In terms of field researches, who actually conducted the research i.e. who designed, prepared and took care of the research plots?
- How were the different perceptions of individuals and groups handled by the researchers? Were the different socio-cultural, economic and political positions of individuals and groups in the community taken into consideration in the conduct of the research?
- What was the objective of the research? For whose benefit was the research conducted?
- What actions (or projects) resulted from the research? Who decided on the type of the action and the objectives of the action? Who were involved?
- What did the farmers learn from the research? What were the behavioural changes the farmers adopted as results of the lessons learned in the research? What did the researchers learn?

Each small discussion group summarises their discussion outcomes on paper and report to the plenary for sharing and discussion.

Print the 6 principles of participatory action research above on a sheet of paper and summarize the plenary discussion based on these principles by discussing the following points:

- Collective action: Did research led to collective action?

- Data collection and analysis: Were the data collected and analyzed by farmers? How were the data and analysis used? Who was the owner of the research? Were the feelings of farmers considered? How?
- Differences of perceptions and interests and ensuring meaning of the research to farmers: How were the differences of perceptions and interests considered and managed? Did the research process ensure that the research is meaningful to individual farmers (of their needs and interests)? How was this done?
- Individual and collective considerations: Was the process both individual and collective?
- Internal self-examination: Was there a critique or self examination component in the research? Were areas for the improvement of farmers' systems identified and changed?

Ask the trainees to form another set of small groups (or reform the earlier groups). They will discuss and summarize on paper how they will conduct their next research using participatory action research. Findings will again be presented in a plenary session where the earlier summary based on the 6 principles above will be reaffirmed.

Assessing the Strengths and Weaknesses of the Farmers' Breeding Systems

Component	Strengths of farmer's PGR systems	Weakness of farmer's PGR systems
1. Setting up the Breeding Objectives.	- The objectives, as set by farmers, closely respond to farmers' real problems and needs; - The objectives will define the morphological and agronomic traits required by the environmental conditions of the farmers' fields; - The objectives will fit the different micro-ecological conditions (micro-specific adaptation) where the varieties will be cultivated; - Although informal, there exist a process of consultation between farmers.	- The objectives are usually targeted to micro-specific adaptation. While this is a strength (because breeding for micro-specific adaptation serves local communities and increase PGR diversity), it is also a weakness. This is because wide adaptation is also needed even by small local communities (for example a semi arid area may have an unusual very wet year and a drought resistant variety may not be adapted to wet conditions); - The breeding objectives are not set systematically (more subjective and intuitional), difficult to quantify and measure in terms of morphological and agronomic traits (aside from overall performance in yield).
2. Access to PGR diversity as raw materials for plant breeding.	- Access to their own local PGR that are well adapted to the growing conditions and stresses of the communities; - Farmers' know their varieties very well, including its weaknesses and potentials;	- Farmers' access is limited to their own communities, neighbors, to local markets and/or within their own districts. Since farmers have been exchanging their varieties for thousands of years within their districts and neighboring places, it is possible that these varieties MAY not have high genetic potential anymore (considering some events in history that caused serious genetic erosion); - Farmers lack access to very rich genetic resources from other countries in the world; - The foundation for successful and strong plant breeding is the availability of rich diversity as raw materials and local farmers do not have access to these resources.
3. Farmers' breeding	- Low cost. Farmers rely on random	- Farmers system of creating diversity is ineffecient. For

techniques. (breeding in the sense of creating diversity, through cross pollination, to select from).	introgression (exchange of genes through exchange of pollen).	example, farmers encourage cross-pollination by planting self-pollinating crops in close rows (it is hard to know which seeds are products of cross-pollination and searching for possible F1 seeds in the next crop is extremely difficult); - There is no systematic selection of superior parent materials (and ensuring that the parents flower at the same time) - Farmers system is weak in creating a bulk of diverse PGR population as the starting materials to select new varieties; - The progenies of random introgression is difficult to identify and manage..
4. Genetic Progress; the rate in which the process of breeding is creating the new types of plants with the traits that were set as objectives.	- The slow rate of progress ensures that the resulting new variety will be locally adapted.	- The rate of progress is very slow (and because of the faster world we all live in now, it is a significant weakness);
5. Selection Techniques. This is the method by which plant breeders use different types of selection techniques to develop and stabilize new types of plants or varieties.	- Farmers' selection will result to genetically diverse varieties. The reason for this is that farmers generally use the technique of mass selection only. Mass selection is the technique of selecting and combining similar superior types with loose or not very strict criteria of uniformity. The resulting variety are heterogenous, or mix populations; - Compared to few plant breeders, selection by farmers is conducted by many farmers; - Selection is conducted under concrete	- Farmers' technique of mass selection is creates varieties at an evolutionary and slower pace; - Farmers do not use the other effective selection techniques that can create varieties faster, and varieties of different level of uniformity or heterogeneity (pedigree selection, single hill/panicle selection, bulk and semi-bulk selection, negative and positive selection); - It is often said that plant breeding is 90 percent selection, therefore the limited technique of farmers' selection is a major weakness; - Because farmers' objectives are more subjective and intuitive and its morphological and agronomic traits are

	farmers' condition resulting to varieties that are adapted to local conditions.	not clearly defined, selection is also systematically guided;
6. Varietal Evaluation and trials. This is the process of evaluating the adaptability and performance of varieties.	- The evaluation is conducted under real farmers' problems and needs; - The evaluation is conducted under the growing conditions of farmers' farms;	- The evaluation is locally specific; - The evaluation is not systematic and not quantitative (for the traits preferred); - The information of the results of farmers' evaluation is not distributed efficiently.
7. Decision making.	- It is the farmers who decide (breeding objective, evaluation criteria, etc); - Decision making is controlled by farmers based on their appreciation of the traits, and their different preferences will result to greater number of varieties..	- Decision making processes and the basis of the decisions are not systematic; - The morphological and agronomic reasons for the decisions are not clearly defined.
8. Ownership. Ownership of the process and results of the plant breeding work is empowering to those who owns it.	- Farmers own the process and the new varieties; - The collective effort and their tradition of sharing PGR will help ensure that the varieties are shared with other farmers.	- Sometimes, it is difficult to clearly identify the farmer or farmer communities who created the new varieties.

Assessing the Strengths and Weaknesses of the Farmers' Breeding Systems

Component	Strengths of farmer's PGR systems	Weakness of farmer's PGR systems
9. Setting up the Breeding Objectives.	**To be worked out**	
10. Access to PGR diversity as raw materials for plant		

breeding.		
11. Farmers' breeding techniques. (breeding in the sense of creating diversity, through cross pollination, to select from).		-
12. Genetic Progress; the rate in which the process of breeding is creating the new types of plants with the traits that were set as objectives.		
13. Selection Techniques. This is the method by which plant breeders use different types of selection techniques to develop and stabilize new types of plants or varieties.		
14. Varietal Evaluation and trials. This is the process of evaluating the adaptability and performance of varieties.		
15. Decision making.		

16. Ownership. Ownership of the process and results of the plant breeding work is empowering to those who owns it.		

CHAPTER 9 VILLAGE BASELINE SURVEY ON PLANT GENETIC RESOURCES

This chapter describes tools for the conduct of a participatory village baseline survey on plant genetic resources as explained in chapter 4. Many of these methodologies have been developed and tested over a period of time in different cultural and environmental settings in farming communities of Asia and Africa. They may be used as stand-alone tools; however, the tools have been specifically designed in preparation for the conduct of a FFS-PPB in the farming community, especially for goal setting purposes. All participatory tools should be used in a flexible way and be adjusted or omitted depending on time, place and social settings. A short sequence of 2-3 days is usually sufficient for the survey to complete, but 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 weeks.

The purpose of the baseline survey is threefold:

- To increase the level of understanding on 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

Prior to the conduct of the village baseline survey, facilitators must select proper parameters for the selection of target villages, participants and appropriate use of tools to capture the variations in terms of crops, regions, behaviours and climates. Some tools may work in certain cultural setting, but not in others.

The baseline survey uses group dynamics through targeted exercises as the main approach. In addition to group dynamic processes, semi structured interviews of focus groups are conducted with feed-back to the plenary which will fill-in gaps of information collected during the group exercises. Final results of the group work and interviews during each step of the survey may be reported using a simple reporting format. This report also includes an analysis in know-how and skills within the farmer community.

Steps

The village baseline survey involves 6 steps, but less is possible primarily depending on whether only one or more crops are included in the survey. For vegetables, a full set is usually required. Each step involves consultations within the community and may include one or more exercises. Steps involved are:

1. Understand farmer production systems and identify crops that play a role in these systems
2. Identify existing varieties, characterise the performance and preferred/non-non-preferred traits, and assess changes in genetic diversity over time
3. Identify the farmer's breeding goals and describe selection strategies to maintain genetic diversity
4. Analyse the existing seed systems within and between communities
5. Describe the markets and market channels for selected crops and varieties
6. Selection of priority crop(s) for FFS-PPB

1. Identification of crops that play a role in the farmer production systems

Purpose:
- Understanding of the amount of crop genetic diversity at community level,
- Understanding of the use of certain crops and varieties, explaining why farmers plant these crops.
- 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 is especially suited to vegetables, but less so in situations where the community or the programme has already decided on a priority crop for the FFS-PPB.

Part 1.1: crop listings & basic categorization

Time: 2 hours

Groupings of 4-5 participants should list on a paper roll the crops that they plant, use/consume and 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 it 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 plant grown in their community, which facilitates in the determination of crop names and types, as well as help farmers in the listing process, especially those who are illiterate. To save on time, participants may be informed the day before to collect the materials. Display the plant or plant parts on the wall or table for easy reference.

Once completed, facilitators should prepare a final list of unique crop names, to be compiled in the plenary. If names are not familiar, verify names listed with 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 table 1 below.

Table 1. Crop listing and categorisation

Crops	I. Crops multiplied from seed by farmers	II. Crops vegetatively multiplied by farmers	III. Crops never multiplied by farmers / always purchased from outside community	IV. Herbal crops collected from the wild	V. Crop trees and shrubs
1.					

2.					
3.					
4. etc					

* Crops may be listed in more than one column

Part 1.2: Four Square Analysis

Time: 1 hour

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

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

Table 2.

	Large areas	Small areas
Many households	A. List of crops	B. List of crops
Few households	C. List of crops	D. List of crops

Note that 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 they 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 exercise all crops listed in table 1 may be used, but if time is a consideration the exercise can be limited to the crops listed in column I, II and III only. Crops listed in Column IV and V usually will not fit in a PPB/PVS programme because of problems in multiplication or long growth cycle.

Part 1.3: Final prioritisation

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 2. 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 (maximum of 6 crops) for further analysis in the baseline survey. Various criteria for selection may be used, such as: commercial attractiveness, use in kitchen, extend of planted area in the community, emotional aspects etc. A variety of selection methods can be used such as: ballot box, cards with individual preferences, or just plain hands voting etc.

Step 2. Status and trend in genetic diversity

Purpose:
- characterize and classify varieties planted by farmers in the community
- understand why farmer decide to grow particular varieties
- 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 shall determine changes in diversity and preferences over time. Group discussions will be complemented with semi-structured interviews with focus groups to uncover answers to remaining questions.

Part 2.1: Variety listing and characterisation

Time: 2 hours

Groups of 4-5 participants shall focus on one crop. Prior to this exercise participants may be asked to bring as many samples of varieties for identification, description, and discussion of desired traits. Use table 3 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 should score the varieties for characteristic no. 1 by using a ranking score for variety performance of 0 (worst/not desired) to 9 (best/highest desired). 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.

Then ask participants to recall and list up-to three negative characteristics (e.g. hairiness) below the other characteristics. This listing is not mandatory and if they cannot find any such characteristics, they should leave it open. 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 Crop:

Characteristic	Variety 1	Variety 2	Variety 3	Variety 4	Variety 5 etc.
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
Total					

Participants then should prepare the total ranking score and compare the varieties. The groups then can present their results in the plenary. Discuss the results and find out whether the final score matches with the farmer's most popular variety and with the area planted in the community.

For (mainly) illiterate communities, varieties should be identified on a paper roll by a live sample (fruit, seeds etc) or a small drawing, recognized by all group members to represent this particular variety. Similarly, the characteristics should be identified by symbols recognized by all to represent that particular trait. Some of these communities may also have difficulties with the interpretation of the scoring method 0-9. In this case, one may use the individual bean ranking scoring method, which exercise is empowering and often appealing for everyone and goes as follows:

- Each group member is handed 20 beans (or stones).
- Ask him/her to distribute the 20 beans among the varieties, giving the highest number of beans to the variety that scores highest for this 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.

Please 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 .

Part 2.2: Four square analysis

Time: ½ hour

This four square analysis is similar to that in exercise 1, but in spite of crops a categorisation of varieties is made to measure 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 4 below:

Table 4

	Large areas	Small areas
Many households	A. List of varieties	B. List of varieties
Few households	C. List of varieties	D. List of varieties

Identify with the farmers:

- Why some varieties are only grown by a few households (C)
- Why many farmers maintain only small areas for certain varieties (B)
- Why some varieties grown are maintained by only a few households (D)

Also discuss what vegetable varieties are most profitable and why?

Part 2.3: Time line analysis

Time: 2 hours

In this exercise, farmers are set to the task to visually recall the varieties that have been grown by farmers between now and 30 years back. This exercise is crop specific, so if farmers choose to study two or more priority crops, the exercise should be repeated for each crop. One group of 4-5 participants may focus on one crop at a time. Make sure that both young and elder farmers, and male and females are represented in each group. Alternatively, groups of elders and young, 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 that 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 what varieties are grown now, 10 years, 20 years, and 30 years ago. Participants may draw the varieties and/or write the name of the variety in the particular block of time. Groups should 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, groups present their drawings. Discuss the level of genetic diversity for each crop, whether this level is desirable, and what should or can be done to improve diversity.

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

Part 2.4: Semi structured interviews

Time: 1 hour

In semi structured interviews with small groups or key individuals (during lunch of after closing of the day's session) additional questions may be asked to clarify farmer decision to keep certain crops and varieties and general selection systems as well as farming system patterns.

Step 3: Identification and setting of breeding goals

Purpose:

- prioritize desired traits breeding and selection goals
- identify desired breeding and selection goals

In this exercise farmers will focus on the traits that they wish to see in a particular variety and determine and how they would select for these traits in their crops. At the end of this exercise farmers will be able to set their breeding goals for new introductions.
The first part of this exercise is used to prioritize selection criteria and breeding goals, while the second part is used to discuss the farmer's selection strategies. Finally, breeding goals are confirmed.

Part 3.1: Priority setting

Time: 1 hour

Once again present Table 5 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.

It may be advisable before prioritisation takes places to further detail the characteristics using the following broad categories:

1) agronomic characteristics
2) characteristics for taste, texture and appearance
3) cooking and processing characteristics
4) characteristics valued in storage and transportation

It is particularly important to discuss the criteria in detail (e.g. length of fruit, resistance to particular pests, diseases etc.). Ask also for criteria that do not appear in the previous lists or in the current varieties grown.

Groups will present and discuss findings in the plenary and summarize the results.

Part 3.2: Identification of selection strategies

Semi structured interviews with small focus groups or key individuals are a convenient way to ask questions concerning seed selection systems and strategies concerning genetic resources management. Prior to this interview ask the villagers to point out who are the crop seed experts in the community, which should be invited to join the focus group. Refer particularly to:

- type of person/gender engaged in seed selection before and after harvest
- person in household who is responsible and decides on the source and type of variety to plant
- procedure and criteria for selection before and after harvest
- consistency in selection criteria
- application of breeding goals in farmer's selection strategies

Confronted with the findings of this discussion in the plenary, participants may once again confirm the validity of the breeding goals. These breeding goals are an important output as they are used again at the start of the FFS-PPB.

Step 4: Analysis of Seed Systems at Community level

Purpose:

- Understand who maintains genetic diversity in the community
- 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 farmer's capacity to access genetic resources, both within and outside the community, for common and exotic resources. At the end of this exercise farmers will have a better picture of the available sources of seed, which will allow them, in the course of the FFS when this issue is re-discussed- to improve on their seed systems.

Part 4.1: Resources Mapping

Time: 2 hours

Split into groups of 4-5 people and ask each group to draw a circle in the middle which represents their own community and to draw some other circles representing nearby communities. Far away communities that are frequently visited such as major cities may also be identified with a circle. Participants should draw important markings such as buildings, monuments, houses of prominent people and farmer fields on the paper sheet for recognition and 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, name the shops and persons where possible
- where they usually obtain seed material for own planting
- the type of varieties
- the quality of seed material and price level
- sources of exotic material

Groups should present their drawings in the plenary and discuss findings respectively difficulties in the availability of and access to seed resources

A quick alternative method for use as resources mapping is conducted by using table 6 below. This table may be used if time is short and farmers are familiar in using tables and figures. Disadvantage is that considerable details on the sources of seed are lost.

Table 5

Crop	Variety	Source of seed	%	Name of supplier
e.g. eggplant	Variety 1	Internal – self	20%	
	•	Internal – other farmer	40%	
		Outside- seed store (kiosk)	40%	

Part 4.2 : 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 most of the time surveyors will need to visit their shops and retail outlets for interviewing. This provides the added benefit to observe the physical status of the shop, the packaging of the seed and the information thereof. 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 may be feed back to the plenary for discussion on how to improve existing seed systems.

Step 5. Crop Market Analysis

Purpose:

- Understand the extend and dynamics of the market for vegetable crops

To fully understand the dynamics for crop markets this usually necessitates the conduct of a separate survey. However, since markets are important factors in determining genetic diversity, two exercises are included in this survey. At the end of these exercises, participants will have an overview of the existing markets and market channels, and an idea on the importance of crops and varieties for income generation in the community.

Part 5.1: Importance of Market to Income Generation

Time: 1 hour

Ask farmers to indicate how many households (out of total number of households) have planted during the last years any of the selected crops and what proportion of the harvest was meant for consumption, respectively for sale. Use table 6 below for compilation.

Table 6 Crop:

Crop	No of households planted last year	Estimate ha planted in community last year	Estimate production in community last year	% of harvest used for own consumption	% of harvest used for sale to market
1					
2					
3					

It may prove sometimes difficult to compile these figures for the whole community. In this case a simplified compilation can be prepared by asking each participant whether he/she planted the crop last year, how much he planted, and how much of the harvest he used for consumption and for sale to market.

Using the table as a guideline, discuss with the participants the following topics:

- What determines the market demand for selected crops ?
- What factors have played a role in the past to develop the market structure like it is now?
- What factors determine diversity in the community?

Part 5.2: Market Chain Analysis

This exercise can best be conducted with a focus group consisting of key individuals (farmer/trader) using a semi-structured interview. 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 gaps in the market for new types of varieties. Findings of the interview may be fed back to the plenary for discussion.

6. Final Prioritisation and Crop Selection

Purpose:

- Farmers select 1 or 2 crops for the FFS-PPB programme

Time: 1 hour

At the end of this exercise, which usually concludes the baseline survey, farmers should make a priority ranking of the crops that are most suitable for inclusion in the FFS-PPB programme. This exercise is not required in case crops have been pre-selected prior to the survey.

Facilitator should provide a summary of the previous steps and exercises and explain the final selection procedure. Ask participants to make a ranking for each of the priority crops included in this survey. Criteria for selection can be: local popularity, profitability for farmers, and breeding potential. A variety of selection methods can be used such as: ballot box, cards with preferences, or just plain hands voting. Discuss the outcome by focusing on the need for new varieties. Finally agree on the most preferred varieties for the FFS-PPB.

CHAPTER 10 - Season Long FFS Course on Participatory Plant Breeding

Introduction

To be worked out

Common Topics

1. Re-visiting the objectives;

Time: 2 hours

At the beginning of the FFS course, it is necessary to re-visit the goal setting process facilitated during the village baseline survey. This is crucial as the FFS participants may not be the same as the people who participated in the baseline survey. Facilitators can walk the participants again through the goal setting process of the baseline survey, however, the experience is that the FFS will benefit most if the process is re-conducted, in particular:

- Listing of strength and weaknesses of cultivated varieties
- Prioritization of preferred variety characteristics

Before starting with this session, farmers may be asked to collect as many live materials of the cultivated varieties as possible, such as seeds, fruits, and whole plants, to support and guide the discussion, which also may facilitate the ranking process. Results should be compared with those from the baseline survey. Goals have an impact on the way the FFS is conducted, however, they may change over time during the FFS course, as farmers come to realize that other characteristics are more important. Sufficient flexibility should be adhered.

2. Setting observations and scoring methods

Time: 3 hours

This exercise aims to set observations which farmers consider to be important and determine scoring methods that they feel comfortable with.

Essentially this exercise will ensure that the trial observations are linked with the breeding objectives, is carried out at the correct level of farmer skills and understanding, and avoid that the variety trial becomes researcher and information oriented. Collecting too many data and too specific details will only confuse farmers.

The crucial exercise follows immediately upon completion of the goal setting process, and begins with listing of the top-5 breeding objectives. Farmers are then led in small groups to discuss how they will ensure that the varieties are compared in accordance with the breeding objectives, what characteristics should be observed in the field and when, and once observations are set, how they will score between low-performing and high-performing varieties.

Some objectives such as maturity and plant height are easily monitored by measuring respectively the days from planting to harvest, and the plant height in cm. However, observation becomes more complicated when it comes to plant features that are not expressed directly in the field, or are compounded, like pest resistance, fruit texture, taste, and yield.

Farmers usually apply various scoring techniques, ranging from plus/minus, good/neutral/bad to more sophisticated 1-5 or 1-9. The latter scoring may allow for a better analysis, but farmers may not be familiar with handling of data sums and averages. A good definition will help farmers acquiring skills in observations and data analysis.

Sometimes farmers are not ready to discuss this topic in detail. Facilitators may then follow a gradual approach and work from broad observations at the beginning of the FFS towards more detailed observations and scoring when farmers start with data collection in the field.

Some examples are worked out in table X

Goal or Breeding objectives	Observations	Scoring method	Time of observations

Once observations are set, they are compiled and integrated with Gensys.

3 Plant Morphology and Growth Stages

Introduction

Farmers generally know their vegetable crop very well. Indigenous knowledge accumulated over time has lead to particular varieties and crop cultivation techniques that are well adapted to the specific growth environment. They generally are eager to learn and improve their crop management practices.

Science has given a lot of information about specific interactions in the agro-ecosystem, such as plant growth, physiology, photosynthesis, and mechanisms on stress resistance, pest and disease resistance and optimal plant types. Supplementing indigenous knowledge and discussing about these topics will assist farmers in better understanding their crops and will provide them guidance in keenly observing characteristics for selection and improvement.

Farmers will easily recognize the aspects of plant morphology and growth stages discussed in this session. This will allow them to get a better understanding of the plant agro-ecosystem and to use this in their variety observations and comparisons.

Objectives

- ✓ To provide an overview of the morphology and growth stages of bitter gourd, angular gourd, and pumpkin
- ✓ To provide a general idea on changes that occur on these vegetable plants at various stages of growth and development

Materials

- Fields with different growth stages and varieties (vegetative phase, flowering phase, fruiting phase). For this exercise, use normal farmer fields or a separately planted plot. Do not use the field studies.
- Newsprint, markers, pens
- Field tools, magnifying glass, scissors, measuring stick

Procedure

1. Split up in three groups and go to the field. Each group is assigned to a distinct crop growth stage.
2. Instruct to collect three specimens of each plant stage and each variety (including root system) by digging up the plants and bring it to the classroom.
3. Ask the groups to observe the plants carefully and note recognizable plant parts and differences between the plant stages and varieties. Prepare drawings of the plants on paper.
4. Groups will present their observations using the drawings. Arrange the drawings on the wall by growth stage and variety.

5. Using the drawings demonstrate the changes that take place in the vegetable plants from seed to maturity. Point out the three main growth phases: vegetative, flowering and fruiting stage, and the various morphological developments that take place in the plant phases.
6. Ask the groups to exchange plants so that each group has all plant stages in front of them. Assign farmers the task to dissect the plants and uncover the flowers and buds and to observe the seed development characteristics from initiation to maturity in the fruits.
7. Facilitate the discussion ensuring that farmers understand the changes in the plant parts, and relate this to cultural yield management and yield potential.

Note for the Facilitator

1. Facilitators can extend this exercise with observations on special topics of interest to the farmers. Small research topics may be worked out by the farmers and features observed and collected throughout the season. This may include such topics like plant density, fertilization, and other genotype x environmental interactions. See further the exercise on GxE interaction.
2. Pictures of the vegetable crops under study are presented in the annex. If needed, these pictures can be enlarged for illustration during the session exercise.

Questions

1. How long does it generally take from emergence to trifoliate leaf stage? And to beginning bloom?
2. How many flowers does a plant generally produce? How many fruits, seeds? Why do not all flowers produce fruits?
3. Can you observe differences between varieties in the number of leaves, root development and flowering?
4. How long or deep is the root system? Can you observe differences between varieties? Does this tell you something about plant growth, and about drought or flood resistance?
5. Is bitter gourd, angular gourd, and pumpkin a self-pollinating or an open pollinating crop? Why?
6. In what stage is the vegetable plant most sensitive to stress such as water shortage or high temperatures?
7. What pests do you commonly observe during the different growth stages?
8. What is the importance of knowing the morphology and growth stages of the cowpea plant?

4. Flower Morphology and Reproduction

The plant reproduction stage is the most critical phase in the breeding process. It is in this stage that the best parent varieties and lines are selected and crossings are made.
Farmers need to understand how the plant manages to reproduce through female parts and male parts development; pollination, pod and seed set, and relate this new acquaintance to cross breeding and selection procedures.
In this session, farmers acquaint themselves with the reproductive characteristics of bitter gourd, angular gourd, wax gourd and pumpkin. This activity is an excellent exercise to prepare for cross breeding.

Objectives

- ✓ To discuss the characteristics of bitter gourd, angular gourd, pumpkin and wax gourd during the reproduction stage
- ✓ To study the respective flower morphology and pollination process

Materials

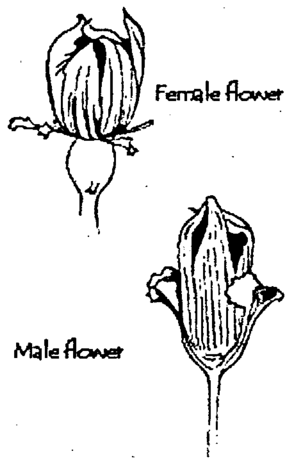
- Vegetable plants in flowering stage, at least 2 weeks after the plant has begun to flower.
- Knife, magnifying glass, forceps, tape, marker pens, counter, notebook, flag sticks, drawing paper

Time: 2-3 hours

Procedure

Flower Morphology

1. The first exercise aims at recognizing the different plant parts involved in the reproduction process.
2. Split up in small groups. Enter a field with a standing crops in flowering stage and ask farmers to observe the flowering stages of the different varieties; in case not all varieties flower, estimate how many days it will take for the varieties to reach the flowering stage, and to produce the first fresh fruit. Note the responses of the varieties down for later reflection.
3. Ask farmers to observe male flowers and female flowers. Note the differences between the flowers by pointing at the presence of stamens in the male flower and the presence of stigma in the female flower. Also point at the "baby pumpkin" (or baby gourd) below the female flower which is clearly lacking with the male flower.
4. Observe the number of stigma lobes (normally 5-6) and
5. Observe the still closed flower buds and ask the farmers whether they can determine which flower buds will open the next morning, and which one not. Mark the flowers with a tag, and ask farmers to return the next morning and to note whether these flowers have opened. Results should be presented in the next FFS session.

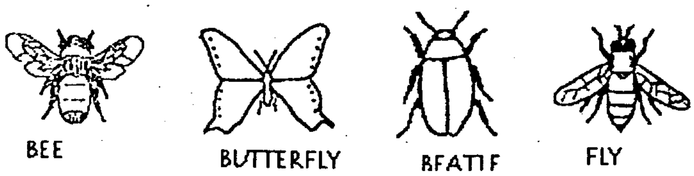


6. Let the farmers randomly select five plants and count the number of female and male buds and flowers on each plant; calculate the female: male rate and the average number of flowers per plant. Ask how many fruits on average a plant will produce. Discuss the imbalance between female and male flowers, and the discrepancy between fruit and flower production.
7. Take a few samples of male and female buds and flowers and put these on water for detailed study in the classroom.
8. Back in the classroom dissect the flowers with forceps and knife, and ask farmer to draw a female and male flower. Using these drawings, explain the flower morphology and fruiting development.
9. Discuss the farmer's estimate on the flowering and fruiting forecasts of the various varieties.

5. Bee Exercise

The next exercise is designed to observe the insects in the field and how they are acting as pollinators between female and male flowers of the same plant and in between plants.

Explain the farmers that each one of them is an "expert" on one specific insect. Split up in groups of four farmers. Show the insect pictures and ask each group member to choose one insect. Thus there are four experts in the group, each for a different insect type.



Then ask each group to choose and mark a small area of the field in which to work. Using a meter stick, place four of the coloured stake flags in a 1 m by 1 m square plot.

Begin by recording environmental information on the data sheet. Be sure to include date, time, temperature and weather conditions. Once the preliminary environmental information is complete, farmers are ready to count their insects within the plot.

Each farmer in the group has the task to count the number of "his/her" insect landings on a flower in the delineated plot during a stretch period of 10 minutes. The procedure goes as follows:

1. The facilitator announces to start; the counting can begin.
2. Farmers observe carefully; every time "his/her" insect enters the plot and lands on a flower, pollinating it, the farmer make a tick in his notebook. If an insect pollinator leaves the plot and comes back, he will count it again.
3. Each farmer tracks another type of insect. He will keep focus on the plot, and not on external animal movements (tracking insects can be very difficult).
4. Farmers stop counting when the facilitator announces that the 10 minutes are over.

After each 10 minute observation plot trial, the farmer observers report their data to the facilitator and move to another marked observation plot. Here, the group will again complete the environmental data sheet and begin with another round of 10 minute observations. Continue until the groups have completed all trial plots. Farmers should use the following form:

Sample Score Table

Group: Date:	Time: ____________________ Temperature:____________________ Weather Condition: ____________________

7. What is the average number of flowers per plant? What is the average number of seeds per flower or fruit? Potentially how many seeds one plant can produce? Do you think this is realistic? Explain how and why seed set is reduced?
8. Do you think insects play a major role in the reproduction process? What factors will influence the role of insects in the pollination? How can we prevent or promote insect pollination? Does pesticide spraying influence the pollination process?
9. Why does wind not play a major role in the pollination process of these vegetable crops?
10. Considering the reproduction process, gourds are cross pollinating plants. Can you mention other plants with similar reproduction mechanisms? What makes gourds different from e.g. rice? Can you identify other plants that are self pollinating? Explain and discuss the implications?
11. Discuss the farmer's selection practices. Are there farmers who mix varieties on purpose in small quantities to improve their original variety? Is this process successful?
12. How can we improve the introduction of preferred characteristics in a local variety? Discuss the various options.