



Designing Participatory Varietal Selection of Finger Millet With Hill Farmers in South Asia: A Methodological Guide

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Abstract

Finger millet is a staple of rainfed hill farming in Nepal, in the Indian Himalaya and in the uplands of peninsular India, yet most of the area is still sown to landraces and few released varieties have spread beyond the plains and plateaux for which they were bred. Participatory varietal selection, in which farmers test a small set of finished varieties on their own land and under their own management, was developed for exactly this kind of gap. This article proposes a design for applying it to finger millet in hill communities. It reviews the methodological sources, compares the trial formats available, and sets out five stages: understanding what farmers need from a variety, assembling candidates that match those needs, running mother and baby trials, evaluating the entries jointly with women and men farmers in the field and after harvest, and linking the preferred varieties to seed supply and formal release. Advice is given on analysing rankings alongside yields and on consent, seed rights and inclusion. The design is proposed from the literature and from the known features of the crop and its farming system. It has not been applied or validated here, and the article states what an application would need to show.

Keywords: *Participatory varietal selection, Finger millet, Eleusine coracana, Hill agriculture, Mother and baby trials, Farmer preference*

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1. Introduction

Finger millet, *Eleusine coracana*, was domesticated in the highlands of eastern Africa and has been grown in South Asia since antiquity (Hilu and de Wet, 1976). It is known as ragi in southern India, mandua in Uttarakhand and kodo in Nepal. The crop tolerates thin soils and uncertain rain, stores for years without serious insect damage, and gives a grain unusually rich in calcium, qualities that have earned it a place in every account of neglected cereals (National Research Council, 1996). On terraced hill land it is commonly transplanted or sown into standing maize as a relay crop, and its straw is valued as winter fodder.

Plant breeding has served these systems poorly. Varieties are selected on research stations with better

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soil and more inputs than a hill terrace receives, and are judged mainly on grain yield. Farmers weigh other things as well: maturity that fits the relay with maize, straw yield, ease of threshing, resistance to blast, and the quality of the flour for local dishes. A variety that wins on the station may therefore be turned down on the farm, and a variety that farmers would have liked may be discarded before they ever see it. Participatory varietal selection was devised to close this gap by letting farmers choose among finished or nearly finished varieties under their own conditions (Witcombe *et al.*, 1996).

This article proposes a design for participatory varietal selection of finger millet with hill farmers. It is a methodological guide. It does not report a programme that was carried out, and no farmer data are presented. The design is assembled from published methods and from what is generally known of the crop, and it should be read as a proposal awaiting field application.

2. Background

The proposal rests on two bodies of work: the development of participatory methods in plant breeding since the 1990s, and the trial formats that grew out of it.

2.1. Participatory varietal selection and its rationale

The approach was set out in a series of papers from projects in India and Nepal. Joshi and Witcombe (1996) described four steps, namely identifying farmers' needs, searching for suitable material, testing it in farmers' fields and disseminating what farmers prefer, and that sequence still organises most programmes. Participatory varietal selection deals with fixed lines, and is distinguished from participatory plant breeding, in which farmers select within segregating material (Sperling *et al.*, 2001). Later writing recast both as forms of client-oriented breeding, the point being that the purpose is a better fit to users and that participation is the means (Witcombe *et al.*, 2005). An early application to finger millet in Karnataka was reported by Gowda *et al.* (2000).

There is a quantitative argument as well as a social one. Atlin *et al.* (2001) examined decentralised selection with the tools of selection theory and showed that selecting in the target environment is advantageous when the genetic correlation between station and farm is low, provided that on-farm trials are replicated well enough to keep heritability acceptable. Hill agriculture, with its steep gradients in altitude, aspect and soil depth over short distances, is a setting where that correlation is likely to be weak. Experience with barley in dry areas led Ceccarelli and Grando (2007) to the same position, and the practical methods are collected in a handbook edited by Ceccarelli *et al.* (2009).

2.2. Trial formats

Several formats exist for testing varieties with farmers, and they differ in what they measure and in the burden they place on participants. The mother and baby design pairs a small number of replicated trials containing all entries with many single-entry or few-entry plots managed entirely by farmers (Snapp, 2002). Triadic comparison of technologies, known as tricot, gives each of a large number of farmers three entries drawn from the full set and asks only for rankings (van Etten *et al.*, 2019). Farm walks and post-harvest tests can be attached to either. Table 1 compares the formats. For finger millet in the hills this article proposes the mother and baby design as the core, for reasons given under the third stage below.

3. The Proposed Design

The design has five stages spread over a preparatory season and at least two cropping seasons. Figure 1 shows the stages with the main output of each. The description assumes a team from a national research station or a non-governmental organisation working in a cluster of villages that share a watershed but span a range of altitude.

3.1. Stage 1: Understand what farmers need

Work begins in the season before any trial, with the methods of participatory rural appraisal (Chambers, 1994). Group discussions, held separately with women and with men, establish which landraces and varieties are grown, on what kind of land, in what sequence with other crops, and why. A matrix ranking

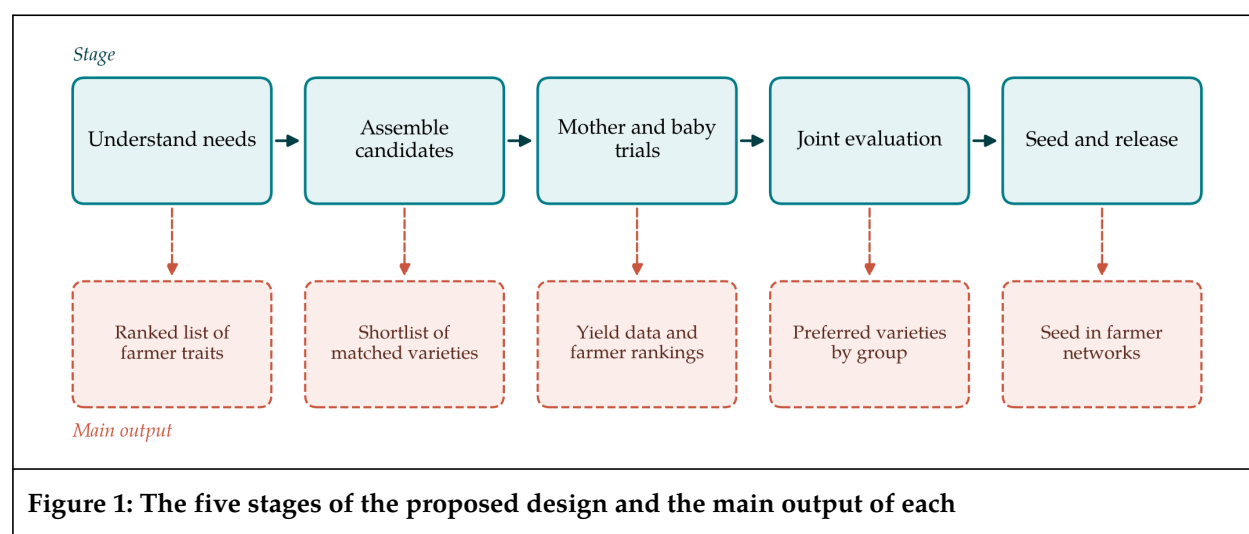
exercise turns the discussion into a list of traits ordered by importance. Women do much of the transplanting, weeding, harvesting and all of the processing of finger millet in most hill communities, so their ranking may differ from that of men and must be recorded on its own. The team also walks transects from valley floor to upper terraces to define the land types that the trials will have to represent. The stage ends with a short written profile of the variety farmers are looking for in each land type.

Table 1: Trial formats used in participatory varietal selection, compared for use with hill farmers

Format	What it involves	Strength	Limitation
Mother trial	All entries together, replicated, researcher-designed and farmer-managed	Measured yields; side-by-side viewing	Few sites; needs a larger plot
Baby trial	One or two new entries beside the farmer's own variety	Real management; many households	Yields are rough; entries unbalanced
Tricot	Three entries per farmer from a larger set; rankings only	Scales to many farms and environments	No direct yield measurement
Farm walk	Group visit to a mother trial near maturity with scoring or voting	Quick; reveals reasons for choice	Dominant voices can sway the group
Post-harvest test	Threshing, milling, cooking and tasting of each entry	Captures traits invisible in the field	Needs enough grain of every entry

3.2. Stage 2: Assemble candidate varieties

The search for entries is guided by the profile from the first stage and not by what happens to be on the shelf. Three sources are worth combining: varieties already released for comparable environments, including those released in a neighbouring state or country; advanced lines from national breeding programmes; and landraces from other hill districts held in genebanks. The core subset of the finger millet collection described by Upadhyaya et al. (2006) offers a structured sample of the last. Between six and ten entries, including the most popular local landrace as a check, is a manageable number. Seed must be obtained under the proper agreements and checked for germination and for seed-borne disease before it is distributed.



3.3. Stage 3: Mother and baby trials

A mother trial containing all entries in two or three replicates is placed on each main land type, on land lent by a farmer who then manages it in the usual local way. Around each mother trial, a larger number of households grow baby trials. Each baby consists of one or two new entries next to the household's own variety, on plots large enough to yield grain for a family meal and straw for a fair comparison. Entries are

allotted so that every one of them appears on a similar number of farms. The design is preferred here to *tricot* for two reasons. Finger millet programmes in the hills usually need measured grain and straw yields to support a release proposal, which mothers supply. And terraces are small, so that a baby with one new entry is easier to host than three unfamiliar ones. Where a programme already has release data and seeks only wide testing, *tricot* would be the better choice.

3.4. Stage 4: Joint evaluation in the field and after harvest

Evaluation takes place at three moments. Near maturity, farmers visit the mother trial in a farm walk. Entries are identified by number, not by name, and each visitor casts votes privately for the entries liked most and least before the group discusses reasons; women and men vote with tokens of different colours so that the tallies can be separated. At harvest, grain and straw are weighed from the mothers, and blast and lodging are scored. After harvest, households that grew babies are asked to rank the new entry against their own for each trait in the first-stage list, and a tasting session is held in which flour from each entry is cooked into the local staple, such as *roti* or the thick porridge called *dhindo*, and scored without the entries being identified.

3.5. Stage 5: Seed supply and release

Selection is pointless if seed of the chosen varieties cannot be had. In the second season, entries that farmers rejected are dropped and the remainder are repeated, while the team arranges seed multiplication of the leading entries with a farmers' group or a community seed bank. Finger millet is self-pollinating and its seed rate is low, so a variety can spread quickly from farmer to farmer once a modest quantity is in the village. In parallel, the mother trial data and the preference records are compiled in the format the national release committee requires, since release procedures in the region, notably in Nepal, have been adapted to admit participatory data as supporting evidence.

4. Analysing Rankings and Yields Together

The trials produce two kinds of data, and the analysis should respect the difference. Yields from mother trials are analysed by the ordinary methods for multi-location trials, with attention to the interaction between entries and land types. Rankings and votes are ordinal. [Coe \(2002\)](#) explains why averaging ranks as if they were measurements can mislead and describes models suited to ranks and ratings from on-farm trials. Rankings of subsets of entries, as in baby trials, can be fitted with models of the Plackett-Luce family ([Plackett, 1975](#)), the approach adopted for *tricot* data ([van Etten et al., 2019](#)). Results should be reported separately for women and men and for each land type before any pooling. A variety preferred strongly by one group and disliked by another is a finding in itself and should not be averaged away.

5. Consent, Seed Rights and Inclusion

Farmers contribute land, labour and knowledge, and the design should treat them accordingly. Participation is voluntary and is agreed after the purpose, the risks of growing an untried variety and the use of the data have been explained in the local language. Households that host trials on scarce terrace land should not bear a loss if a new entry fails, and the simplest safeguard is to keep babies small relative to the household's own crop. Landraces brought in from genebanks, and any local landraces that the team collects, are handled under the International Treaty on Plant Genetic Resources for Food and Agriculture ([FAO, 2009](#)) and the national laws that give effect to farmers' rights. Care is needed over who is invited. Programmes that work through village leaders tend to recruit better-off men with larger holdings, and a deliberate quota for women and for households with little land corrects this ([Weltzien et al., 2003](#)).

6. Limitations and What Remains to Be Shown

The design is a proposal and has not been tested in this article. An application would need to show several things. The first is whether mother trials on small, irregular terraces can be run with enough precision to separate entries, since heritability on farm is the condition on which the case for decentralised

selection depends (Atlin *et al.*, 2001). The second is whether the preferences recorded in farm walks and baby trials predict what farmers actually sow in later seasons, which only a follow-up of adoption can answer. The third is cost per household reached, compared with the tricot alternative.

Some limits are built in. Two seasons cannot reveal how a variety behaves in a severe blast year or a failed monsoon unless one happens to occur. The entries are limited to what already exists, so if nothing in the candidate set matches the farmers' profile the exercise will show the gap and not fill it; in that case the appropriate next step is participatory breeding within crosses involving the local landrace. Finally, preferences are local. A result from one watershed is evidence about that watershed, and extending it to other hill districts requires trials there.

7. Conclusion

Finger millet in the South Asian hills is a crop for which the usual route from research station to farm has delivered little, and for which farmers' criteria are many and specific to place. The design proposed here begins from those criteria, selects candidates to match them, tests the candidates in mother and baby trials on the land types that matter, gathers the judgements of women and men at three points in the season, and ties the outcome to seed supply and release. Each element is drawn from established practice. Their combination for this crop and setting is offered for trial, and its worth will be decided by whether farmers keep growing what they chose.

Conflict of interest

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References

- Atlin, G.N., Cooper, M. and Bjørnstad, Å. (2001). [A comparison of formal and participatory breeding approaches using selection theory](#). *Euphytica*, 122(3): 463-475.
- Ceccarelli, S. and Grando, S. (2007). [Decentralized-participatory plant breeding: An example of demand driven research](#). *Euphytica*, 155(3): 349-360. <https://doi.org/10.1007/s10681-006-9336-8>
- Ceccarelli, S., Guimarães, E.P. and Weltzien, E. (eds) (2009). [Plant Breeding and Farmer Participation](#). Food and Agriculture Organization of the United Nations, Rome.
- Chambers, R. (1994). [The origins and practice of participatory rural appraisal](#). *World Development*, 22(7): 953-969. [https://doi.org/10.1016/0305-750X\(94\)90141-4](https://doi.org/10.1016/0305-750X(94)90141-4)
- Coe, R. (2002). [Analyzing ranking and rating data from participatory on-farm trials](#). In: Bellon, M.R. and Reeves, J. (eds), *Quantitative Analysis of Data from Participatory Methods in Plant Breeding*. CIMMYT, Mexico, D.F..
- FAO (2009). [International Treaty on Plant Genetic Resources for Food and Agriculture](#). Food and Agriculture Organization of the United Nations, Rome.
- Gowda, B.T.S., Halaswamy, B.H., Seetharam, A., Virk, D.S. and Witcombe, J.R. (2000). [Participatory approach in varietal improvement: A case study in finger millet in India](#). *Current Science*, 79(3): 366-368.
- Hilu, K.W. and de Wet, J.M.J. (1976). [Domestication of *Eleusine coracana*](#). *Economic Botany*, 30(3): 199-208.
- Joshi, A. and Witcombe, J.R. (1996). [Farmer participatory crop improvement. II. Participatory varietal selection, a case study in India](#). *Experimental Agriculture*, 32(4): 461-477.
- National Research Council (1996). [Lost Crops of Africa: Volume I: Grains](#). National Academy Press, Washington, DC.
- Plackett, R.L. (1975). [The analysis of permutations](#). *Applied Statistics*, 24(2): 193-202.

- Snapp, S. (2002). [Quantifying farmer evaluation of technologies: The mother and baby trial design](#). In: Bellon, M.R. and Reeves, J. (eds), *Quantitative Analysis of Data from Participatory Methods in Plant Breeding*. CIMMYT, Mexico, D.F..
- Sperling, L., Ashby, J.A., Smith, M.E., Weltzien, E. and McGuire, S. (2001). [A framework for analyzing participatory plant breeding approaches and results](#). *Euphytica*, 122(3): 439-450.
- Upadhyaya, H.D., Gowda, C.L.L., Pundir, R.P.S., Reddy, V.G. and Singh, S. (2006). [Development of core subset of finger millet germplasm using geographical origin and data on 14 quantitative traits](#). *Genetic Resources and Crop Evolution*, 53(4): 679-685.
- van Etten, J., Beza, E., Calderer, L., et al. (2019). [First experiences with a novel farmer citizen science approach: Crowdsourcing participatory variety selection through on-farm triadic comparisons of technologies \(tricot\)](#). *Experimental Agriculture*, 55(S1): 275-296.
- Weltzien, E., Smith, M.E., Meitzner, L.S. and Sperling, L. (2003). [Technical and Institutional Issues in Participatory Plant Breeding from the Perspective of Formal Plant Breeding: A Global Analysis of Issues, Results, and Current Experience](#). PPB Monograph No. 1. CGIAR Systemwide Program on Participatory Research and Gender Analysis, Cali.
- Witcombe, J.R., Joshi, A., Joshi, K.D. and Sthapit, B.R. (1996). [Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity](#). *Experimental Agriculture*, 32(4): 445-460. <https://doi.org/10.1017/S0014479700001526>
- Witcombe, J.R., Joshi, K.D., Gyawali, S., et al. (2005). [Participatory plant breeding is better described as highly client-oriented plant breeding. I. Four indicators of client-orientation in plant breeding](#). *Experimental Agriculture*, 41(3): 299-319.