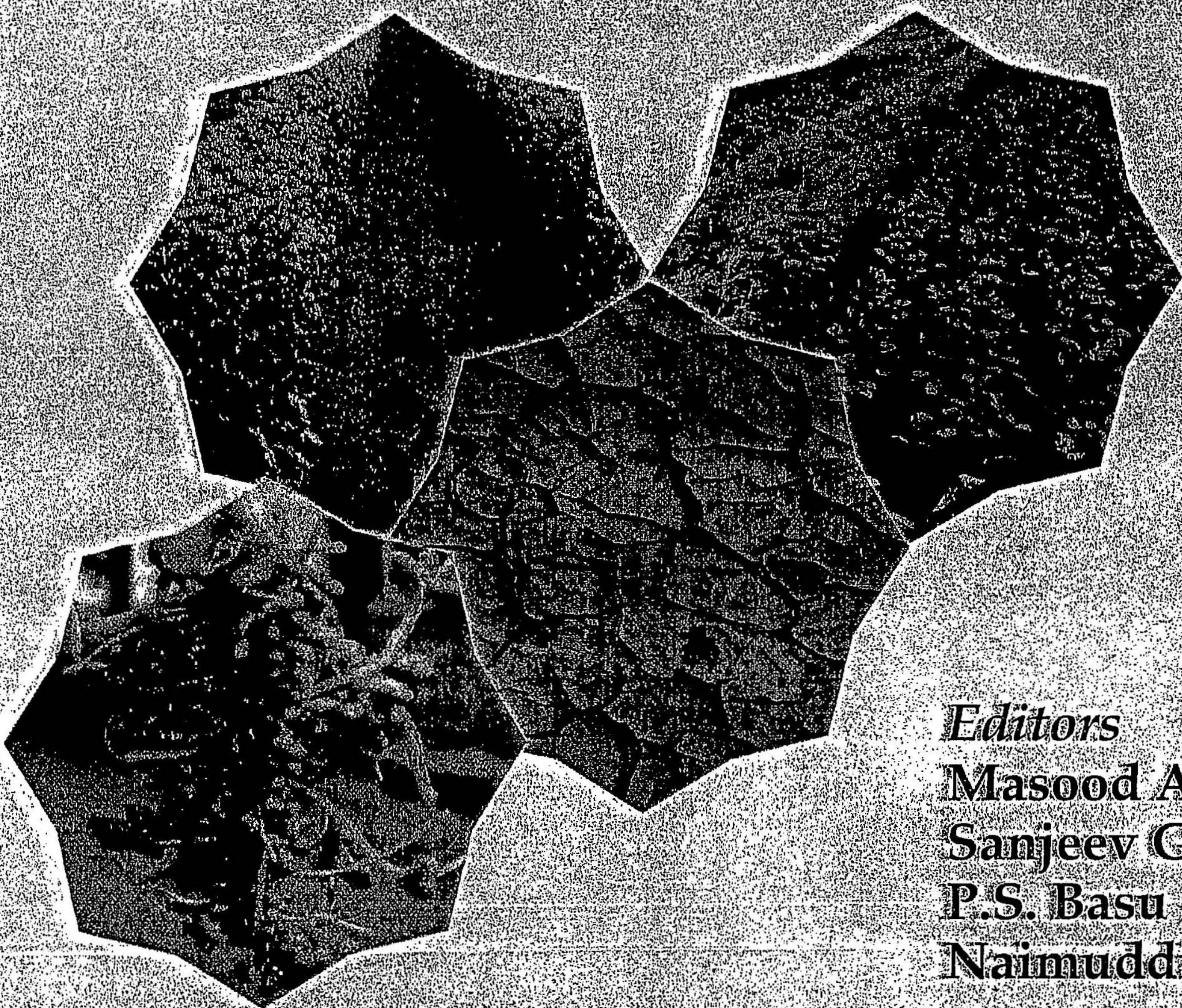
Legumes for Ecological Sustainability



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Designing farmer-participatory varietal selection

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ABSTRACT

Farmer-participatory approach in agricultural research and development is gaining increasing popularity among researchers, policy makers and development investors. Besides complementing on-station research, it provides an alternate channel to researchers to allow them to reach farmers quickly with greater acceptance of technological innovations among the farming communities. The farmer-participatory approach ensures that technological innovations are compatible with local agroecological conditions and socio-economic and cultural profiles of the farmers. Researchers need to follow certain principles to ensure success of farmer-participatory approach as farmer is the ultimate decision maker in this approach. The same general principles apply in participatory varietal selection also. The advantages of participatory plant breeding include improved local adaptation, promotion of genetic diversity, increased breeding efficiency, evaluation of 'subjective' traits and empowerment of rural communities. The 'subjective' traits include taste, aroma, texture and other characteristics that determine suitability of a particular variety for local culinary use. However, these advantages involve high cost of breeding programmes, high cost for participating farmers and additional training to scientists in farmer-participatory approaches. The paper discusses various issues (number of genotypes, plot size, number of replications, experimental design, choice of control etc.) involved in generating credible data of wide spread acceptability from participatory varietal selection trials.

Introduction

The conventional approach in varietal development and release in India and in many other countries follows a set path: making desired crosses, generating and selecting in breeding populations for desired traits using appropriate screens, stabilizing the selected breeding lines and on-station evaluation of these stabilized breeding lines for identifying lines for inclusion in national/state testing systems. Based on their performance in multilocation national/state on-station evaluation trials, varieties are identified for release and notification by appropriate authorities. Newly released varieties in India are demonstrated to farmers through front-line demonstrations conducted in their fields. Except for farmer-related awareness events (farmers' field days/fairs *etc.*), in the whole process of variety development, evaluation and release, farmers, the ultimate users of genetic enhancement research products, are no where in the scene. Barring well-endowed environments, most of the improved varieties developed through conventional approach fail to receive farmers' acceptance in high risk marginal environments. As a consequence, the rate of adoption of new varieties (variety replacement rate) and their area coverage (seed replacement rate) remain dismal, particularly in the case of legumes in rainfed marginal environments; thus depriving the resource poor farmers of the benefits of public investments made in variety research and development.

Farmer-participatory approach in agricultural research and development provides an alternate channel to obtain faster acceptance and impact of new technologies in farmers' fields. It brings farmers at the centre stage. In spite of initial skepticism on the part of scientific community and policy makers on farmers' being at the centre stage and decision maker, the farmer-participatory approach has rapidly gained popularity in the past few years with due consideration being given to the knowledge, problem and priorities of farming families.

On-farm trials can be broadly classified into three categories: researcher designed and researcher managed, researcher designed and farmer managed, and farmer designed (assisted/prompted by researcher) and farmer managed (Franzel *et al.* 2001). Each category of trials serves different objectives. The first category assesses the biophysical properties of different materials, the second eli
determines the acceptability of different materials and/or promote farmer innovations. The farmer-participatory on-farm research does not replace on-

station research, rather complements it and enhances the rate of progress and impact of agricultural research and development on the livelihoods of poor farming communities, particularly, in high risk marginal rainfed environments. However, as the participation of farmers increases, they must invest increasing amounts of time, energy and resources and provide intellectual inputs and draw up on sophisticated analytical skills.

Principles of participatory on-farm research

On-farm research is a step-by-step procedure. A systems perspective in on-farm research is essential as no farm activity exists in isolation. It is important to keep the following principles in mind while planning and executing farmer-participatory on-farm research.

1. **Understand farmers and their socio-economic and cultural conditions:** Natural and socio-economic circumstances and cultural factors influence farmers' decision on production and consumption and their attitude towards a new technology.
2. **Farmers determine the course of action:** Farmers are the primary stakeholder in participatory on-farm trials. They have better understanding of needs and opportunities their fields offer; they should determine the subject of research and choice of appropriate technology.
3. **Role of scientists:** Scientists should help farmers in articulation of their demand for innovation, to offer a choice of technological options to satisfy their demand and provide principles and methods for testing suggested options. The suggested options should be technically sound, economically viable and warrant sustainability.
4. **Testing of options:** The suggested options are to be tested in farmers' fields under farmers' management and using farmers' own practice as control. Thus, the control may vary from farmer to farmer in a participatory on-farm trial. The scientists could use an option to add an additional control from their side which would be common across farmers in a trial.
5. **Evaluation criteria:** The response of farmers is the primary criteria of evaluation as they are the ones who would decide whether an option is adopted or not. The success of an option is measured by its adoption.

It is important to involve extension workers in the participatory research process right from the beginning. Their participation in planning and assessment of technologies helps to accelerate the dissemination of results. Participatory farmers also play a significant role in knowledge transfer in farmer-to-farmer extension.

Participatory genetic enhancement research

Although farmers were the first who domesticated the crop from wild about 12000 years ago for human consumption, the modern plant breeding separated from farmers' breeding

The modern plant breeding evolved based on Darwin's theory of evolution through selection based on principles of genetics and statistics with strong partnership with other disciplines such as physiology, pathology, entomology and biochemistry. In traditional farmers' breeding, the farmer carried out all the tasks associated with plant breeding - selection of source germplasm, trait improvement, cultivar development and final evaluation of varieties whereas in modern breeding all these tasks are performed by the scientist (Morris and Bellon 2004). The farmers' varieties were location specific where as the modern breeding focused on geographically wide adaptation.

With the advent of participatory approach, three models of participatory breeding have emerged: (i) Complete participatory breeding where all the earlier described tasks are carried out jointly by farmer and researcher, (ii) Efficient participatory breeding where farmer and researcher interface at selection of source germplasm and varietal evaluation stages, and (iii) Participatory varietal selection where both researcher and farmer come together at the varietal evaluation stage (Morris and Bellon, 2004).

The advantages of participatory plant breeding include improved local adaptation, promotion of genetic diversity, increased breeding efficiency, evaluation of 'subjective' traits and empowerment of rural communities. The 'subjective' traits include taste, aroma, texture and other characteristics that determine suitability of a particular variety for local culinary use. However, these advantages involve high overall cost of breeding programmes, high cost for participating farmers and additional training to scientists in farmer-participatory approaches.

To encourage participatory plant breeding, national regulatory framework that governs evaluation, approval and release of new varieties will have to modify its rules and regulations. Similarly, ways are needed to ensure that participating farmers receive due credit for the products of farmer-participatory plant breeding. A record of their contributions should be properly maintained.

Designing participatory varietal selection

In participatory varietal selection, farmers evaluate in their fields finished or near finished products of plant breeding. It is also important to bring in traders/millers/food processors/consumers in the evaluation process to ensure farmer-market [illegible] facing the participatory varietal selection is to develop evaluation methods capable of generating credible data of widespread acceptability.

Choice of villages and fields: The objectives of the on-farm research and the recommendation domain guide the selection of villages. A multistage sampling scheme should be used with village as the primary unit and farming households as secondary units. As large variation exists among farmers' fields, they should be selected carefully to ensure conclusions apply to appropriate group of farmers. The farmers/fields should be grouped according to socioeconomic conditions and agroecologies. A representative sample of fields and farmers who are willing to participate in on-farm research should, then, be selected for on-farm trials. Stratified sampling may be adopted to ensure that a wide range of fields are selected. The sample of farmers should be large enough for valid analysis when split into different groups for example soil type, tenants and owners, access to credit or not *etc*. Repeated use of the same village for on-farm research should be avoided as such villages become less representative of the region.

Priority setting: Focus group interviews and matrix ranking techniques can be useful for eliciting and prioritizing traits of importance to selected group of end users. If respondents are selected using valid sampling methods, the scores or ratings can be analyzed in a statistically rigorous way (Coe 2002). In the case of participatory genetic enhancement research, it is essential to take cognizance of preference of all the players engaged in production-processing-marketing-consumption chain – farmers, traders, food processors and consumers. Such information is essential to align the on-station breeding programme with demands of farmers, market and consumers.

Choice of treatments and units: Based on priority traits identified by all stakeholders (farmers, traders, millers, food processors and consumers), appropriate released varieties/prerelease varieties/advanced breeding lines from different sources should be assembled by the researcher for inclusion in participatory varietal selection trials. All relevant information (description and performance data) on these selected genotypes should be presented to the group of participatory farmers who make the final choice on genotypes to be included in a trial. Sometimes, farmers may suggest a few varieties from their side, which they might have heard or learnt about from different sources. Although it is desirable to have a uniform set of genotypes in a trial, sometimes, trial composition may vary among the farmers depending up on their choice and preference. Farmer's current variety should be included as 'control' in the trial. However, this 'control' variety may vary from farmer to farmer. Therefore, researcher should also include one more standard 'control' variety which should be common across all the locations of a trial.

The minimum number of test genotype in a trial could be one. However, there is no consensus on the maximum number of genotypes to be included in a participatory trial. Although 20-30 genotypes are mentioned as maximum number in some literature, the author's experience working with farmers in Andhra Pradesh indicates that inclusion of more than 8-10 genotypes in a participatory varietal selection trial could confuse the farmers and make the choice of preferred variety/varieties difficult.

Plot size: It is often assumed that the plot size should be larger for on-farm than for on-station trials. However, there is no statistical justification for this assumption. Normally, there is balance between the preference of farmer and researcher for larger plots on the basis of realism or ease of application and the statistical precision from more smaller plots. In the case of participatory varietal selection, availability of seed of selected genotypes also has a bearing on the plot size. If fewer treatments are there in a trial or lateral interference (*e.g.*, in fertilizer or irrigation management trials) is considerable, a larger plot size may be advisable. One has to keep 'border effects' also in mind while deciding up on plot size. The desire for larger plot size should not lead to a burden on participatory farmers. For variety trials, 30-50 m^2 plot size is suggested in literature (Werner 1993).

Number of replications: For precise treatment comparisons, there needs to be sufficient replications. It is preferable to have more fields and fewer repeats of the same treatment per field rather fewer fields and more replication within a field. Consequently, there could be more farmers but each farmer with one replicate of each treatment. More than two replications to be appropriate in trials with farmer participation (Werner 1993). If the objective of the on-farm trials is to also study farmer x treatment interaction, replicating the trial in the same field will be obvious way to do this. The number of replications required will be dependent on the number of treatments, the number of zones or target groups defined, the expected degree of precision sought and the expected magnitude of difference to be detected. As a rule of thumb, degrees of freedom for the error term in ANOVA between 15 (Mutsaers *et al.* 1986) and 20-30 (Hammerton and Lauckner 1984) are suggested in the literature. If the variability due to environment or management practices is expected to be small, fewer degrees of freedom would suffice. Table 1 gives a procedure to calculate degrees of freedom for error in a randomized complete block design.

Table 1: Procedure to calculate degrees of freedom for error in a randomized complete block design

Trial design		Degrees of freedom for error
Replication within field	**Different zones (or target groups)**	
No	No	(f-1) (t-1)
No	Yes	z (f-1) (t-1)
Yes	No	f (r-1) (t-1)
Yes	Yes	z f (r-1) (t-1)

t= number of treatments, f= number of fields per zone (or target group), r= number of replications per field, z= number of defined zones or target groups

(Adapted from Werner 1993)

Layout in each field will primarily be guided by perceived or known variation within the field. Farmers' knowledge about the variation in their fields should come in handy in locating and blocking the trial. Ideally, as far as possible, the whole trial should receive a homogenous growing environment.

Experimental design

Experimental design requires consideration of composition and nature of treatments, field layout to apply treatments and replication of treatment within and across farmers' fields. Complex experimental designs should be avoided in farmer-participatory on-farm research.

Participatory varietal selection trials are single factor trials where each variety stands on its own and is compared with all other varieties. A randomized complete block design is the simplest design to follow if all varieties occur at least once in each farmer's field. One-farmer one-replicate approach is found practical in farmer-participatory on-farm research. However, if we wish to estimate intra- *vs.* inter-farmer variability and genotype x farmer interaction, replicated trials will have to be conducted in each field.

'Mother-baby' varietal evaluation system (Snapp 2002), which has become popular in recent years, combines Category 1 and Category 2 of farmer-participatory trials in different locations within the same target area. Some breeders believe that 'mother-baby' trial system provides a cost effective approach to generate data that are credible to all involved in the plant breeding process. 'Mother-baby' varietal evaluation system consists of two types of trials – mother trial (Category 1) and baby trial (Category 2). The mother trial consists of a full set of varieties with different replicates distributed in different sites within a village. Baby trials are single replicate sub-set of varieties included in mother trial laid out in farmers' fields in the vicinity of mother trial. A typical scenario would be one replicated mother trial and numerous unreplicated baby trials within one village. Field design of mother trial, depending up on nature and number of treatments, could be suitably chosen – complete (RCBD) or incomplete block (lattice or alpha) designs. Baby trials can also be designed using incomplete block design (such as alpha) provided all baby trials in a village are treated as a single trial. However, in case alpha design is followed for baby trials, farmers loose the freedom to choose the treatments. For agronomic treatments, split plot/strip plot designs could be considered.

Observations to be recorded: In general, objectives of the trial determine what variables should be measured. Data could be quantitative, qualitative, textual, visual or verbal. Key data set would include the following.

Primary experimental data (depending up on defined objectives)

- Yield parameters (and oil content in case of oilseed crops) as defined by objectives
- Farmers' response
  - (a) End of season = Farmers' assessment of produce quality (colour, processability, cooking quality, taste, storability *etc.*), effectiveness of resource utilization (productivity related to area of land, inputs and labour) and availability of inputs and marketability of produce.
  - (b) In the season following trial season = Adoption/degree of adoption of tested technology, reasons for adoption/ non-adoption and modification tried by farmers

Supporting data (useful for analysis of agronomic data)

- Days to emergence and germination count/score
- Days to flowering and maturity
- Plant stand at harvest
- Incidence of diseases and insect pests
- Dates of key field operations
- Type and amount of inputs used

Socio-economic data

- Farm and family size
- Labour resource availability
- Distance to input and produce markets
- Input costs and produce price in local market
- Benefit: cost analysis

Environmental data

- Daily rainfall record

- Field slope and location
- Soil type and nutrient status
- Plot history

Review of results and conclusion : Researchers should present results of trials (both primary experimental data and supporting data) in a farmer-friendly manner to a group of participating and other farmers in the village. They should facilitate the discussion. Farmers after considering all available information may decide on the choice of variety/varieties that they would like to grow in their village next season.

In spite of proper planning and good intention of all the partners, one has to be prepared for 15-20% failure in trials due to various reasons including failure of rains, breakout of diseases and pests, animal damage, pressing social obligations of partner farmers etc. It is always desirable to have as a backup a full set of replicated on-farm trial at research station or KVK located in the target region. Although, there is increasing awareness of farmer-participatory research and development approach, it is still evolving and is highly flexible.

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