Sorghum

Pearl millet

Finger millet

Little millet

Foxtail millet

Barnyard millet

Proso millet

Kodo millet

Handbook on Participatory Varietal Selection (PVS)

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Handbook on Participatory Varietal Selection (PVS)

Contents:

APPROACHES TO CROP IMPROVEMENT IN MILLETS

Crop improvement or plant breeding is the art and science of changing the traits of plants to produce desired characteristics. The basic methods of crop improvement are domestication, introduction, hybridization, and selection. Plant breeding is an applied, multidisciplinary science based on the application of genetic principles and practices for the development of cultivars more suited to the needs of people. It uses knowledge from agronomy, botany, genetics, cytogenetics, molecular genetics, physiology, pathology, entomology, biochemistry, bioinformatics, and statistics (Schlegel, 2003). In the beginning, plant breeding was more of an art than science; now it is not just science, but technology too. As a science, plant breeding started soon after the rediscovery of Mendel Laws at the beginning of the 20th century. Before that, farmers had done plant improvement for several thousand years. After domesticating the crops, which give food, feed, medicines, textiles, etc., today, they have continued to modify them and move them from continent to continent, adapting them to new climates, new cultural practices, and new uses. There is evidence that hybridization also started before 1900 (Strampelli, 1944).

For centuries, crop improvement was in the domain of farmers. They were responsible for creating rich crops and varietal diversity. Their selection process was unique as it involved both farmers' perspective as well as natural influences, which operated over a long period in their habitat. The varieties so evolved adapted to the specific sites resulting in increased varietal diversity. The traditional knowledge and skills of the local farmers in maintaining crop and varietal diversity also enriched over the years. One can assume that the genetic makeup of such varieties was never fixed in time and space but remained ever-changing through evolutionary forces. In that sense, plant breeding by farmers was a part of co-evolution of different biological systems that formed important component of a particular ecosystem.

Later, with the advent of crop improvement as a science by public and private research organizations in the last two centuries, large-scale changes happened related to plant breeding. Besides natural variation- it was possible to create new variation artificially through hybridization and mutation. Simultaneously, advanced selection procedures and tools were also developed. These mechanisms helped to hasten crop improvement processes. With the advancement of scientific knowledge in molecular genetics now scientists can manipulate genetic systems through biotechnological tools in any manner they can think. Thus, plant breeding has remained a progressive science, with continued success in developing and

deploying new cultivars across the world. This conventional plant breeding (CPB) approach was successful in increasing productivity and production of major food and commercial crops, heralding the green revolution. On average, around 50% of productivity increases can be attributed to genetic improvement (Fehr, 1984). With these changes, crop improvement moved from the domain of farmers to the domain of public and private organizations.

But, over time, the cracks in the conventional approach of plant breeding became visible. It failed to make a significant impact in vast farming areas characterized by diversity in soil, weather, crops, local farmers' needs, and farming practices. Much of the progress made in varietal improvement through conventional approach is limited to a few major crops. Most of the modern varieties are bred under controlled conditions (on research farms) to suit favorable growing situations. The varieties developed may not be suitable for target production areas, because of the existence of large Genotype X Environment (GxE) interactions (i.e. differences) among the performances of the breeding materials in different environments. GxE led to large differences in the performance of these materials between research stations (the selection environment) and the field of poor farmers or the marginal areas (the target environment).

Further, the improved varieties are developed mostly based on breeder's perspective and not much attention is given about the specific needs of the farmers in the target production areas, especially during early phases of selection process. The varieties are tested only at final stages before their release on the farmers' fields for their suitability. Once an improved variety is released with recommendation for a specific production area (at zone or state or national level), easy access to quality seeds of such varieties is also ensured through formal seed chain to ensure large scale cultivation. Such a move replaces gradually the existing traditional as well as popular varieties of that region, making it more vulnerable in future due to reduction in varietal diversity. In addition, there is little scope for effecting changes in genetic makeup of such varieties to suit local situations because of high genetic purity and seed replacement on a regular basis. So, in the absence of inbuilt mechanisms to adjust with the changing surroundings, most of the introduced varieties lose their existence after some years.

The main deficiencies of conventional plant breeding according to Ceccarelli, 2012 are,

1.   Plant breeding has not been successful in marginal environments and for poor farmers.

2.   It still takes a long time (about 15 years) to develop and release a new variety in developing countries.

3.   Farmers adopt only a few of the officially released varieties.

4.   Even when new varieties are acceptable to farmers, their seeds are either not available or too expensive.

5.   There is a widespread perception of a decrease in biodiversity associated with conventional plant breeding programs.

Despite these issues, the conventional approach remains the main domain of public and private research organizations at national, regional, and global levels. These issues gave impetus to think about participatory approach for crop improvement. The term "Participatory crop improvement (PCI)" became established in the 1990s, as several projects were undertaken under this banner (Vernooy, 2003). PCI emerged especially as a response to alarming loss of traditional varieties in farmers' fields and growing marginalization of farmers in crop improvement and agriculture development (Searice, 2007).

Participatory approach helps in integrating farmers' expertise, their indigenous technical knowledge, ecology and growing environment of the local varieties synergistically with appropriate scientific skill and knowledge (Arunachalam, 2007). By involving the farmers in the various stages of selection process through on-farm trials in the target production areas, the participatory approach aims to strengthen the dynamic farmer system of co-evolving and co-adapting varieties to the changing environment. PCI need not be considered as the alternate method to the conventional approach of crop improvement. Both can complement each other. An integration of formal and traditional knowledge can develop a relevant solution to the diverse farming situations the farmer encounters in shortest period. Among the various crop improvement activities taken up under the broad umbrella of PCI, participatory varietal selection (PVS) is one (Joshi and Witcombe, 1996).

Box 1: Stages in plant breeding program

In all breeding programs, it is possible to identify three main stages (Schnell, 1982; Ceccarelli, 2009):

1. **Generating genetic variability:** This includes making crosses (selection of parents and crossing techniques), inducing mutation, and introducing exotic germplasm.

2. **Selection:** This involves selection of the best genetic material within the genetic variability created in the first stage. In self-pollinated crops, this primarily involves implementing various breeding methods, such as classical pedigree, bulk pedigree, backcross, recurrent selection, or the F2 progeny method. In self-pollinated tree crops, this includes progressive evaluation of individual plants. In cross-pollinated crops, synthetic varieties, composites, open pollinated varieties and hybrids are used, and in vegetatively propagated crops, there are clones and hybrids. Marker assisted selection could also be used in this stage for early generation selection of target traits.

3. **Testing of breeding lines:** This includes comparisons between existing cultivars and the breeding lines emerging from trials, and the appropriate methodologies to conduct such comparisons. These comparisons take place partly on-station (on-station trials) and partly in farmers' fields (on-farm trials).

Introduction to Participatory Varietal Selection

What is Participatory Varietal Selection?

Participatory Varietal (or Variety) Selection is a selection among fixed lines by farmers under target environment.

> **Box 2: Difference between Adaptive research trials (ART) done before release of varieties and Participatory varietal selection (PVS)**
>
> PVS differs from ART in several ways such as
>
> a) Only farmer management is used (no package),
> b) Farmers' opinions about varieties, being tested are systematically collected,
> c) Environmental replication is extensive,
> d) Released, pre-release and proven local varieties are included and
> e) Trials are taken up in three stages.

Fixed lines are varieties that do not segregate in the next generation and have stable characteristics (i.e.) finished or nearly finished varieties. Target environment here means the farmers' fields. It is a simple way for breeders and agronomists to learn which varieties perform well on-farm and preferred by farmers. It is both a research and extension method.

Different practitioners view the role of PVS in crop improvement differently (see Box 1 on stages in plant breeding program). Ceccarelli (2012) stated that PVS is always an integral part of Participatory Plant Breeding (PPB), representing it in final stages; but it can also be a standalone intervention in an otherwise non-participatory breeding program. Abay and Bjornstad (2008) and DeBoef et al (2010) opined that PVS could even be used to identify local varieties that perform well in the target environment. In this manual, PVS is considered a starting point for crop improvement in a site and involves selection among the promising traditional, released and pre-release varieties by the farmers in the site.

Why Participatory Varietal Selection?

- The basic premise behind PVS is that there are heterogeneous crop environments that require specific efforts for varietal selection than centralized breeding efforts. Further, breeders may not be aware of some of the important traits that are needed or preferred by farmers, and varieties selected on research stations may not perform well under farmer management. PVS

- helps overcome these issues.

- PVS is a more rapid and cost-effective approach in identifying farmer-preferred cultivars than conventional approach, provided a suitable choice of cultivars exists (Yadavendra and Witcombe, 2007).

- Involving farmers in the varietal selection process increases the chances of adoption of these varieties. So PVS can be considered as a step in the formal breeding process.

- PVS can be organically linked to community-based seed production (Ceccarelli et al., 2009). This ensures access to good quality seeds of the most preferred varieties by a large number of farmers within a short time.

- Many of the traditional varieties, which have evolved over a long period as a response to the local environment, have vanished in the last two decades and the process is still going on. Farmers are losing various cultivars, which are of value to them. For many contemporary issues and needs faced by farmers, including climate change related issues, the solution could be adoption of well-adapted, well-performing traditional varieties. Therefore, it is important to evaluate the traditional varieties for their suitability for current and emerging problems. PVS offers such a possibility.

- In essence, PVS helps in identifying additional farmer-preferred varieties (FPVs) in each site, which in turn increases the varietal diversity and productivity realized. This is important in the context of the fast decline of varietal diversity, deskilling of farmers, increasing vulnerability due to climate change, and increasing nutrition insecurity. PVS in combination with on-farm conservation and seed system development at the local level is expected to increase the resilience of small and marginal farmers in the long run.

Different stages in PVS

A successful participatory varietal selection program has four phases:

1.   Participatory evaluation to identify farmers' needs in a cultivar

2.   A search for suitable material to test with farmers

3.   Experimentation on acceptability of suitable material on farmers' fields and

4.   Wider dissemination of farmer-preferred cultivars

Participatory evaluation to identify farmers' needs in a cultivar

It is important to understand the requirements of farmers in a site related to the varieties of a particular crop for initiating varietal selection and to set breeding goals. This is done through

various participatory methods like

i) focus group discussion (FGD),

i) voting for preferred traits separately by each gender

iii) matrix ranking. Consumer/market survey can also be taken up.

The traits preferred by the farmers identified through these methods need to be considered at different phases of PVS cycle for varietal selection process. The data collected will vary depending on the familiarity of the research team with cropping situation in the site. The field research team should equip themselves to conduct these methods of inquiry and prepare necessary checklist or guidance sheet beforehand.

A search for suitable material to test with farmers

Once the requirements of farmers in the particular region are understood, search for suitable varieties from various sources needs to be taken up. The possible sources are,

a. National list of released varieties

b. District/ agro-climatic zone level recommended varieties

c. Biodiversity fair

d. Community seed bank

e. Varieties documented by Community biodiversity register

f. Local varieties performing well in the nearby areas falling in similar agro-climatic situations

g. Seed available at markets

h. Network of breeders

i. International/national gene bank

Experimentation on acceptability of suitable material on farmers' fields

Once potential cultivars that meet the requirements of farmers in a particular site are chosen from various sources, they need to be tested on the farmers' fields for their suitability to meet the requirements of farmers and to understand their acceptability by the farmers. For this purpose, three kinds of PVS trials are conducted. They are,

1. Mother trials

2. Baby trials

3. Informal research and development (IRD)

Further, post-harvest studies can also be conducted as part of PVS and they include,

1. Organoleptic tests for food crops

2. Analysis of other quality traits like nutrition analysis

More details and illustrations of the different trials carried out for testing the short-listed varieties in the farmers' fields are furnished in the next sections.

Wider dissemination of farmer-preferred cultivars

After identifying farmer-preferred varieties in the earlier steps, they need to be disseminated to a large number of farmers in the selected site. Seed packets are distributed, and community-based seed production (CBSP) is done for further dissemination of the preferred varieties.

PVS Trials: Mother/Baby/IRD

Mother trial

Replicated Vs Unreplicated mother trials

Mother trial is the first stage of the PVS that is laid out either in a replicated design if resources permit or in an unreplicated design. It is planted and harvested under the supervision of researchers in farmers' fields using improved crop management practices. The mother trials are usually located close to the research station or on-farm centrally in a village. It is recommended to have a minimum of 3 to 4 replicated mother trials (villages) at a site for consistent and credible results. The experimental design commonly used in a replicated mother trial is the randomized complete block design (RCBD).

A set of new lines, either released or pre-release, are compared with local checks. Yield and other important agronomic traits are measured. On the other hand, unreplicated mother trials across many locations allow sampling of wider variations and improve the precision of cultivar means. There needs to be a minimum of 25 representative villages in each testing site for the mother trials, to get at least 15 trials meeting the expected standards with reliable data. This number is applicable for trials taken in rainfed conditions where the control over the crop performance is limited and where the heterogeneity of site villages in terms of slope, soil, altitude, etc. is greater. If the heterogeneity is less and if the crops are growing in an assured situation, the number of trials can be reduced to 15. Thus, an adequate number of trials should be planned to account for GxE and to allow for trial failures (Box 3).

Box 3: Minimum number of quality trials needed for statistical analysis

The number of trials is determined based on two criteria. One is the extent of diversity in the experimentation site in terms of soil, microclimate, socio-economic classes, etc. If the diversity is more, then the number of trials will be more to cover all the diverse environments. The other is "error degrees of freedom", which is the product of "number of replications or trials minus one" and "number of treatments or varieties minus one". The minimum error degrees of freedom should be 12 and above for statistical precision. For example, if there are five varieties to be tested and if the number of trials is 10, then the error degrees of freedom is equal to (5-1) X (10-1) = 36. **However, there must be a minimum of two replications even if the varieties are 13 or more.**

Selection of hamlets/villages/sites/communities

It is important to capture the performance of the test varieties under various agro-ecological situations (like soil type, land quality, and altitude) and socio-economic conditions (like caste) in the research site. Therefore, it is essential to distribute the mother trials based on diversity of agro- ecological and socio-economic conditions within the village. For making this possible the number of hamlets (a smaller region of a village) selected in one big village (revenue village/ Panchayat in India), must be two and above. These hamlets need to be located far away and different from one another in terms of soil type, land quality, altitude, and social group (caste).

Give preference for the hamlets, where the implementing agency has good quality farmers' organizations, and the site staff has considerable influence. A minimum of two and a maximum of three trials need to be planned in one hamlet to avoid complete collapse of PVS in one hamlet due to uncontrollable factors like poor rainfall and to optimize human resources. If there is a difference across the hamlet in terms of soil type, altitude and social group (caste), representative farms that are different from one another need to be selected **(Table 1a, b)**.

Choice of Varieties

Only 8-10 varieties need to be included in one mother trial for ease and precision. One of them will be the common variety of the locality/usually grown by the farmers (standard check). Groups of farmers are invited to visit the trials to rate the varieties using some simple techniques like matrix ranking and preference analysis (PA). Based on the data and information collected, the varieties suitable for the experimented area are identified and taken forward to the baby trial.

Choice of farmers
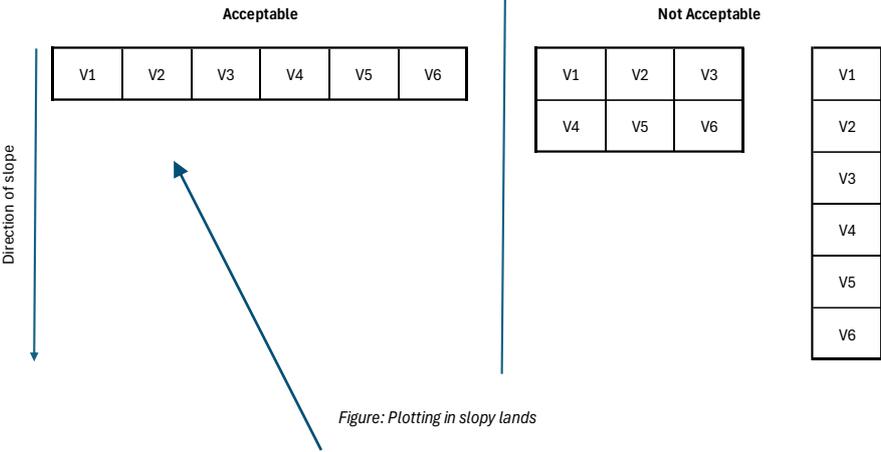
   i.   Select farmers who are willing to take up experimentation on their farm.
  ii.   Select an equal number of men and women farmers or ensure that at least **33 percent** of the farmers selected are women. Take extra efforts to get the viewpoints of women in all stages of the mother trial.
 iii.   Select farmers from all landholding size categories, with more of them from small and marginal farmers.
  iv.   Give preference to the members of farmers' groups/ organizations and SHGs.
   v.   Give preference to the farmers with whom the site staff have a good relationship and influence.

vi.   List the potential farmers and visit them to know their interests and to motivate them. Add their names after getting their consent to the final list.

vii. Give orientation to the selected farmers on the purpose of the mother trial, its various steps, and the role of a trial farmer and the research agency. Share the details about cost-sharing arrangements or incentives, if any, in advance.

viii. There is no need to change farmers and hamlets over the years. Continuing the trials with the same farmers will make the trials easier to run, as the trial farmers involved will have gained clarity and skills.

Selection of field plots

1. Do not select plots with shade.

2. Do not select plots that can be affected by soil erosion.

3. Select plots that can be accessible with moderate efforts.

4. The plot size of each variety tested needs to be one cent (40 sq. m), and the minimum area required for the trial would be around 320-400 sq. m (for 8-10 test entries). If only smaller plots must be selected, reduce the plot size accordingly.

5. There should be a clear demarcation between the plots of different varieties. At least a 0.5m gap between adjacent plots needs to be ensured. If possible, grow intercrop between two plots.

6. The field layout for the trial should be in such a way that all the tested varieties receive uniform soil and fertility conditions. In a slopy land, the alignment of plots must be across the slope (Figure 1) and each block should accommodate all the treatments.

7. Leveled lands need to be selected at least for some of the trials. For the rest, representative land types can be selected.

8. Select the experimental plot with the help of the experimenting farmer.

Figure 1: Alignment of plots for an experiment

Acceptable

| V1 | V2 | V3 | V4 | V5 | V6 |

Direction of slope

Not Acceptable

| V1 | V2 | V3 |
| V4 | V5 | V6 |

| V1 |
| V2 |
| V3 |
| V4 |
| V5 |
| V6 |

Figure: Plotting in slopy lands

Any differences in varieties caused by the slope will be associated with blocks. We control for the slope.

Table 1a: Details of the research station conducting the trials

Site Name	Latitude/ Longitude	Ecosystem (Rainfed/Irrigated)	Crop Area	Soil	Villages that can produce high impact	Accessibility to the research station (kms)	No. of farmers per village	Presence of NGO
1					1			
2					2			
3					3			

Table 1b: Format for hamlet-wise/village-wise planning of mother trial in a site

Name of the village	Name of the hamlet (smaller portion of the village)	Trial (Mother / Baby)	District name	Crop Area	Area under irrigation	Soil	Max/Min temp	Rainfall	Abiotic stress	Other problems	No. of farmers	
											Male	Female
1												
2												
3												

Box 4: Guidelines for layout of field experiments

In most of the cases, farmers' field poses different kinds of hurdles for systematic layout of field experiments. Finding an ideal field with proper levelling, free from shade from border trees, having definite shape and with easy accessibility is not that simple. Since the object of on-farm trial is to have the experiments in farmers' fields, some guidelines are necessary to meet minimum requirements of field experiment principles. Uniform conditions need to be maintained in all experimental plots to avoid the effects of other possible sources, except the effect of treatments. This includes slope, shade, variation in soil depth and hardpans beneath the soil surface, which affect the treatments differently contributing too much to the total effect of unknown causes. Follow the steps given below to ensure near uniform conditions in all the plots.

Step 1: Survey the field; check its boundaries and direction of slope; decide the appropriate location for the trial within the field, which is free from border and shade effects. The experimental field as far as possible need to be located at one end of the field, so the farmer can utilize the rest of the area without any hindrance.

Step 2: Fix the line rope along the length of the field and this line is considered as baseline. Then fix adjacent borderline perpendicular to the baseline using measuring tape. Check to maintain right angle at the juncture.

Step 3: Keep pegs at all corners of the plots for demarcation and maintain till the harvest of the crop.

Procurement and packeting of seeds

1. Calculate the seed quantity required based on the seed rate with respect to the site. For example, if the prevailing seed rate for finger millet is 10 kg per hectare (10000 sq.m.), then the seed rate for one plot (40 sq.m.) is 0.04 kg or 40g.
2. Take necessary care to procure good quality seeds of the selected varieties in time and store them properly.
3. Packeting and labelling of the seeds should be done in advance.
4. Procure the pegs and label them in advance.

Preparing seed packets and name pegs

Pack the needed quantity of seeds of each variety in small plastic covers with name labels inside.

Arrange the seed packets of the varieties of each set in the order specified in the set. Then number

each packet in such a way that the name of the variety, the replication number and the variety sequence number [E.g. Sittan samai (name of the variety), I (for replication), 3 (for variety sequence number in the set I)] are clearly visible. Then, place the seed packets of one complete set in a bigger bag, with the name of the set labelled on it. Distribute such a pack with pegs to farmers well before the sowing season (at least 10-15 days before the expected sowing date). Write the variety sequence number on the pegs.

Orienting the farmers

During seed distribution, orient the trial farmer on the mother trial modalities and finalize the layout of the trial plot. This is important for two reasons:

- To make the trial farmer understand mother trial
- To get willingness to offer part of his or her land
- To gain confidence through handing over seeds and pegs
- To avoid last-minute confusion during sowing

Keep in mind that the farmer's priority would be different during sowing season. They will be in a hurry to complete sowing of their primary crop before the soil moisture dries up.

Unreplicated Mother trial: Execution

Varietal sequence- Randomisation

- The sequence of varieties should not be the same in all mother trials, as that will result in certain varieties occupying always favorable positions and certain others in unfavorable positions. For example, the varieties in the border may have favorable or unfavorable conditions when compared with the varieties in the middle of the plot. To avoid this, follow different sequences based on randomization mentioned in the next step.

- First, generate at least five random sets of test varieties. Then list the selected farmers in the order of hamlets in each village/ Panchayat. The varietal sets are allocated to the listed farmers village-wise. The design should be such that the farmers from the same village get different sets. Do not change the allotted set for any reason. Even if one farmer is replaced with another, follow the same set allotted to the earlier farmer.

Sowing of experiments

Repeatedly advise trial farmers to inform the sowing date 3-5 days in advance to the research agency staff, so that they can properly guide the trial farmer during sowing which is crucial. Ensure that the allotted set of varieties is sown in the specified sequence. Complete sowing of all the varieties tested in mother trial on the same day- there should not be any difference in the sowing date across the varieties tested in a trial. It takes more time to demarcate the plot followed by sowing on the same day. Further, on receiving rain, almost all the farmers will attempt to sow simultaneously. Therefore, it is better to layout the field 2-3 days before the probable date of sowing and keep the land ready for sowing.

Monitoring and observation of the trials

Visits by the research staff are necessary

- To monitor crop growth and ensure intercultural operation (maybe twice)
- To measure growth parameters
- To do pre-harvest evaluation
- To measure yield parameters and get feedback from the trial farmer

Involve experts and a group of interested farmers during the visit related to pre-harvest evaluation. Observe the incidence of any insect pest or disease in each variety and note the extent of damage. In case of any prolonged dry spell or waterlogging situation, record the response of each variety to moisture-related stress.

Data collection

Collect the data on the trial in the specified format given in Attachment 1. The data collected for each trial has two components namely,

i) General information – about farmers and trial field

ii) Experimental details – quantitative and qualitative data on trial management and performance of varieties in the trial. The experimental details in mother trial can be divided into five groups:

- Details on entries (varieties tested), field layout and allotment of entries to the plots.

- Details of cultural operations starting from land preparation to harvesting and threshing.
- Observations of the crop stand and performance of crops at various stages, including pest and disease incidence and stress tolerance.
- Growth parameters
- Yield data and feedback from the trial farmer.

Growth parameters are collected in a mother trial to understand the morphological and duration differences between the varieties. Some of these parameters may also help in interpreting the yield data and the preferred traits of farmers. In small millets, the growth parameters collected are: i) plant population, ii) days to 50 % flowering, iii) plant height, iv) number of productive tillers, v) panicle size, vi) grain yield (kg/plot), and vii) straw yield (kg/plot). These parameters may vary from crop to crop. Measure all the other growth parameters during physiological maturity or just before harvesting. Some guidelines for collecting growth parameters are as follows.

1. Days to 50% flowering – Record the number of days from the sowing date when about 50% of plants in a plot show anthesis of the panicle.
2. Plant population – Count the individual plants (not tillers) in a sample plot. Calculate the average value.
3. Plant height (cm), Number of productive tillers per plant, and Panicle size – Collect data from five randomly selected plants or panicles and record the figures in the format. Calculate the average value later.
4. Measure panicle size from the node of the peduncle and not just from the base of the panicle.
5. Grain yield and Straw yield- Calculate the yield per plot.

Preharvest participatory evaluation

A group of interested farmers evaluate the performance of the varieties when the varieties are near maturity or at maturity. Employ one of the following two methods – 1. Matrix ranking 2. Farmers' Preference Analysis (FPA) (Box 5) to consolidate the results.

Box 5: Farmers' Preference Analysis (FPA) in mother trial

FPA is a method to assess rapidly the opinion of a group of farmers on a set of varieties in a trial in a simple way. This is done by allowing the farmers to —vote for their preferred varieties during a field day conducted in one of the best performing mother trials just before harvesting. Conduct at least one FPA for each village or Panchayat, as the preferences varies across Panchayats. Orient the participating farmers about the background of the project/ program, about mother trial, the purpose of the FPA and the steps to be followed. Keep a bag/ box in front of each plot. Give each farmer two tokens of different colour to show their highest and least preferences. Ask each farmer to visit all the plots in the trial individually and observe the varieties and express their preference by depositing the token in a bag or box. Do not ask farmers to rank all varieties, a process they find tedious. Only ask them to identify the highest and least preferred varieties. Later separately, ask each one of them about their preference and the reasons for the same. Then the votes are counted, and the most preferred variety is identified based on the weighted scores. Weighted score systems is followed for easy comparison among the tested varieties. After the results are known, ask the participating farmers to share the reasons for their preference as a group in terms of different varietal traits. The preference analysis thus generates two kinds of data:

1. Quantitative preference scores for each variety in terms of highest preferred variety and least preferred and the total weighted score value.
2. A list of characteristics of the preferred varieties liked by the farmers.

Farmers enjoy the FPA process. It can be described to them as an —election or a —beauty contest. It is simple to use, requiring no survey forms, and produces a quantitative score for each variety that is easy to analyze statistically. Importantly, this method works well with illiterate farmers, since they do not have to be able to read or write to take part.

Preference analysis is a snapshot of preference of participating farmers at the harvesting stage, rather than a completely reliable estimate of what farmers think about the varieties tested in the trial. However, preference analysis can reveal important information about traits valued by farmers as well as their first impressions of new varieties. Thus, FPA is only a tool for preliminary identification of varieties, which need to be followed with more extensive farmer-managed evaluation.

Useful tips for conducting FPA

1. It is easy to conduct voting procedures in FPA with large numbers of farmers. However, the focus group discussion to clarify the voting results is best done with a group of not more than 10-12 farmers at a time. If a large group of farmers participates in the voting procedure, break them into smaller groups for the focus group discussion.

2. Conduct separate events for men and women farmers. If a mixed group is engaged, then in the ballot/ token mention "F" and "M" to indicate the gender. Take extra care to elicit information from women in the mixed group.

3. At least two researchers are needed, one to guide farmers, and another to tabulate and record.

4. Bags or boxes and ballots should be prepared in advance.

5. The ballots/ tokens need to be in different colors and shapes for the ranks.

6. Place grain samples in front of the plot, so that farmers can also judge based on grain size and shape.

7. Ensure that each participant observes and ranks individually and not influenced by a dominating person in the group.

8. Similarly, collect the reasons behind ranking of varieties from everyone separately to avoid other people's influence.

Analysis of data generated through Farmers' Preference Analysis (FPA)

The cumulative preference score for each of the varieties tested must be determined by counting the ranking given by the participating farmers (Highest preferred, least preferred) and listing against

corresponding local variety. If sufficient number of both men and women farmers are available among the participants, the results could be presented gender wise as well as pooled one. The scores listed need to be converted into weighted scores by multiplying the highest and least preferred rank scores by 3 and 1, respectively, for easy comparison (Attachment 2).

The reasons given by each participant for his/her preference for a particular variety need to be listed in order of importance. The trait mentioned by a maximum number of farmers preferring a particular variety needs to be identified; second and third most frequently mentioned traits should also be identified. The list of traits considered by the farmers needs to be exhaustive, as it helps in understanding farmers' perception regarding a particular variety. If sufficient number of male and female farmers participate, then divide the traits based on gender.

CHOICE OF TRAITS BY FARMERS	
MALE	FEMALE

Matrix ranking in mother trial

Matrix ranking is a tool to compare and characterize a set of varieties in qualitative and quantitative manner. Like other ranking tools, it is often used in PVS and PPB. The procedure includes the following steps.

Step 1: Make a matrix with the traits in the first column. For this, use the traits identified earlier through brainstorming or FGD. Mention the names of varieties in the first row or for convenience use cards or symbols to represent the varieties (Attachment 3).

Step 2: Supply the participants with a fixed number of seeds (like beans) or other local materials to express their ranking of traits. Ranking can be done individually or as a group.

Step 3: Let participants rank the varieties for each trait by placing the seeds/ local materials in the inter section of column and row as per ranking- 1=low/bad and 5=high/good. Variety with the

most desirable trait (like highest yield and tolerance to moisture stress) needs to be given a score of 5, while the one with the lowest / least desirable trait (like low yield, grain shattering and lodging) needs to be given a score of 1. The varieties falling between these two extreme situations need to be given corresponding intermediate values.

Step 4: Farming community does not give equal importance to all the traits. To reflect this, calculate a weighted ranking of varieties as the product of "the value for the trait" and "the ranking score for that trait" for each variety. The weighted ranking helps in comparing all varieties.

Data collection during harvesting of the trial

Harvest the trial fields once the crops attain physiological maturity. Advise trial farmers repeatedly to inform the harvesting date to the research agency staff at least 5-7 days before, so that they can guide the trial farmer during harvesting. Observe the following points during yield data collection:

- Harvest whole plants (straw with ear head) from three sample plots of 1 sq. m each in the plot of each variety and keep for sun drying (1 or 2 days) and then bundle it for recording "total weight" of harvested plants.

- After proper threshing and cleaning, record the weight of grain. The "straw weight" needs to be estimated by subtracting the value of "grain weight" from "total weight" value.

- Thresh harvested produce of different varieties separately to avoid mechanical mixtures. Keep threshed and cleaned produce of each variety in separate gunny bags or containers. If needed, gunny bags need to be given to the trial farmers.

- Harvest the varieties, which mature early at the right time to avoid grain shattering or other kinds of losses. So, in mother trials involving varieties with varied duration, the research agency staff needs to visit more than once to collect harvest data.

Other data to be collected

a) Visit the plot with the concerned trial farmer and his or her spouse just before harvesting. Facilitate them to rank the tested varieties and to share the specific reasons behind their preferences. Record the varieties selected by trial farmers for next year's cultivation.

b) Synthesize the observations of the research agency staff for each mother trial and record them in the data format.

Replicated Mother trial: Execution

Design of replicated mother trial

The design of the replicated mother trial depends on the following factors

1. Farmer who is willing to take up the trial and the field
2. Varieties to be tested.
3. Experimental design
4. Number of replicates
5. Plot size to be used
6. Recommended crop management practices

In the case of single factor experiments where varieties are the only treatment factor, Randomized Complete Block Design (RCBD), is the common experimental design used for field layout. The experimental field is divided into more or less homogeneous blocks, and each variety occurs once per block. RCBD is effective when there a unidirectional gradient in the field and when the variability can be controlled by blocking. However, RCBD should not be used to test a large number of entries. One or two replicated trials comprising the same set of varieties might be essential in farmers' fields to strengthen the results of unreplicated mother trials. An example of replicated mother trial followed for testing little millet varieties is given below.

Number of varieties	10
Design	RCBD (Randomized Complete Block Design)
Plot size	4m x 3m (12 sq. m)
Replications	3
Number of trials	One each for short duration and long duration varieties

As far as possible, select a levelled field without shade. If land has slope, arrange plots across the slope (as suggested for mother trials) and let the blocks be along the slope. It can be observed that the replications I, II and III have the different arrangements, i.e. varieties are allotted randomly to each plot as shown in the *Varietal sequence- Randomisation* section.

Follow the recommended seed rate. Ensure the quantity of seeds in each packet based on the plot

size. Arrange seed packets for each replication (also known as Blocks) separately as per the field layout plan before taking them to the field. In the field, place the seed packets according to plot numbers within each replication. This exercise helps to avoid any mistakes in allotting seed packets to each plot in the field.

Example: Randomized complete block design (RBD) field layout plan for 10 test entries

Name of the Entry	Replication 1		Replication 2		Replication 3	
	Randomised Entry No.	Plot Number	Randomised Entry No.	Plot Number	Randomised Entry No.	Plot Number
A	4	101	1	201	6	301
B	9	102	7	202	10	302
C	1	103	2	203	5	303
D	10	104	9	204	1	304
E	8	105	10	205	4	305
F	6	106	3	206	7	306
G	3	107	5	207	8	307
H	7	108	8	208	2	308
I	5	109	4	209	9	309
J	2	110	6	210	3	310

Replication	Row/Column	1	2	3	4	5	6	7	8	9	10
R1	1	101	102	103	104	105	106	107	108	109	110
R2	2	201	202	203	204	205	206	207	208	209	210
R2	3	301	302	303	304	305	306	307	308	309	310

Direction of slope

Seed sowing and crop management

i. After proper land preparation, apply the recommended dose of fertilizer uniformly. For this, workout the quantity of fertilizer needed for the experimental area. Do not apply farmyard manure, as it is difficult to maintain uniform fertility levels among the plots.

ii. Using field layout plan, mark replication/blocks and plots. Keep 0.5-1m space between each replication for easy demarcation and for easy movement while collecting data from each plot.

iii. Follow line sowing to have uniform plant population in each plot. Open shallow furrows lengthwise, about 2 cm deep, using marker or pickaxe manually, with 30 cm spacing between rows and 10cm between the plants.

iv. Place the seed packets in each plot according to the field plan. Sow the seeds in furrows uniformly in such a way that the recommended quantity of seeds covers the whole plot. As the quantity of seeds sown in each plot is meagre, one needs to be careful in sowing. Initially use minimum quantity in each row; if excess seeds are there, then distribute the same uniformly in all the rows. Cover the furrows with soil.

v. Complete sowing of all the plots on the same day; otherwise it leads to variation due to unknown causes.

vi. Follow regular weeding and top-dressing, maintaining uniform treatment for all of the plots. For this, workout the quantity of fertilizer required for top dressing for each block of the experimental area from the recommended quantity per acre/ha.

vii. Avoid any plant protection measures (spraying pesticides) against insect pests and diseases to know the reactions of the varieties to different pests and diseases.

Data collection

Follow the same procedure suggested for unreplicated mother trial but record the data for each replication separately. To avoid confusion in the field in locating the variety while taking measurements, just follow the plot number in each replication instead of serial number of varieties. While processing, the data can be resorted in the order of varieties.

> ### Box 6: Need to have a replicated mother trial in a study site
>
> Based on the experience it is suggested to have one well organized replicated mother trial following recommended package of practices along with many unreplicated mother trials under prevailing farmers' practices spread across the working villages in a site. While the replicated mother trial will help in understanding the potential of varieties tested in the site environment, the unreplicated mother trials will help in understanding the performance of varieties under varied environments that exist in the site under farmers' management conditions.

The data available from mother trials are:

1. Growth parameters of varieties included in the trials
2. Yield parameters of varieties (grain and straw yield)
3. Farmers' Preference Votes
4. Specific observations recorded by the research team and experts

Data pre-processing

Data preprocessing involves compiling, cleaning (verification), sorting and preparing the final data sheet for analysis. Consider the two types of field data sheets mentioned above (General information and Field performance of varieties under testing) and then follow the steps given below. Arrange the data of the trials, hamlet wise within each village/ Panchayat and village wise/Panchayat wise within the site. Check once again the data collected thoroughly; fill the gaps, if any, and correct the inadvertent values caused by wrong entries.

- Use two different Master Excel sheet formats for entering the individual trial's information - one for general experimental information and another for experimental data (Attachment 4 and 5). Fill in the two types of data from each trial in these two Master sheets. These Master sheets will have consolidated data of all the trials.
- The processed data needs to be arranged in a suitable format (in Excel sheet) ready for statistical analysis.

Box 7: Sharing of responsibilities in mother trial

The list of various responsibilities of different people participating in the mother trial person is given below and the detailed notes on few of the responsibilities are shared the following pages. Technical aspects of mother trial like plot layout, data collection, etc. are taken care of by field research staff.

Responsibilities	Who is responsible?
1. Layout of the trial	Field research staff
2. Randomization of the treatments	Field research staff
3. Sowing of the trial	Farmer and supervised by field research staff
4. Crop and trial management	Farmer
5. Trial monitoring and data collection	Field research staff
6. Farmers preference analysis	Field research staff & assisted by farmer
7. Harvesting and threshing	Farmer &supervised by field research staff
8. Recording grain and straw yield of varieties and getting feed back	Field research staff & assisted by farmer

Data analysis

The steps in the data analysis include:

1. Setting up analysis objectives based on the hypothesis

2. Data preparation and preprocessing

3. Exploratory analysis

4. Model building

5. Interpretation.

Analysis in a mixed model framework:

A mixed linear model has a mixture of two types of effects (i) fixed and (ii) random. The levels of the fixed effects are the levels selected purposefully, and inferences are to be made only concerning the levels defined for the study. In the case of random effects, there is an 'infinite' set of levels or a population of levels, and the levels present in the study are a sample from that population. While the prime interest is on the means for the fixed effects, it is on the variances for the random effects.

Replicated mother trial planted in RCBD

The underlying mixed model that explains each observation in a replicated trial is

$$y_{ij} = \mu + g_i + b_j + \varepsilon_{ij}$$

$$response = \begin{pmatrix} overall \\ mean \end{pmatrix} + \begin{pmatrix} variety \\ effect \end{pmatrix} + \begin{pmatrix} block \\ effect \end{pmatrix} + residual$$

where y_{ij} is the response of the ith variety in the jth block, μ is the overall mean, g_i is the effect of the ith genotype, b_j is the ffect of the jth block and ε_{ij} is the residual. Varieties are considered as fixed and blocks are set to be a random effect.

Unreplicated mother trial planted in RCBD

In one-farmer, one-replicate approach, farmer forms the block of the RCBD and the number of replications of a variety is equal to the number of mother trials in the site. The model is therefore re-written as

$$response = \begin{pmatrix} overall \\ mean \end{pmatrix} + \begin{pmatrix} variety \\ effect \end{pmatrix} + \begin{pmatrix} farmer \\ effect \end{pmatrix} + residual$$

For example, the data of mother trial located in one hamlet or in one village Panchayat or from the whole site can be analyzed separately to understand the suitability of a particular variety for the pertaining geographical unit. The planned allotment of mother trials within individual hamlets, among hamlets within village Panchayat and finally covering all the Panchayats within the site, makes it possible to get such relevant information from the study.

The above analysis will be carried out using suitable analysis software. A table containing average values of parameters for each of the varieties together with the other model parameters such as standard error of mean values (Sem), least significant difference at 5% probability (LSD at 5%) and experimental coefficient of variation (CV%) for each of the parameters will be generated. Each of these statistical measures will be used to interpret the results critically. In brief, let us look at what they mean exactly.

Experimental mean – It indicates overall performance of varieties in the mother trial for different parameters. It is used to know which of the varieties are above or below the average performance for a particular parameter.

Standard error of mean (SEM) – It indicates the efficiency of the experiment. In other words, it indicates the extent of influence of error component (uncontrolled factors) on the total variation

among the individual unit values. So, the mean value of each parameter for particular variety is within the probable range of plus or minus of its SEM.

Least significant Difference (LSD) at 5% - ANOVA of RCBD data involves using of two statistical tests of significance, namely, F-test and t-test, which are known as statistical tests of significance. In simple words, whether the observed differences in mean values of different varieties in the trial for a particular trait is because of real cause effect or just by chance is revealed by these tests. If F-test is found significant, then t-test for pairwise differences is followed. If the difference between mean values of two varieties for particular trait is more than the corresponding LSD value, then the difference between the varieties is considered as statistically significant.

Coefficient of Variation (CV %) - It also measures the extent of influence of uncontrolled factors on total variation of values in the trial and used as a measure of reliability of the data collected. The reliability level fixed for field trials is usually 20%. If the CV values are too high, the experiment is considered a failure, as it cannot identify the real difference among the tested varieties. CV value of trials cannot be too low either, as some variation due to uncontrolled factors is bound to exist in an experiment.

Conducting organoleptic test

Acceptance of a particular variety by the local farmers does not depend only on its field performance. It also depends on its desirable attributes related to consumption such as taste, color, dough consistency, flour recovery, keeping quality, etc. Hence, to collect systematic and reliable information on the consumption aspects, organoleptic tests are carried out. The results of the organoleptic test need to be used in conjunction with results obtained from quantitative analysis of mother trial data discussed above for selection of the most suitable varieties for the site. The procedure of organoleptic test is described below.

Steps:
1. Collect 1 kg of cleaned grains of identified and popular local varieties of the crop subjected to PVS.
2. Process the 1 kg grain for getting flour (in the case of finger millet) or rice (in other small

millets); take extra precaution to avoid mixtures while processing the grains in the mill.

3. Measure the volume of flour of each variety separately (uniform handling is necessary while measuring volume) and record it for estimating flour recovery.

4. Prepare two different locally popular recipes for each variety using flour or rice. A minimum of 500 grams of recipe for each variety needs to be prepared. Ensure following the same procedure while preparing recipes for each variety.

5. Invite 5 men and 5 women local farmers/ persons to evaluate the prepared food from different varieties.

6. Serve 50 grams of the first recipe of each variety in 10 different paper plates (or paper cups for gruel) with marking as "A"; for the other varieties mark as "B", "C", etc. (any other letter can be used; but use different letter for each variety; do not mention the name of the variety). Arrange the plates in 10 different groups, each group containing the same recipe prepared from all the tested varieties. Place them at distant places to avoid discussion among the evaluators.

7. Before starting the evaluation, share the purpose of the activity and the instructions to be followed for evaluation with the participants (evaluators). The instructions include tasting the recipe by taking a small quantity (by chewing or drinking), feeling its consistency (stickiness, soft or hard), colour (dark, medium or light), and arranging them in the order of their preference, among many. Most desirable needs to be placed at the top and least one at the bottom; in case it is difficult to distinguish the recipes and some of them appear more or less the same, then they can be placed side by side.

8. Record all the scorings in the data sheet with the remarks for each variety given by the evaluators. After completing the evaluation, fill the decoding column with the name of the varieties tested. From individual data sheets, prepare the final results.

9. Repeat the same procedure for the second recipe.

10. The final table of results can also be prepared with separate scores for each parameter like appearance, color, consistency, taste, aroma, flour/ rice recovery, shelf life, etc., along with scores of overall preferences. Pairwise ranking might be helpful for scoring in case of certain parameters like taste and aroma, as it would be difficult to find differences among items of 8-10 samples.

11. It is to be noted that parameters of organoleptic tests vary from crop to crop, and even recipes within the crop. Standard protocols are available for certain crops like rice and vegetable crops. In the absence of standard protocol, develop ad-hoc procedures based on common parameters. The procedure mentioned above is one such type developed for small millets.

Box 9: Tips for ensuring effective participation of farmers

Process of participation of farmers in PVS is as important as that of product of PVS and is a non-negotiable aspect in PVS. The tips for ensuring effective participation of farmers are,

1) Involve the existing well-functioning community organizations at the district level or village level like federation of farmers group/ women group and farmers' cooperatives from the beginning in the PVS intervention.

2) Form a farmers committee at the village level with the representatives from various communities and both genders to support and guide the PVS activities. Enroll the interested farmers and accomplished office-bearers of the community organizations in the committee. Consult with this committee for all the PVS steps, starting from participatory evaluation to identify farmers' needs in a cultivar, on a periodic basis.

3) Select trial farmers among the members of community organizations. Facilitate the sharing of the learning by the trial farmers to other members in various ways such as physically visiting the plot and sharing during regular meeting of the community organization.

4) Give special attention to ensure effective participation of women farmers. Involve women Self Help Groups and women federations as it helps a lot in effective participation of women farmers.

5) Take all efforts to recruit women field staff.

6) Train all the staff on gender analysis and gender perspective and undertake gender analysis of farming in the first year.

7) If possible, give incentives to participating farmers to compensate the loss of yield from the trial plot or to meet the expenses of cultural operations.

8) The field research staff need to be sensitive about the power equation between the farmers and scientists, farmers and themselves, men and women, different castes and different income classes in the site. They need to ensure effective participation of all the vulnerable sections such as small and marginal farmers, tribals, scheduled caste and women, by addressing the issues arising from the various power equations. They need to follow "New Plant Genetic Resources Professionalism" as described by De Boef et al. (2013) while working with farmers.

Nutrient analysis of the selected local/ improved varieties

The varieties identified as farmer preferred varieties through PVS in a site need to be tested for their nutrient content to understand their advantages over the other varieties. Some of the indigenous varieties may be on par with the prevailing varieties in yield, but they may be more nutritious. The reverse can also be the case. Therefore, nutrient analysis may help in fine-tuning the recommendations from PVS.

Deriving inferences from mother trial results

The inferences drawn from analysis of i) growth and yield parameters, ii) opinion of the participating farmers and iii) preference expressed by group of farmers through FPA and the specific insights, if any, recorded by the research team and experts will be considered to work out the following outputs:

1. The most suitable variety or varieties for individual site

2. The traits of the tested varieties most preferred by the farmers

3. The varieties with special characteristics such as adaptability to particular soil types, tolerance to moisture stress, taste and short duration.

Shortlist the suitable varieties identified in the mother trials for testing in the baby trials.

Attachment 1

MOTHER TRIAL INFORMATION SHEET

I. Trial farmer's family details

1. General information

- Country   :
- District   :
- Village   :
- Name of the farmer :
- Farmer ID   :
- Gender   :
- Family members no.:
- Literacy status   :

2. Land details

Farm size (acres)	Own	Leased in	Total
a. Rain-fed			
b. Irrigated			
Irrigation facilities	Open well/ Bore well/ Other source		

3. Crop details

All crops			
Rainfed		Irrigated	
Crop	Area (acre)	Crop	Area(acre)
1		1	
2		2	
3		3	
4		4	

4. Experience in cultivating small millets:

Mother trial details

1. **Crop:**

2. **Preferred traits of the crop**

3. **Field ID**

4. **Field details:**

a. Area, dimension:

b. Land condition (Plot)   Plain (slope < 3%)   With slope > 3%

c. Soil type   (Indicate below the specific features by circling it)

- Color   Red/ Light brown/ Black/ Any other
- Texture   Clayey/ Sandy/ Loamy/ Sandy loam/ Others……
- Depth   Deep(>70 cm)/ Medium (20 – 70 cm)/ Shallow(<20cm)
- Fertility status   Very good/ Moderate/ Poor

d. Abiotic/ Biotic stresses:

e. Last year crop:

f. Whether fertilizer applied last year? Yes / No

g. Whether manure applied last year? Yes / No

h. Possibilities of protective irrigation: Possible/ Not possible

5. **Local check variety:**

6. **List of test varieties**

Name of the variety	Entry Number.
1	
2	
3	
4	
5	
6	
7	
8	

9	
10	

7.Experiment field location with direction -Latitude and direction:
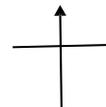
8. Field layout plan:

Replication	Row/Column	1	2	3	4	5	6	7	8	9	10
R1	1	101	102	103	104	105	106	107	108	109	110
R2	2	201	202	203	204	205	206	207	208	209	210
R2	3	301	302	303	304	305	306	307	308	309	310

9. Plot size (sq.m):

10. Plot dimensions:

11. Cultural operation details:

Operations	Date	Detail information of the practice
Land preparation		
Manure application		
Fertiliser application		
Sowing		
Transplanting, if applicable		
Thinning		
Weeding		
Top dressing, if applicable		
Harvesting		
Drying		
Threshing		

10. Observations made during field visit:

Date	Visited by	Observations*

*Observations include, stage of the crop, germination, establishment, plant type (vigorous/ not vigorous), disease and pest incidence - its impact, dryspell and its impact, difference of impact over varieties, intercultural operations taken up like weeding, top dressing of fertilizers, earthing up, pesticide and fungicide application, damage to crop by wild animals, shade effect, erosion, farmers opinion about crop performance and other relevant factors.

MOTHER TRIAL DATA SHEET

Date of sowing:

Plant population per plot (in replicated trial) or in a one square metre region from a minimum of 3 spots (in unreplicated trail)

Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1										
2										
3										

Days to 50% flowering

Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1										
2										
3										

Days to maturity

Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1										
2										
3										

Plant height (cm) of randomly selected five plants per plot (in replicated trial) or in a one square metre region from a minimum of 3 spots (in unreplicated trail)

Replication / Spots per trial	V1						V2						...Vn						Avg
	1	2	3	4	5	Avg	1	2	3	4	5	Avg	1	2	3	4	5	Avg	
1						###						###							###
2						###						###							###
3						###						###							###

Number of productive tillers per plant of randomly selected five plants per plot (in replicated trial) or in a one square metre region from a minimum of 3 spots (in unreplicated trail)

Replication / Spots per trial	V1						V2						...Vn						Avg
	1	2	3	4	5	Avg	1	2	3	4	5	Avg	1	2	3	4	5	Avg	
1						###						###							###
2						###						###							###
3						###						###							###

Panicle length(cm) of randomly selected five plants per plot (in replicated trial) or in a one square metre region from a minimum of 3 spots (in unreplicated trail)

Replication / Spots per trial	V1						V2						...Vn					
	1	2	3	4	5	Avg	1	2	3	4	5	Avg	1	2	3	4	5	Avg
1						###						###						###
2						###						###						###
3						###						###						###

Grain yield(kg) of randomly selected five plants per plot (in replicated trial) or in a one square metre region from a minimum of 3 spots (in unreplicated trail)

Replication/ Spots per trial	V1						V2						...Vn					
	1	2	3	4	5	Avg	1	2	3	4	5	Avg	1	2	3	4	5	Avg
1						###						###						###
2						###						###						###
3						###						###						###

Straw yield(kg)) of randomly selected five plants per plot (in replicated trial) or in a one square metre region from a minimum of 3 spots (in unreplicated trail)

Replication/ Spots per trial	V1						V2						...Vn					
	1	2	3	4	5	Avg	1	2	3	4	5	Avg	1	2	3	4	5	Avg
1						###						###						###
2						###						###						###
3						###						###						###

Attachment 2

MOTHER TRIAL- PREFERENCE ANALYSIS

Variety	Farmers -Males (N=)				Farmers -Females (N=)				Researchers (N=)				Total (N=)			
	Highest preferred variety		Least preferred variety		Highest preferred variety		Least preferred variety		Highest preferred variety		Least preferred variety		Highest preferred variety		Least preferred variety	
	Variety	Reason	Variety	Reason	Variety	Reason	Variety	Reason	Variety	Reason	Variety	Reason	Variety	Reason	Variety	Reason
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

Highest preferred variety	
Least preferred variety	

Attachment 3

MATRIX RANKING

Traits	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
Maturity										
Tolerant to dry spell										
Tolerant to rainfall										
Lodging										
Grain shattering										
Resistance to diseases										
Resistance to pest										
Grain yield										
Straw yield										
Colour preference										

Score:	
Low/Bad	1
High/Good	5

Attachment 4

CONSOLIDATED GENERAL INFORMATION OF MOTHER TRIAL

Trial farmer's family details

S.No.	Country	District	Village	Field ID	Farmer name	Farmer ID	Gender	Village	Family size	Literacy status	Age	Participation year
1												
2												
3												
::												
::												
n												

Trial farmer's land details

Farmer No.	Farm acres		Irrigation facility			Livestock	
	Rainfed	Irrigated	Open well	Borewell	Other	Number	Type
1							
2							
3							
::							
::							
n							

Trial farmer's crop details

Farmer No.	Crop cultivation area (previous year)						Crop selected for PVS		
	Rainfed			Irrigated			Crop	Seed source	Years of experience
	Crop 1	Crop 2	Crop 3	Crop 1	Crop 2	Crop 3			
1									

Trial details	Farmer No.				
	1	2	3	..	n
Crop					
Preferred traits of the crop					
Field ID					
Plot area (sq. m), dimension					
Land slope (Plain/ with slope)					
Soil colour (Red/ Light brown/ Black/ Any other)					
Soil texture (Clayey/ Sandy/ Loamy/ Sandy loam/ Others)					
Soil depth (Deep/ Medium/ Shallow)					
Fertility status (Very good/ Moderate/ Poor)					
Abiotic stresses					
Biotic stresses					
Previous crop					
Last year fertilizer application (Yes/No)					

Last year manure application (Yes/No)			
Protective irrigation facility (Possible/ not possible)			
Number of test varieties			
Local check variety			
Plot size (sq. m)			
Cultural operations dates			
a. Land preparation			
b. Manure application			
c. Fertiliser application			
d. Sowing			
e. Transplanting, if applicable			
f. Thinning			
g. Weeding			
h. Top dressing, if applicable			
i. Harvesting			
j. Drying			
k. Threshing			
Observations made by researchers			

Attachment 5

CONSOLIDATED DATA SHEET FOR MOTHER TRIAL FOR DATA ANALYSIS

Field ID:	
Crop:	

Plant population

Farmer ID	Name of the trail farmer	Village/ Panchayat	Date of sowing	Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1	1	..	..	1										
				2										
				3										
2	2	..	..	1										
				2										
				3										
3	3	..	..	1										
				2										
				3										
n	n	..	..	1										
				2										
				3										

Farmer ID	Name of the trail farmer	Village/ Panchayat	Date of sowing	Replication/ Spots per trial	Days to 50% flowering									
					V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1	1	:	:	1										
				2										
				3										
2	2	:	:	1										
				2										
				3										
3	3	:	:	1										
				2										
				3										
n	n	:	:	1										
				2										
				3										

Days to maturity

Farmer ID	Name of the trail farmer	Village/ Panchayat	Date of sowing	Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1	1	::	::	1										
				2										
				3										
2	2	::	::	1										
				2										
				3										
3	3	::	::	1										
				2										
				3										
n	n	::	::	1										
				2										
				3										

Number of productive tillers per plant

Farmer ID	Name of the trail farmer	Village/ Panchayat	Date of sowing	Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1	1	::	::	1										
				2										

				3										
2	2	..	..	1										
				2										
				3										
3	3	..	..	1										
				2										
				3										
n	n	..	..	1										
				2										
				3										

Panicle length(cm)

Farmer ID	Name of the trail farmer	Village/ Panchayat	Date of sowing	Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1	1	..	..	1										
				2										
				3										
2	2	..	..	1										
				2										
				3										
3	3	..	..	1										
				2										

			3
n	n	:	1
			2
			3

Grain yield (kg/plot)

Farmer ID	Name of the trail farmer	Village/ Panchayat	Date of sowing	Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1	1	:	:	1										
				2										
				3										
2	2	:	:	1										
				2										
				3										
3	3	:	:	1										
				2										
				3										
n	n	:	:	1										
				2										
				3										

Straw yield (kg/plot)

Farmer ID	Name of the trail farmer	Village/ Panchayat	Date of sowing	Replication/ Spots per trial	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
1	1	..	..	1										
				2										
				3										
2	2	..	..	1										
				2										
				3										
3	3	..	..	1										
				2										
				3										
n	n	..	..	1										
				2										
				3										

Baby trials

Baby trials are conducted to validate the performance of identified varieties from mother trials by comparing the performance of each one of them with the prevailing farmers' variety across the site. It is the second cycle in the PVS process. The varieties validated in baby trials are recommended for Informal Research and Development (IRD).

Planning and execution of baby trials

1) Conduct a minimum of 25 baby trials for each variety. Increase the number of trials based on seed availability.

2) Include one or two promising varieties identified from mother trials as test varieties.

3) Farmer's own variety will be the check.

4) The experimental design involves growing the check and test varieties in the same field adjacent to one another. If the experimental field is sloped, arrange the plots across the slope (not along the slope). Ensure that except the variety, there should not be any difference in land preparation, manure application, seed rate, sowing date, intercultural operations and other practices between the test variety plot and the check variety plot.

5) Ensure the plot size for each tested variety is a minimum of 10 cents (400sq.m).

6) Distribute the trials across the villages of the site selected.

7) Enroll both men and women farmers for the trials.

8) Enroll farmers from all kinds of land holding size categories, with more of them from small and marginal farmers.

9) Supply seeds to farmers well in advance with poles/ nameplates for display.

10) Select levelled fields at least for some of the trials. While for the rest, select representative land types in the site.

11) Ensure regular observation of crop performance in the trials by the trial farmer and the field research staff.

Promising variety identified from mother trials (Test variety)	Farmer's variety (Check variety)

Direction of slope
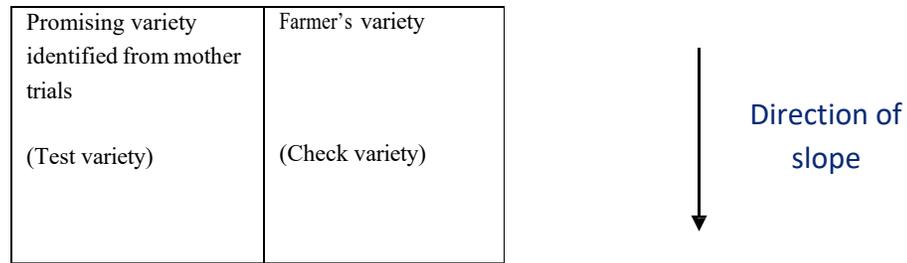
Data collection

In the case of baby trials, only the opinion of the farmer on the varietal performance and yield of the tested varieties is considered for deriving the results. Collect data for baby trials in the formats given in attachment 6 and compile the details of the farmer, land, crop, farm operations and observations of the researchers similar to mother trial as shown in Attachment 4. For collecting data on yield, mark two random sample plots of 10 m^2 area (5m X 2m) each in the test and check variety. Harvest the crops from these plots after they attain physiological maturity and keep the harvested produce of each variety separately. Ensure sun drying, weighing, and threshing of produce from each trial plot separately. Record the grain yield and straw yield. Estimate the straw yield by deducting the weight of the grain yield from the weight of the harvested crop of the sample plots. Collect feedback from the trial farmer on the performance of the test variety in comparison to the check variety on various parameters in the format given in Attachment 7.

Data processing and analysis

The various steps involved in data processing and analysis for baby trials are shared below.

Step 1 – Preparing the consolidated yield data sheet

The model for the consolidated baby trial data sheet is given in Attachment 8. Average values of grain and straw yield data of two sample plots (of size 10 sq. m each) from each variety are calculated and then converted into estimated values per acre. Same procedures should be followed for a second test variety if included and for the check (farmer's) variety.

Step 2 –Preparing the yield table

From the consolidated data sheet, construct the final yield table. For calculating the difference in yield between the test variety and check variety use the following formula:

Percent increase in yield = (Yield of test variety – Yield of check variety) x 100

....

Yield of check variety

A positive value indicates percentage increase in yield of test variety over the check variety and a negative value indicates percentage decrease.

Step 3 – Processing data on trial farmers' assessment of test variety

The trial farmer's feedback format captures the opinion of the trial farmer on the test variety pertaining to different traits in comparison with his or her own variety. It is expressed as more, same, or less and the corresponding score is 1, 2 and 3. Compile the opinion data in the excel sheet given as Attachment 9. Count each score value (1s, 2s, and 3s) in each column that is for each trait. Calculate percent values from these number values. For seed saving column, count number of "Yes" and "No" and calculate their percentage values. Use the percentage values for deriving inferences to use in the report together with comments.

Step 4 – Interpret the results furnished in the tables

Infer the performance of the test variety on yield from per cent of trials with the increase or decrease in yields and the farmers' opinion on this trait. Infer whether the trial farmers prefer the test variety from the feedback table, based on the specific traits for which they have answered in favor of the test variety. The traits not liked by the farmers can also be derived from the feedback table. Use this information and the opinion of the research team and experts on the performance of test variety, if any (consolidated in the format given in Attachment 9), to derive the following outputs:

1. The most suitable variety or varieties for the individual site
2. The traits of the selected varieties most preferred by the farmers

Informal research and development (IRD)

IRD is the third cycle in the PVS process. Its specific objective is to validate the suitability of a variety identified in baby trials by getting an opinion from a large number of farmers based on its performance in their fields. The second important objective is to introduce suitable varieties identified to as many farmers as possible at a particular site. It also serves the purpose of producing quality seeds of the identified variety for further dissemination in the next year. The varieties validated by IRD are disseminated widely for large-scale adoption.

The IRD farmers may or may not grow their own variety as checks along with the test variety, as in case of baby trials. To understand the comparative performance of the identified varieties for another season, it is better to study at least 25 IRD fields having farmers' varieties as checks, besides the other IRD trials without checks. Since the research design for IRD is same as baby trials, follow the same procedures for field operations, data collection, data processing, and analysis. The trials having checks (farmers' varieties) need to be treated as baby trials. The data collected is processed and analyzed following the steps in Attachment 6 and compiled as in Attachment 8. For the rest of the trials (without checks) the feedback of trial farmers alone needs to be collected in the specified format (Attachment 7), which needs to be compiled in an excel sheet as in Attachment 9.

Synthesis of research results of PVS

The results of one cycle of PVS over a period of three crop seasons/ years can be synthesized for effective presentation and for preparing action plan. The action plan indicates the farmer preferred varieties identified for wider dissemination and potential varieties to be tested in the next cropping season for validating their suitability for the site. It is to be noted that a lot of uncertainties exist while experimenting under rainfed farming conditions, especially with respect to adequate and timely availability of rainfall. Therefore, it is better to test each promising variety at least two years. This will help in better assessment of the variety for its suitability to the site. A case in point is GPU-28 performance in Jawadhu Hills. When GPU-28 variety of finger millet was introduced in Jawadhu Hills in 2011, it did not perform well, but in the subsequent three years, it performed well.

The PVS cycle has to be continued when new promising varieties are identified for the site. If promising materials are not available for testing, participatory plant breeding can be planned to create additional varietal options for the site.

BABY TRIAL INFORMATION SHEET

1. Farmer details

Field ID
Village
Famer Name
Farmer_Id
Gender

Household	Male headed
	Female headed

No. of family members
Literacy status
Experience in small millets

2. Field details

Land type

Field size (hectares)	rainfed
	irrigated
Irrigation method	rainfed / irrigated

Area of the crop

Slope	Plain (slope < 3%)	With slope > 3%

Soil type	Clayey/ Sandy/ Loamy/ Sandy loam/ Others……

Soil colour	Red/ Light brown/ Black/ Any other

Fertility status	Very good/ Moderate/ Poor

Soil depth	Deep (>70 cm)/ Medium (20 – 70 cm)/ Shallow(<20cm)

Abiotic stress

Biotic stress

Fertilizer	Name
	amount (kg/ha)
Manure kg/ha	

3. Farm operations

Name of the operation	Date	Details of the operation
Land preparation		
Manure /Fertiliser application		
Sowing		
Transplanting		
Thinning		
Weeding		
Top dressing		
Harvesting		
Drying		
Threshing		

4. Crop details

Name of the crop

Preferred traits

Variety

Test

Farmer

Field layout plan

Test variety	Control

Plot size

Plot dimensions

Grain yield (2 quadrats of 1m2)

Test

Farmer

Straw yield (2 quadrats of 1m2)

Test

Farmer

5. Field visits by researchers

Date	Visited by	Observations*

*Observations include, stage of the crop, germination, establishment, plant type (vigorous/ not vigorous), disease and pest incidence - its impact, dryspell and its impact, difference of impact over varieties, intercultural operations taken up like weeding, top dressing of fertilizers, earthing up, pesticide and fungicide application, damage to crop by wild animals, shade effect, erosion, farmers opinion about crop performance and other relevant factors.

	Crop
6. PREVIOUS YEAR	Fertilizer
	Manure

Attachment 7

BABY TRIAL FEEDBACK FORMAT

Compare test variety with your own variety B.

Maturity	Earlier	Same	Late
Tolerant to dry spell	High	Same	Less
Tolerant to rainfall	High	Same	Less
Lodging	High	Same	Less
Grain shattering	High	Same	Less
Resistance to blast	High	Same	Less
Grain yield	High	Same	Less
Straw yield	High	Same	Less
Colour preference	Better	Same	Poor
Flour recovery	High	Same	Less
Taste	Better	Same	Poor
Grain shattering	High	Same	Less
Would your like to save the seed of test variety?	Yes	No	

Note: The parameters on which farmer's feedback is collected may change from crop to crop.

Opinion of the research team

Sl. No.	Name of the farmer	Village/ Panchayat	Date of sowing	Test variety	Check variety	Comments on the performance of test variety with respect to check variety
1						
2						
.						
.						
25						

Attachment 8

CONSOLIDATED DATA SHEET FROM BABY TRIALS

Yield parameter	Variety	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5
Grain yield (2 quadrats of 1m2)	Test					
	Farmer					
Straw yield (2 quadrats of 1m2)	Test					
	Farmer					

Attachment 9

CONSOLIDATED FEEDBACK INFORMATION FROM BABY TRIALS/ INFORMAL RESEARCH AND DEVELOPMENT (IRD)

Farmers' name	DOS	MAT	TDS	THR	RBL	LDG	DRN	GYD	SYD	COL	FLR	GSH	TST	SSAVE (Yes/No)
1		1	2	3	1	2	3	1	2	2		1		Y
2		2	3	3	1	2	2	1	1	2		1		Y
...		...	...	...	...	...	...	...	...	...	...	...	...	...
...		...	...	...	...	...	...	...	...	...	...	...	...	...
...		...	...	...	...	...	...	...	...	...	...	...	...	...
N		1	3	1	1	2	3	2	1	2		2		N

Date of sowing (DOS), Maturity (MAT), Tolerant to dry spell (TDS), Tolerant to heavy rainfall (THR), Resistance to blast (RBL), Lodging (LDG) Damage by rains during maturity (DRN), Grain yield (GYD), Straw yield (SYD), Colour preference (COL),Flour recovery(FLR), Grain shattering (GSH), Taste (TST), Saving seeds of test variety (SSAVE).

Note: Scoring for the traits done from Low=1 to High=5

Wider dissemination of farmer-preferred cultivars

The first 3 phases of PVS help in generating site-specific farmer-preferred varieties (FPVs). The varieties so generated need to be widely disseminated for their adoption by the target community. As mother trials, baby trials, and IRD are conducted in the farmers' fields and as trial farmers have access to seeds of their preferred varieties, horizontal spread of the FPVs can be expected to an extent. However, specific efforts must be made to ensure large-scale dissemination. This step is crucial to spread the results of PVS to a large number of farmers. Two sets of key activities needed for wider dissemination of the identified FPVs are: 1) Familiarizing the FPVs to the local farming community and generating demand and 2) Production of seeds of FPVs to ensure timely supply of quality seeds for the next season.

Familiarizing the FPVs to the local farming community and generating demand

These activities need to be started by the end of IRD stage itself, as by that time the site-specific FPVs are already identified. The key activities for familiarizing and generating demand for the FPVs can be classified as follows:

a) Dissemination activities to be taken by the end of IRD

1. Arranging exposure visits to a large number of local farmers to successful IRD trials: As IRD trials are taken up under varied land quality and management practices, there will be variations in the expression of identified FPVs. Select one IRD plot which has visually appealing crop stand and easily accessible for each identified variety for each cluster of hamlets/villages. Organize the interested farmers in the particular cluster, for an exposure visit of one to two hours duration to these few IRD plots. Seek the opinion of the visiting farmers/ members on the varieties observed and their willingness to grow in the next season. Systematically record these opinions and give necessary support to willing farmers before the next crop season to try their preferred variety in their farm.

2. Identification of interested farmers: Among the IRD farmers, identify those farmers who are highly enthused by the performance of a particular FPV, eager to integrate them in their cropping system and share their positive experience with other farmers. Encourage them to share their experience with other farmers individually and in the meetings organized for this purpose.

b) Dissemination activities to be taken before the next cropping season

1. Display of panicles, grain and other crop samples of the identified FPVs in the local weekly market.

2. Sharing relevant communication materials with many farmers: Prepare communication materials (pamphlets, posters, and wall paintings) on the identified FPVs covering their salient features from the perspective of the farmers/ users. Ensure reaching of these materials to many farmers in the site.

3. Raising demand in the meeting of local organizations: Give an orientation to the office bearers of farmers' federations and cooperatives, so that they understand the advantages of the identified FPVs and share the same with their members. Give orientation and raise demand for the identified FPVs in the regular/monthly meetings of SHGs, farmers groups, etc. Do it in a systematic way using a format which captures member-wise and variety-wise demand. Based on the demand raised, take necessary efforts for supplying seeds in time.

4. Distribution of the seed kits: Distribute seed kits to farmers who have expressed demand for the FPVs with information on varieties. Distribute seed as a "kind loan", which needs to be returned twice/ thrice in quantity by the end of the season.

c) Dissemination activities to be taken during the next cropping season

1. Demonstrate the FPVs in major hamlets throughout the site. If possible, demonstrate FPVs along with site-specific suitable production practices such as optimum seed rate and thinning. This helps in demonstrating the full production potential of variety. Choose motivated local farmers who are impressed by the performance of the FPV for demonstration.

2. Arrange exposure visits to large number of local farmers to successful demonstration plots.

Production of seeds of FPVs to ensure a timely supply of quality seeds for the next season

Parallel to raising demand for the seeds of farmer-preferred varieties (FPVs) identified through PVS, take necessary efforts for production of seeds of those varieties to meet the demand created. The following section shares briefly about community-based seed production (CBSP) to meet this purpose. The practices related to CBSP for FPVs are not much different from seed production for proven varieties.

Community-based seed production

CBSP is the most feasible option for production of quality seeds of identified FPVs, if the selected varieties are not part of the formal seed chain (as in the case of local varieties) and if farmers in the site do not have adequate access to formal seed chain. Further, if the local varieties identified in FPVs have mixtures, systematic seed production will help in purification to an extent. The two options for CBSP are shared below.

1. **Identification of fields for seed procurement from existing IRD plots**

   Many farmers participating in baby/IRD trials use the seeds of selected promising varieties. Take advantage of regular visits to these fields from the initial stages of crop growth and identify two to five IRD trial fields for each FPV having good crop stand with uniform plant population. Keep a record of selected fields such as address of farmer, name of variety, date of sowing, crop condition and instructions given to the farmers.

2. **Establishing exclusive seed production plots**

   Seed production plots of large size, say 1-2 acres, for each identified traditional variety could also be established in the fields of interested farmers by using the seeds purified during previous season.

   Similarly, seed production of identified released varieties can also be planned using foundation or breeder seeds from research centers, if necessary.

   For both options follow the standard procedures for seed production mentioned briefly in Box 10 to ensure quality of seeds. The seeds thus produced will meet all the minimum requirements of good quality seeds and can be considered truthfully labelled seeds. The genetic purity of the seeds produced is not very high, but their extent of purity is much higher than the seeds used

by the farmers. Hence, one can expect better yields by using these seeds. Repeating production of seeds of local variety without mixtures could help in preserving its identity.

Box 10: Standard procedures for seed production

Ensure minimum seed standards specified for each crop related to genetic purity, physical purity, germination percentage and free from pest and disease incidence by following the steps given below.

1. Select interested farmers and train them on seed production.
2. Select fertile and levelled land with possibilities of irrigation for seed production. If already planted field is considered, then choose field with uniform and good crop stand.
3. Maintain required isolation distance between the seed production field and neighboring fields of same crop to avoid contamination through undesirable pollens. The isolation distance will depend on the pollination mechanism of the crop grown (self/ cross/ often cross pollinated).
4. Ensure good crop management such as optimum seed rate, application of sufficient manures, optimum plant population, weed management and plant protection measures for healthy and vigorous crop growth.
5. Follow purification through rogueing of off plants at flowering and maturity stages.
6. Harvest at right stage of maturity.
7. Thresh, clean and grade the harvested produce separately with necessary precautions to avoid mechanical mixtures.
8. Dry the seeds to optimum moisture level and store in proper containers.
9. Keep record of selected fields such as address of farmer, name of variety, date of sowing, crop condition and instructions given to the farmers.

Box 11: Basic requirements for establishing decentralized community-based seed business unit

a. Size and scale of the unit

The seed unit needs to produce seeds for as many crops as possible and not restrict only to the identified FPVs, to reach economic viability. Volume of sales needs to be adequate to cover all costs and to make some profit.

b. Planning for quality seed production

Planning for quality seed production needs to be done meticulously. The plan should include aspects such as number and types of crops (self-pollinated, often cross-pollinated and cross-pollinated), number of varieties in each crop, cropping season, the quantity of seeds, sourcing foundation seeds and training to seed producers. Regular visits of seed certification team to the seed production fields at proper stage of crop growth for assessing genetic purity also need to be planned.

c. Seed processing, testing and packaging centre

Quality of seeds is determined by optimum physical and physiological conditions such as physical purity and moisture content, besides genetic purity. To meet these requirements, establishing a mini seed processing centre is needed, which will take care of proper processing, germination testing and bagging/ packaging of the seed lots. Each seed processing centre needs to have the following infrastructure.

1. Seed grader cum cleaner
2. Bag closer, trolleys, scales and furniture
3. Building to house the equipment
4. Seed storage structure
5. Seed threshing cum drying yard
6. Seed testing laboratory

Mini seed processing unit is a business venture by the community organization for the benefit of the local farming community. Sufficient investment and building space need to be arranged, either from concerned government departments/ funding agencies/ financial institutions or from own sources, for establishing such a unit.

d. Internal quality control system

Success of community seed production venture mainly depends on the supply of quality seeds in sufficient quantity at the right time for crops, which are in demand. The brand under which the seeds are sold should create confidence among the farmers and should be the symbol of assured quality.

Hence, the internal quality control system is an essential aspect. Quality of seed production needs to be monitored by a team consisting of representatives from community organizations (like farmers' federation), technical staff and qualified technical personnel from research institutes.

e. Registration of the Unit

Decentralized seed production and distribution are a business venture and hence, needs to adhere to the existing rules and regulations of seed industry. It needs to register, get a license and comply with all the stipulated norms.

Post-PVS activities

In general, an in-depth assessment of a technological intervention will be done three to five years after its completion. This is the case with PVS also. However, in the case of PVS, it is important to take up structured efforts for two years after the PVS cycle to understand the immediate effects of the identified FPVs in the site. This will help in addressing any constraints in their adoption and in providing feedback to improve the PVS process elsewhere. The following activities are suggested for understanding the immediate effects of PVS:

- Take survey in each village/ Panchayat during cropping season to collect information on spread of identified varieties- i) number of farmers cultivating the identified FPVs, ii) varieties under cultivation, and iii) area under each of such varieties (approximate estimation).

- Select randomly at least ten fields having crops of identified FPV variety in each Panchayat to collect individual farmer's feedback on the performance of the variety. Use the format shared in Attachment 9.

- Collect yield data from three to five random fields from the selected farmers mentioned above in each village/ Panchayat for each variety to verify the farmers' perception on its yielding ability.

- Select 20 PVS trial farmers across the site per each FPV and try to understand the following: a) continuation of cultivation of the identified FPV by the trial farmer, b) if continued, whether that years' experience with the variety reinforced their earlier understanding about the FPV on its advantages and problems and c) the spread of varieties from him/ her to the neighboring and distant area.

- Arrange one FGD in each village/ Panchayat, preferably immediately after the harvest season. Ensure the participation of both men and women farmers, and farmers cultivating newly identified varieties as well as the farmers using other varieties. Elicit the following information on the introduced FPV - availability of seeds, source of seeds, method of sowing, quantity of seeds used per acre, plant population and crop stand, incidence of pest and diseases, response of the FPVs to dry spell or heavy rains if any, crop duration, plant height, tillering ability, panicle size, grain and straw yield, grain shattering, taste, flour recovery and willingness to grow in future with specific reasons.

- After collecting all the information as listed above, it needs to be analyzed to understand the effect of PVS in the target area in terms of: a) Area under newly identified varieties, b) Number

of introduced FPVs cultivated, c) Number of farmers cultivating each of these varieties, d) Increase in yield and other benefits realized by the farmers, e) Self spread effects observed, f) General opinion of the local farming community and g) The factors constraining the spread of the variety.

- The results need to be shared with the committee of community members formed in the site to validate and get additional comments and suggestions for increasing the spread of the variety. An action plan needs to be prepared to facilitate the spread of variety with the support of the community.

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Resources for further learning

Plant Breeding With Farmers: A Technical Manual, Author: Salvatore Ceccarelli

This manual on Participatory Plant Breeding (PPB) is based primarily on the direct experience derived from several years of implementing PPB programs in a number of countries and on a number of crops, and secondly, from a number of training courses (China, Ethiopia, Jordan, Australia, South Africa) and when necessary, on relevant scientific literature, as part of the ICARDA research program. The methods presented here have been used by in rural communities over the course of several years particularly in North Africa (Tunisia, Morocco, Egypt and Algeria), the Horn of Africa (Eritrea and Ethiopia), the Arabian Peninsula (Yemen), the Near East (Syria, Jordan and Iran) and by others (NGOs, Universities, IARCs, etc.) in other countries. Most probably, the methods described will not suit every situation that researchers and partners are likely to encounter; therefore, the manual will attempt to give some general principles that may help in adjusting the methodologies to new situations.

Guide to Participatory Varietal Selection for Submergence-tolerant Rice

Authors: T.R. Paris, D. Manzanilla, G. Tatlonghari, R. Labios, A. Cueno, and D. Villanueva, IRRI, 2011

The Green Revolution averted the threat of famine through the rapid adoption of improved rice varieties. However, despite this huge success, hundreds of millions of poor rice-farming families in rainfed areas still live in poverty and suffer from food (rice) insecurity. Despite many improved rice varieties released for rainfed conditions, farmers still use local varieties that can withstand drought and floods but have low yields or they use the same varieties for many years because of a lack of better varieties. Rainfed rice farmers are slow to adopt improved varieties because of several problems. One problem is more of extension than breeding - many farmers, particularly those living in remote rainfed areas, may not have access to or information about the seed of new varieties. Another problem is that variety testing programs are often conducted on-station, which does not represent farmers' fields. Moreover, conventional rice breeding programs usually seek farmers' input only at the very end of the process, when newly released varieties, usually one or two per year, are evaluated in on-farm demonstration trials. Often, in remote and unfavorable areas, subsistence farmers, who comprise the majority of

the rural farming population in Asia, give importance to social and cultural dimensions aside from the agronomic performance of the new rice varieties. The complexities of developing acceptable varieties for variable and stressful rainfed environments require that breeders become deeply familiar with men and women farmers' needs and preferences. Since 1977, IRRI has been making efforts to improve communication among farmers, breeders, and extension workers so that men and women farmers' concerns and preferences are considered in plant breeding objectives. Participatory varietal selection (PVS) is a simple way for breeders and agronomists to learn which varieties perform well on-station and on-farm and to obtain feedback from potential end users in the early phases of the breeding cycle. It is a means for social scientists to identify the varieties that most men and women farmers prefer, including the reasons for their preference and constraints to adoption. Based on IRRI's experience in collaboration with national agricultural research and extension system partners and farmers, PVS, which includes "researcher-

managed" and "farmer-managed" trials, is an effective strategy for accelerating the dissemination of stress-tolerant varieties. PVS has also been instrumental in the fast release of stress-tolerant varieties through the formal varietal release system. This guide on PVS will complement the various training programs given by IRRI for plant breeders, agronomists, and extension workers engaged in rice varietal development and dissemination.

Participatory tools working with crops, varieties and seeds: A guide for professionals applying participatory approaches in agrobiodiversity management, crop improvement and seed sector development

Authors: Boef, W.S. de; Thijssen, M.H.

Outline to the guide: Within our training programs on local management of agrobiodiversity, participatory crop improvement and the support of local seed supply participatory tools get ample attention. Tools are dealt with theoretically, are practiced in class situations, but are also applied in field study assignments. The objectives of practicing participatory tools in training on local agrobiodiversity management and related to that of the objectives of this guide are many. However, the current guidebook has the following key objective to provide professionals working in genetic resources management, crop improvement and seed sector development context a kit with a diversity of tools developed for participatory learning and

action that have been adapted to their specific context. In addition to this main goal, we aim to enhance those professionals' creativity and flexibility in conducting group-oriented, participatory learning and action types of diagnosis, research planning and implementation, and monitoring and evaluation with agrobiodiversity, plant breeding and seed projects. We used the handbook as developed by Frans Geilfus, which covers 80 tools for participatory development as an important base for this tools guide. A selection of tools from Geilfus and others have been adapted in a series of participatory instruments that support agrobiodiversity management, crop improvement and seed sector development. The structure is basically derived from this book. The examples and selection of tools have been inspired on actual experiences during courses on participatory crop improvement, seed sector development, and local management of agrobiodiversity as organized by Wageningen International over the last 10 years. Some other tools are derived from other sources. The tools have been tested in local projects in various countries in South America (Brazil, Colombia, Ecuador, Peru and Venezuela), West Africa (Ghana, Nigeria, Cameroon and Côte d'Ivoire), Ethiopia, Nepal and India. The guide has been designed in such a way that it is easy to use as a reference in the field. The sequence of the tools is like that often used in participatory analysis, starting with general tools, moving to tools providing more details on specific topics, and going up to more analytical tools that can be applied with communities, but also can assist the facilitation team in analyzing (after the diagnosis) the information gathered. However, which tools to apply, what type with whom, in what sequence, depends very much on the setting and the objectives of the exercise. Please consider this not a recipe book, but rather a kit with tools you can or may use. We consider the guide an inspiration to encourage you in adapting, merging and thereby designing your own tools.

Quantitative Analysis of Data from Participatory Methods in Plant Breeding

Editors: Mauricio R. Bellon and Jane Reeves

Although Participatory Plant Breeding (PPB) is gaining greater acceptance worldwide, the techniques needed to analyze the data from participatory methodologies in the context of plant breeding are still not well known or understood. Scientists from different disciplines and cropping backgrounds, working in international research centers and universities, discussed and exchanged methods and ideas at a workshop on "The Quantitative Analysis of Data from

Participatory methods in Plant Breeding". The papers in this volume address the three themes of the workshop: designing and analyzing joint experiments involving variety evaluation by farmers; identifying and analyzing farmers' evaluations of crop characteristics and varieties; and dealing with social heterogeneity and other research issues. Topics covered included different statistical methodologies for analyzing data from on-farm trials; the mother- baby trial system, which is designed to incorporate farmer participation into research; the identification and evaluation of maize landraces by small-scale farmers; and a PPB process that aims to address the difficulties of setting breeding goals and choosing parents in diversity research studies. Summaries of the discussion, as well as the participatory breeding work currently conducted by the participants, are provided.

Seed Production Techniques for Vegetables

Publisher: Centre for Indian Knowledge Systems (CIKS), Chennai; Publishing date: 2013

This manual is part of a series of booklets published by Centre for Indian Knowledge Systems (CIKS), the RRA Network's thematic node for seeds, to build the capacity of the Comprehensive Pilots as well as various field groups who are involved in the efforts to build community managed seed systems. This publication describes the procedures involved in the production of quality seeds of 15 vegetables.

Glossary

ANOVA – It is a statistical tool for partitioning the total variation among the treatments in an experiment due to various sources and for finding statistical significance of the outcome of the experiment.

Baby trial – The location specific 1 or 2 promising varieties identified among the tested varieties in mother trials are again evaluated in baby trials for validating their field performance by more number of farmers in comparison with their own varieties.

Biodiversity fair – Biodiversity fair is a participatory tool for raising public awareness on the value of conserving local landraces, bringing the farmers from different communities together to exhibit the range of landraces so that traditional systems of seed and knowledge transmission continue to conserve.

Check variety – The popular or standard variety against which the identified or developed new varieties are tested for their performance.

Community seed bank – These are community organizations involved in conservation and promotion of local varieties. Community Seed Banks provide farmers with free and easy access to seeds of local varieties under the condition that a farmer returns twice the number of seeds he or she borrowed.

Crop improvement/ Plant breeding – It is the art and science of changing the traits of plants/ crops to produce desired characteristics.

Cross pollination – When pollen is exchanged between different flowers from the same or different plants.

Cultivar – A plant variety that has been produced in cultivation by selective breeding.

Entries – Treatments or varieties under test in an experiment

Experimental design – These are statistical designs developed for testing accurately the treatment effects.

Farmer-preferred variety – The variety developed or identified through participatory crop improvement approach for a specific area.

Farmers Preference Analysis (FPA) –It is a participatory method in which the local farmers assess the varieties included in the mother trial and share their preferences, and observations and opinions about the varieties.

Focus group discussion (FGD)- It is a rapid assessment and semi-structured data collection method in which a purposively selected set of participants gather to discuss issues and concerns based on a list of key themes the researcher/facilitator has earlier drawn up. It is a cost-effective technique for eliciting views and opinions of farmers—the clients of prospective innovations Seasonal calendars- A seasonal

calendar is a visual participatory research method of showing the distribution of seasonally varying phenomena (such as economic activities, resources, production activities, problems, illness/disease, migration, and natural. events/ phenomena) over time.

Fixed lines – The lines (varieties) selected from segregating populations, which are mostly homozygous, homogeneous, and stable.

Genetic purity – It is one of the criteria for determining the quality of the seeds where the crop raised from such seeds show uniformity in most of the traits.

Gene bank – Gene banks are a type of biorepository, which preserve genetic material. For plants, this could be by freezing cuttings from the plant or stocking the seeds (e.g. in a seed bank). For animals, this is the freezing of sperm and eggs in zoological freezers until further need.

Growth parameters – The parameters related to plant growth performance such as maturity, plant height, colour, etc.

Informal Research and Development (IRD) – In IRD, the varieties selected through mother and baby trials are given to a large number of farmers for dissemination and further validation of their suitability to the location.

Isolation distance – The minimum distance suggested between two varieties of the same crop to avoid genetic contamination of the variety under seed production.

Key informant surveys – These are interviews with selected key individuals who have extensive experience in a certain community or specialized knowledge or skills on a particular topic (Box 1). One disadvantage here may be the possible biases of the individuals being interviewed. Thus, it is important to validate or ask probing questions that will verify the information given.

Matrix ranking – It is a tool to compare and characterize in qualitative and quantitative manner a range of varieties. It is used to compare local varieties, or to compare local varieties with introduced or tested varieties. It shows how farmers evaluate varieties. Matrix ranking is also helpful in comparing and evaluating other resources, issues and ideas.

Mother trial – It is on-farm experimental trial conducted for evaluating a set of promising varieties, which may comprise genetically improved lines or traditional cultivars or combination of both, under prevailing cultural practices followed by the participating farmer for the purpose of participatory varietal selection. The experimental design usually followed is replicated trial like the ones conducted on research farms but it could also be unreplicated trial.

Often cross pollinated varieties – In many self-pollinating species, cross pollination may occur up to 5% or even reach to 30%; such species are referred as often cross pollinating species

Open pollinated varieties – Open-pollinated varieties are stable varieties resulting from the pollination between the same or genetically similar parents. Not hybrid.

Organoleptic test – The analysis of the properties of products and materials-mainly foodstuffs- by means of the sense organs.

Pairwise ranking –It is a tool to compare varieties and know how farmers evaluate varieties. During probing, it is important that the facilitators record the reasons for choosing a variety when comparing them.

Participatory crop improvement – Development and identification of suitable varieties through participation of farmers.

Physiological maturity – For most seed-producing crops, it is that stage of growth in which the plant has completed all of its development, including seeds which, when planted, can survive on their own. In non- seeding crops such as potatoes, it is the stage when all plant development has completed and the desirable part of the plant (in this case, the tuber) can be harvested.

Participatory varietal selection (PVS) – It is a system for identifying location specific most suitable varieties for enhancing productivity as well as varietal diversity in a particular location. It involves evaluating performance of a set of varieties on farmers' fields by the local farmers, scientists and other stakeholders.

PVS cycle – It is the period in which farmers and scientists evaluate the base materials (potential varieties) for their suitability for a particular location together.

Quality seeds – The seeds showing expected levels of physiological viability, physical purity and genetic purity with optimum level of moisture content.

Released variety – Variety developed and evaluated by professional plant breeders in research organizations like agricultural universities and recommended for release by State or Central Variety Release Committee.

Replicated trial – It is an experimental design where a particular treatment or variety is repeated more than once for reliability of its performance.

Rogueing– Removal of off type plants of the same crop in the seed production plot to avoid mechanical and genetic contamination. Off types should be removed before their flowering stage. Off- types should also be removed after harvest, during drying, processing and storage. Timely rogueing is critical for the conservation of the genetic purity of the seeds.

Self-pollination – When pollination takes place within a single flower, usually before it opens.

Traits – Characters of plants determined by their genetic factors.

Traditional variety – Variety identified and cultivated by the local farmers over a long period. While most of the traditional varieties are well suited to the place of origin, some of them may show wider adaptability.

Unreplicated trial – It is an experimental design where particular treatment or variety is not repeated more than once. Such a research design is followed when replicated trials are not

feasible for various reasons. Unreplicated trials are repeated many times within a geographical area in such a way that each trial is considered as a single replication.

Yield parameters – The parameters related to yield components like grain yield and straw yield per unit area and grain size.

About

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a pioneering non-profit organization focused on scientific research for development, committed to transforming dryland farming and agri-food systems. Working with global partners, ICRISAT develops innovative solutions to address hunger, poverty, and environmental degradation, benefiting 2.1 billion people across the drylands of Asia, Africa, and beyond.

ICRISAT was established under a Memorandum of Agreement between the Government of India and CGIAR, dated 28 March 1972. In accordance with the Headquarters Agreement, the Government of India has extended the status of a specified "International Organization" to ICRISAT under section 3 of the United Nations (Privileges and Immunities) Act, 1947 of the Republic of India through Extraordinary Gazette Notification No. UI/222(66)/71, dated 28 October 1972, issued by the Ministry of External Affairs, Government of India.

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