Results

The white-grained maize varieties were tested by Gujarat Agricultural University (GAU) in the system of state trials that is used to identify varieties for release. The mean performance of these entries was superior for grain yield by 7%–29% (depending on the variety) in a multi-year, multi-locational trial to that of Gujarat Makka 1 (GM 1), a variety that out-yields the most widely grown local landrace by 10% for grain. They also silked two to six days earlier than GM 1.

In the rainy season (kharif) 1997, GDRM 185 and GDRM 187 were tested in farmer-managed participatory-research (FAMPAR) trials in Itawa and Bihar (Madhya Pradesh); Sarjumi, Bar, and Katarani Palli (Gujarat); and Khundini Rupa, Mathura Khali, and Kunda (Rajasthan). Focus-group discussions showed that both varieties were much preferred by farmers over the local varieties. Both were perceived to be earlier than the local varieties (GDRM 187 particularly so) and to be higher yielding. GDRM 187 was reported to have much better grain quality than the most widely grown local variety, and GDRM 185 was reported to have somewhat better grain. Both varieties were reported to have fewer plants that failed to produce cobs, more plants with two cobs, larger cobs, and, unlike the local varieties, cobs that were filled to the tip.

In kharif 1998 GDRM 187 was tested in three villages in Gujarat and one in Rajasthan (figure 1). Yield increases in farmers’ fields were higher in percentage terms than those found in higher yielding research station trials. Overall, GDRM 187 was the variety most liked by farmers. Like GDRM 185 and GDRM 186, it yielded more than the local varieties, but it had the added advantage of being significantly earlier to mature. In addition, farmers commented that its cobs were tightly and completely enclosed by the husk, reducing insect attacks, and they also commented on the superior quality of its grain.

![Figure 1. The performance of GDRM 187 in FAMPAR trials compared to the local varieties in four villages: Sarjumi, Gujarat (20 trials); Umariya, Gujarat (5 trials); Bansripada, Rajasthan (6 trials); and Bar, Gujarat (15 trials) (The advantage of GDRM 187, averaged over 46 trials, was 28%).]
Discussion

PVS does not always work but it builds the foundation of a sound PPB program

The PVS in maize was not very successful. Perhaps this is not surprising since most of the varieties that were tested were not bred in the target environment. Gujarat Makka 1, the only cultivar that was bred in the area, was selected from the local landrace “Farm Sameri.” Although this selection was successful in producing a statistically higher-yielding variety in trials, the difference was insufficient. On farmers’ fields its 10% yield advantage was not noticed by farmers.

Even a PVS program that does not identify highly successful varieties is of use. In this case, it enabled target traits to be identified—for example, the preference for white grain and extreme earliness. Most important, it allowed the identification of parental genotypes.

Was this a participatory plant-breeding program?

Biggs (1989) classified participation into four types, two of which are collaborative and consultative participation. Collaborative participation by farmers was selecting in the populations in their own fields was attempted, but failed. It was difficult for farmers to prevent cross-pollination of the composite with locally grown material by, for example, planting the crop in an isolated plot. Farmers were reluctant to mass select by uprooting undesirable plants because of the loss of yield this would entail. The alternative of detasseling undesirable plants and rejecting them at harvest time would be possible but difficult. However, the breeding program did involve consultative participation—farmers were involved in the identification of parental material and target traits, and in the evaluations of the breeding generations on the research farm. Of major importance was the decentralization of the breeding program. Although selection was not in farmers’ fields, it was in the target geographical area. The composite was grown under lower input levels than normally found in a research station and closer to the levels used by farmers.

The breeding program also had innovative aspects that were not related directly to farmer participation. Wide crosses were made between yellow- and white-endosperm maize with reselection for white. Quite elaborate designs during the random mating of the composite were employed: hill planting and detasseling was done to increase the pollination between progeny of the original nine crosses and reduce sibbing within them. In the random-mating generations, grains with pale yellow were selected to advance the next generation. This color is the most probable phenotype of heterozygotes and selecting for it maximized the possibility of recombination around the locus controlling grain color.

It is not possible to know which component was most important in the success of the program—collaborative selection of parents by PVS, consultative PPB, decentralization to the target environment, or innovative breeding techniques. However, part of the breeding philosophy in PPB, argued by Witcombe et al. (1996), is the need to concentrate on only a few crosses or populations, which allowed the required resources for the novel techniques used in the breeding program.

Was PPB cost effective?

Conventional breeding had never produced a cultivar that was preferred by even a significant minority of the farmers in the project area. In about five years, PPB had produced at least one cultivar, GDRM 187, that was liked by most farmers for most of their fields. It yielded significantly more grain (about 15%-30% more) even though it was significantly earlier to flower (about one week earlier). This combination of higher yield and earlier flowering is extremely valuable for farmers.
and is normally a difficult combination to achieve in any maize-breeding program. GDRM 187 also had other advantages, including improved grain quality, that should increase its speed of adoption and its adoption ceiling. All this was achieved with modest resources, since only a single composite was created and only a few varieties were derived from it.

References


Towards a Practical Participatory Plant-Breeding Strategy in Predominantly Self-Pollinated Crops

J.R. Witcombe, M. Subedi, and K.D. Joshi

Abstract

There is a limit to the capacity of any breeding program, and the more crosses that are made, the smaller the size of each cross. The theory of the optimum number of crosses in inbreeding crops is briefly reviewed. The theory is unsatisfactory in determining the optimum number of crosses, but models that take linkage into account show that very large populations are needed to recover specified genotypes. Hence, one possible strategy is to select a small number of crosses that are considered favorable and produce large populations from them. This strategy is ideally suited to the particular constraints and advantages of participatory plant breeding (PPB). When a breeding program is based on few crosses, the choice of parents is crucial and farmer participatory methods are highly effective in narrowing the choice. Modified bulk-population breeding methods are desirable strategies in the participatory plant breeding of self-pollinating crops when combined with a low-cross-number approach, and a participatory breeding program for rice in Nepal is described.

Introduction

In most, perhaps all, conventional breeding programs for inbred crops on research stations, breeders deal with many crosses each season. Even with fairly limited resources many hundreds, or even thousands, of $F_2$ or $F_3$ lines can be tested. Unless there is considerable researcher input into the lay-out of trials in farmers’ fields, participatory plant breeding (PPB) has to employ many fewer crosses and entries than conventional or classical breeding. In farmer-designed, farmer-managed trials, each farmer usually grows only one entry (e.g., Joshi and Witcombe 1996) and the number of participating farmers thus limits the number of entries. However, a very large population of any entry can be grown, with little or no cost, or even with a benefit. In PPB, a farmer replaces his or her cultivar with a population for PPB on land that would normally have been devoted to the crop. The cost of this replacement is any decrease in value of the harvest caused by the replacement and the benefit is any increase in harvest value. In contrast, in classical breeding all the costs of any increase in the area of the cultivated crop are borne by the breeding program. We briefly review the theoretical evidence on the number of crosses that are required in a breeding program. We describe a rice breeding program in Nepal that is using a low-cross-number, high-population-size strategy.

Theory on the number of crosses in a breeding program

The optimum number of crosses required in an inbreeding crop was reviewed by Witcombe and Virk (forthcoming) and only a summary is presented here. To calculate the optimum number of crosses, crucial assumptions are required on the rate of the inevitable decline in the potential value of each cross as more and more crosses are made. If the decline is very significant (e.g., a few

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crosses can be identified as having a higher probability of giving desirable segregants than others),
then only a few crosses are needed. If the decline cannot be predicted, then many are required. The
lack of quantitative data to support assumptions on the rate of decline limits the role of theory in de­
ciding the optimum number of crosses. However, to recover specified genotypes, large population
sizes are needed that, given a limit to the overall size of any breeding program, will limit the number
of crosses. Whether a high-cross-number or a low-cross-number approach should be used depends
greatly on the judgment of the researcher as to whether the value of crosses can be predicted with
any certainty. In a decentralized breeding program, the target environment and the required traits in
a finished variety are known, and the knowledge of existing adapted germplasm is considerable.
This allows such predictions to be made, so a low-cross-number strategy appears sensible. Many
fewer crosses than are common in most breeding programs will be used, and for all of them there
will be logical reasons as to why the cross should have a high probability of producing favorable
segregants. There will be many fewer crosses than commonly suggested from theoretical calcula­
tions that invariably assume there is no prior information on the value of any cross, i.e., that all
crosses are considered to have an equal chance of success (Yonezawa and Yamagata 1978; Wricke

In a large-cross-number strategy, population sizes are likely to be limited to a few hundred rather
than several thousand. In a low-cross-number strategy, population sizes can be larger and increase
the probability that desirable segregants that are an improvement over the best parent are recovered.
All that is needed is that the two parents differ significantly for an important trait (a practical
certainty) at some point in the genome. A segregant that has a genome substitution from the other
parent at this point will be superior, providing the sum of the rest of the genome is equal to the best
parent. The existence of a cross that cannot give rise to superior segregants is theoretically impos­
sible, although the population size required to recover desirable segregants may be impractically
large. However, choosing complementary parents increases the likelihood that there will be a suffi­
ciently high frequency of desirable segregants for them to be selected.

Towards a practical participatory breeding strategy

PPB is ideally suited to the strategy of rigorously selecting parents, using a small number of crosses
and employing large populations. Participatory varietal selection (PVS) is the first step in selecting
desirable parents. It allows local and introduced germplasm to be evaluated using participatory
approaches; it identifies candidate varieties having suitable traits and determines their acceptability
to farmers.

A PPB program in an inbreeding crop can start on the basis of one cross or very few crosses. Even
with a low-cross-number strategy, the number of crosses covered will gradually increase over time
if one, or a few, new crosses are made each year. This will help to maintain the farmers’ interests by
a supply of novel germplasm and allows a continuing incorporation of new genetic material from
more centralized breeding programs.

Pedigree breeding generates a large number of lines (the selection units) that can only be accommo­
dated with difficulty in a PPB program. The most effective methods keep the number of selection
units to a minimum, thus allowing one, or an acceptably low number, of selection units per farmer.
However, large population sizes can be used because the marginal costs to the program of increas­
ing population size are very low (figure 1). Hence, bulk-population breeding is ideal for PPB, in
either its pure form or modified by dividing the population into sub-populations according to
farmer-important traits. Bulk-population approaches have been used with success in classical
breeding, e.g., Carver and Bruns (1993) report that 30% of wheat releases from a breeding program
resulted from bulk population breeding that took less than 8% of the resources.

We are conducting a PPB program in rice, targeted at a range of environments in Nepal. These vary
from the Terai (alluvial, low-altitude, flat land in the southern part of Nepal at about 150 m altitude)
in both the main season (sown in June) and the chaite season (sown in February). The breeding pro-
gram is also targeting a range of irrigated environments up to 1500 m altitude. Only a few crosses
have been made during the course of this breeding program, which commenced in 1996 with two
crosses made by the International Rice Research Institute (IRRI) at the request of the project and
one cross made at the Center for Arid Zone Studies (CAZS), Bangor, by Dr. D.S. Virk.

All three crosses involved the upland rice variety Kalinga III as one of the parents. Kalinga III was
identified in western India in a PVS program (Joshi and Witcombe, 1996). Farmers like it for its
very short duration and, an unusual trait for an upland rice variety, its slender grains. Although it is
an upland rice variety adapted to marginal conditions, it is widely adapted even though it was
rejected from All-India Co-ordinated Crop Improvement Program multilocational trials. It was
released for rainfed, drought-prone, cold-susceptible environments only in Orissa, on the basis of
trials in that state, but is now widely grown in Bihar, West Bengal, Madhya Pradesh, Rajasthan, and
Gujarat. In PVS trials, it performs extremely well as a chaite rice in the Nepal Terai under partially
irrigated conditions and can be grown as a main-season rice in the low hills of Nepal up to 1000 m
under rainfed conditions.
Towards a Practical Participatory Plant-Breeding Strategy in Predominantly Self-Pollinated Crops

One of the crosses made at IRRI was Kalinga III × IR64. IR64 is a longer duration, high-yielding variety adapted to irrigated conditions. At one time it was the most widely grown rice genotype in the world and has occupied the majority of the rice-growing area in the Philippines and Indonesia. It has also been released in India for Tamil Nadu but is widely grown in other states as well, e.g., West Bengal and Haryana. It has wide adaptability, multiple pest and disease resistance, and slender, translucent grains.

It is clear that in this low-cross-number strategy, an enormous amount of information is available on the parents. Kalinga III has weak straw and a low yield potential. IR64 has complementary traits: a very high yield potential and it is highly resistant to lodging. It can also contribute pest and disease resistance to Kalinga III, even though this variety has few susceptibilities. In targeting high-yield-potential environments, Kalinga III can contribute earliness to IR64, and because of its extreme genetic divergence from IR64, it is reasonable to expect transgressive segregation for yield in these environments. For the chaite season and somewhat higher-altitude, high-yield environments, Kalinga III contributes cold tolerance.

In PPB, an essential part of the strategy of selecting appropriate parents is that one of them is locally adapted. Kalinga III has been adopted by farmers for partially irrigated conditions in the chaite season. However, it is a niche variety and other crosses have been made involving the most popular chaite rice, CH45, and the most popular main-season variety, Masuli.

In the early stages of creating the bulk populations, the breeding program for the cross Kalinga III × IR64 was entirely researcher managed on land rented from a farmer. Initially 290 F3 lines of the cross were grown in the chaite season of 1998. The progeny rows were highly diverse and they were grouped into six bulks based on their height (tall or dwarf) and maturity classes (early <110 days seed to seed; medium 110-125 days; and late >125 days). The bulks were named as follows: ED = early dwarf; ET = early tall; MD = medium dwarf; MT = medium tall; LD = late dwarf and LT = late tall. Of these, the performance of the early dwarf proved to be unsatisfactory and it was dropped. The performance of the MT bulk was good but highly variable, so it was further divided into four: MT1 = earlier shorter; MT2 = earlier taller; MT3 = later shorter; and MT4 = later taller (figure 2).

After dropping the ED bulk and dividing the MT bulk into four, there were eight bulks. Three were then advanced without further division (the two dwarf bulks and the late bulk). However, in five of the bulks, further division was made among the F5 seed into grain type, i.e., long, intermediate or short in length. In the F6 generation, the resultant bulks were grown by researchers and evaluated by farmers (consultative participation). Combinations of maturity and grain types were selected and rejected. For example, in later-maturing bulks that more or less matched the maturity of CH45, only nonslender types were acceptable. For rice of this maturity, the harvest of which coincides with the rains, it is only economic to produce roasted, flattened rice, for which only less-slender-grained varieties are suitable. In contrast, in the earlier groups, all grain types were acceptable.

By the F6 generation the bulks were recognizable by farmers, because most of the plants shared common traits, but the bulks still had significant genetic heterogeneity within them for farmers to be able to make selections. In the chaite season of 2000, farmers were given the bulks at the F7 stage and the results of this farmers’ selection will be evaluated.

As well as the modified bulk populations breeding approach, we are also trying variants of single-seed descent (SSD) such as equal-seed descent. In classical breeding programs, SSD is increasingly employed to rapidly and cost-effectively produce homozygous lines. It concentrates
selection in advanced generations that are highly homozygous and where selection is more effective than in earlier, more heterozygous generations (e.g., Delzer, Busch, and Harelant [1995] and Van Oeveren [1992] in wheat; Fahim et al. [1998] in rice). We have modified SSD to retain even more variation by using equal- rather than single-seed descent in the earlier selfing generations. It also allows multiplication so that by the F₃ or F₄ generation, large quantities of seed of each bulk (or sub-bulk) can be supplied to many farmers. The probability of selecting desirable segregants is increased when the entire selection process is replicated across farmers.

Participatory techniques must complement and cannot replace classical breeding. Some low-heritability traits can only be selected under controlled environments, and modern techniques that facilitate wide crossing, such as embryo rescue, are confined to the laboratory. No single participatory plant breeding program can hope to screen more than an insignificant proportion of the germplasm available in collections of genetic resources or, for example, attempt to create populations with novel resistance traits. Classical breeding is a strategic approach that creates improved parents for the cost-effective, adaptive approach of participatory plant breeding.

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Towards a Practical Participatory Plant-Breeding Strategy in Predominantly Self-Pollinated Crops


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Participatory Crop Improvement for Intercropped Maize on Bari Land Terraces with Trees

T. P. Tiwari, Daljit S. Virk, and Fergus L. Sinclair

Abstract

Maize (Zea mays L.) is the most important crop in the middle hills of Nepal and is mostly grown in association with finger millet (Eleusine coracana Gaertn) and fodder trees. Seven maize varieties have been recommended for the hills but few farmers have adopted them. As a prerequisite to designing a participatory maize-improvement program for the middle hills that could reverse declining yields, local knowledge and practice were investigated and combined with micro-meteorological measurements at three sites, each with 20 participating farmers.

In a participatory maize-improvement program, both participatory varietal selection (PVS) and participatory plant breeding (PPB) were carried out side-by-side with varieties selected on the basis of criteria derived from farmers’ knowledge. Four different varieties were tested (Manakamana-1, Arun-1, BA-93-2126#2, Population-22) with local varieties at each site. Participatory trials, where each farmer grew a new variety alongside local varieties, were combined with display trials of all the varieties at five locations. Questionnaires and focus-group discussions were used to assess farmers’ evaluation of varieties. Population-22, despite its late maturity, was liked by farmers for disease tolerance, higher yield potential, white and large grains, and its stay-green characteristics. Statistical analysis of grain yield confirmed farmers’ preference for Population-22, since this out-yielded the other new varieties (p<.05), which were similar in yield to local varieties. A seed-multiplication program of this preferred variety has been initiated by participating farmers. As part of the PPB program, the best four local varieties (Marga local, Muga local, Madi local, and Fakhamara local) were collected from various parts of the middle hills and crossed with adapted exotics (Manakamana-1, Arun-1, Population-22, and Pool-21). Five composites have been created by random mating so as to offer choices to farmers in the coming seasons, thus increasing the genetic diversity they are able to evaluate and utilize.

Introduction

Maize (Zea mays L.) is the most important crop grown in association with finger millet (Eleusine coracana Gaertn) and fodder trees in Nepal. About 80% of maize is grown in the hills, which constitutes 20% of the total cereal production of the country with productivity of slightly more than 1.5 t ha\(^{-1}\) (CBS 1997). There has been a decline of 20% in maize productivity in the hills since the mid-1970s (Palikhe 1996; Adhikari 1998; NMRP 1997). This is proof of the inefficiency of the traditional approach to maize improvement. The problem with the present approach is that it has assumed that biophysical and socioeconomic factors are commonly shared. The nature and importance of farmers’ knowledge is poorly understood, and farmers’ involvement in the research process has not been realized. The complex system of growing maize/millet with trees has been overlooked and farmers have not been recognized as research partners in the process of maize improvement.

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Participatory Crop Improvement for Intercropped Maize on Bari Land Terraces with Trees

technology generation. Consequently, the impact of seven newly released maize varieties has been insignificant.

It is not surprising that most of the maize-growing areas in the middle hills of Nepal are covered by the traditional varieties. Either new varieties are not reaching a majority of farmers or those farmers with access to them are not continuing to use them (Khadka et al. 1993). Pham, Waddington, and Crossa (1989), in their review report on the impact of germplasm from the International Institute for Wheat and Maize Improvement (CIMMYT), mentioned that in most developing countries, maize farmers are, by and large, growing the old established landraces.

It was therefore realized that it is necessary to develop a more efficient and effective approach where researchers, maize breeders, and farmers can work together for a common goal. The need to bridge the gap between local and scientific knowledge is a necessary prerequisite to developing an effective maize-improvement strategy. A farmer-participatory approach would involve developing a community-based adaptive research capacity, achieved by working with groups of farmers, maximizing the use of rural resources, and utilizing farmers' knowledge in parallel. This approach can bring farmers' knowledge (farmers' perspectives) and scientific ideas (researchers' perspectives) together (Walker et al. 1997; Sinclair and Walker 1998; Wagner 1993; Joshi 1997). Besides the acquisition of local knowledge, a fuller understanding of the maize-growing environment and how farmers manage scarce resources are major prerequisites for investigation.

**Farmer participatory maize improvement**

During the early 1970s, when research on maize started, there were high expectations that the development of maize in Nepal would offer better varieties to farmers. However it has been realized that the adoption of new varieties by farmers was not as simple as the researchers and development workers had thought. The farmer-participatory approach began in response to the inefficient, traditional, top-down approach, where more focus was paid to a few researchers' traits of interest rather than to the needs of farmers managing complex and heterogeneous systems.

There are many good reasons to encourage farmers' participation in the process of agricultural research and development (Farrington and Martin 1988; Farrington 1998; Witcombe et al. 1996; Joshi and Witcombe 1996; Witcombe and Joshi 1996; Witcombe and Virk 1997; Sperling and Scheidegger 1995; Shapit, Joshi, and Witcombe 1996; Subedi, Rana, and Joshi 1997). The complexity of the system is only understood by the farmers. The traditional approach is deficient both in understanding such systems and in using farmers' talents. The participatory approach will help empower local groups of farmers by enhancing production (through the acceptance of preferred varieties), genetic diversity, and "togetherness" (Sperling and Scheidegger 1995; Eyzaguirre and Iwanaga 1996; Chambers and Mascarenhas 1990).

As part of farmer-participatory maize improvement, both participatory varietal selection (PVS) and participatory plant breeding (PPB) were carried out side-by-side, although the latter is usually initiated when PVS fails to identify farmers' preferred genotypes (Witcombe et al. 1996; Joshi and Witcombe 1996). The two activities were carried out at the same time in order to create broad, genetic-based populations simultaneously with PVS activities so as to offer choices to the farmers as quickly as possible.
Materials and methods

Participatory varietal selection

Farmers' criteria for selecting maize genotypes were based on local knowledge. Suitable varieties were sought to meet the important traits that were identified as preferred by farmers, particularly those relating to grain size, color and type, plant height, suitability for agroecological niches, and compatibility with the system. Varieties were selected as suggested by Witcombe et al. (1996) from the releases for the same domain (Manakamana-1), for one other domain (Arun-1 for lower hills but for the middle hills a new introduction), and from pre-releases (Population-22 and BA-93-2126#2).

Sites were chosen where maize is the important crop for household income, in farming systems that were representative in terms of agroenvironmental and socioeconomic conditions, and where there were no political or social obstacles to effective researcher-farmer interactions. Marga, Patle and Fakchamara were selected for the farmer-managed, participatory-research (FAMPAR) trials.

A total of 60 packets (15 of each variety) containing 500 g of seed were distributed randomly to 20 farmers at each site to compare with their local varieties. Therefore, FAMPAR trials of one variety were replicated over five participating farmers at each site. Farmers were asked to grow the new varieties alongside their local variety in the same field and under the same management conditions. However, fields for the FAMPAR trials were to be selected mutually by farmers and researchers for their representativeness (not too sloping, not too marginal or too fertile, and with some degree of tree shade, if possible). Periodic farm visits and interactions with farmers were made so as to observe performance of varieties at different stages. Assessments of the pre-harvest traits of test varieties were made by joint visits between researchers and farmers to each participating farmer's fields. A wide range of issues, covering field management and performance of varieties in the complex and heterogeneous environment, were discussed. Farmers' observations of experimental varieties and their own local varieties were discussed at greater length and were recorded using household-level questionnaires (HLQs). Farmers were asked to harvest both new and local varieties separately and to measure grain yield using their local measurement units. They were also requested to store the harvests separately using existing practices and to assess/evaluate other postharvest characteristics, such as grit-to-flour ratio, grain type and color, cooking quality, taste, and market value. They were also asked to assess fodder quality.

Also as part of the PVS program, demonstration trials were conducted in five different sites (Marga, Patle, Fakchamara, Murtidhunga, and Parewadin). The same four FAMPAR varieties were given to one farmer at each site to grow together with his/her local variety for comparison; 500 g of seed of each variety was given to farmers to grow on their own farms.

Group visits were organized to see FAMPAR trials in the field grown by individual farmers in various growing conditions. The performance of the FAMPAR varieties was assessed jointly, and finally, farmers were brought to see varietal demonstrations to compare all varieties at one site. At the end of the session, focus-group discussions were organized and views were collected as per questionnaires developed for the discussions. Male and female farmers were grouped separately and discussions were initiated accordingly. Based on the performance of FAMPAR varieties, farmers were asked to rank the varieties.
**Participatory plant breeding**

The germplasm that farmers felt was best adapted to the eastern middle hills of Nepal was collected. Before collection, the fields where these varieties were grown were visited and their performance was assessed. Individual growers and local farmers were consulted in order to identify the best-adapted local germplasm. The varieties Muga local, Madi local, Fakhamara local, and Marga local from local varieties and Manakamana-1, Population-22, and Arun-1 (white) and Pool-21 (yellow) from the improved varieties were used in the PPB program. A total of five composites were prepared with different crossing combinations of farmer-preferred varieties (table 1).

Sowing time was staggered according to the maturity class of the variety so as to synchronize flowering. A purposive randomization was followed to equalize the chances of random mating. Three seeds per hill were sown and later thinned to one. At the vegetative stage, individual plants were tagged to detassel later. Diseased and other abnormal plants were removed as soon as the tassel appeared. These composites were sown on-station with irrigation, because the previous year there had been a severe drought (the longest in 35 years). Seed priming was practiced for early establishment. Final selection was done by farmers from tagged and detasseled plants. Laboratory selection was done for flinted and white grains, rejecting yellow, dented, and diseased grains.

Farmers prefer white-grained maize varieties; however, some yellow-grained types possess desirable traits. A novel PPB program was followed to exploit yellow-grained types in composite breeding, where pale yellow grains are used for further cycles of random mating (Goyal, Joshi, and Witcombe, this volume). Pale yellow grains represent a cross between white- and yellow-grained varieties. All other grain types, being more likely to be parental types, are rejected.

**Results and discussion**

Unlike PPB, which requires a long phase of breeding before its products can be tested in FAMPAR trials, PVS provides a means for immediate identification of farmer-preferred varieties. The products of PPB are not yet ready for such an evaluation but the results of the PVS program are available and are presented in this paper.

**Participatory varietal selection**

Group interviews were conducted to compare all experimental varieties with local varieties at the end of the growing season. The objective and expected outcome of the project was reviewed once again as a reminder to the group members, since they are the ultimate users. Groups of farmers visited each other's fields to see all the FAMPAR varieties grown by different farmers, which may be under different management but were grown under similar growing conditions (with respect to altitude and system). Each trait they mentioned was recorded. Most of the traits were compared against local varieties; however, the overall ranking of the acceptability of the varieties was made among test entries, including local varieties. Farmers' perceptions of major pre- and postharvest traits are summarized in figures 1a and 1b. It was noted that most of the farmers could not make confident contributions regarding cooking quality and taste. Assessment of problems with pest in the stored grain is continuing because it has not yet been taken out of the thangkro (maize crib).

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1. Descriptions based on farmers' knowledge about and experience with varieties were prepared but not included in this report.
Table 1. Farmer-Participatory Maize Breeding Plan

Parent selection: Well-adapted landraces with good phenotypic traits were selected by farmers. Locally adapted new varieties identified from the search program as suggested by Witcombe et al. (1996).

A. White composite

<table>
<thead>
<tr>
<th>Composite 1</th>
<th>First year, Season-1 (March sowing, hill) Season-2 (September, teral)</th>
<th>Second year</th>
<th>Third year</th>
<th>Fourth year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population-22</td>
<td>Sowing time adjusted according to maturity class.</td>
<td>First-based composite</td>
<td>Upgrading continued at station.</td>
<td>Upgrading continued.</td>
</tr>
<tr>
<td>Muga local</td>
<td>Purposive randomization done to allow equal chance for random mating.</td>
<td>First 3 composites grown together to prepare broad-based composite.</td>
<td>Good maize growers invited for field selection.</td>
<td>Co-coordinated multilocational trials (CVTs).</td>
</tr>
<tr>
<td>F/mara local</td>
<td>50% plants detasseled and selection concentrated only from those.</td>
<td>Sown by purposive randomization to allow equal chance for random mating at Rampur during winter.</td>
<td>FAMPAR trials.</td>
<td>Disease nurseries.</td>
</tr>
<tr>
<td>Good maize growers invited during the field selection.</td>
<td>Other techniques not changed.</td>
<td>Seed increase in farmers' fields.</td>
<td>Seed increase in farmers' fields.</td>
<td></td>
</tr>
<tr>
<td>Lab selection for healthy, white-flinted grains.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composite 2</th>
<th>ditto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manakamana-1</td>
<td>ditto</td>
</tr>
<tr>
<td>Marga local, F/mara local</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composite 3</th>
<th>ditto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arun-1, Madi local, Marga local</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composite 4*</th>
<th>ditto</th>
<th>ditto</th>
<th>ditto</th>
<th>ditto</th>
</tr>
</thead>
<tbody>
<tr>
<td>all above four locals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composite 5</th>
<th>Best ears from the respective farmers' fields selected by farmers and collected from three different sites.</th>
<th>Seed of different varieties mixed and sown as composite.</th>
<th>Bulk sowing.</th>
<th>Upgrading continued.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAMPAR varieties</td>
<td>Good maize growers invited to select in field.</td>
<td>Good maize growers invited to select in field.</td>
<td>Random mating as other composites.</td>
<td>FAMPAR trials.</td>
</tr>
<tr>
<td></td>
<td>50% of plants detasseled for random mating.</td>
<td>FAMPAR trials.</td>
<td>FAMPAR trials.</td>
<td>Co-coordinated multilocational trials.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Seed increase in farmers' fields.</td>
<td>Seed increase in farmers' fields.</td>
</tr>
</tbody>
</table>

*ditto indicates the same as previous.
Table 1. Farmer-Participatory Maize Breeding Plan (continued)

B. Composite breeding using yellow types

<table>
<thead>
<tr>
<th>Pool-21 yellow (Female)</th>
<th>Arun-1, Madi local Manakamana-1 Population-22</th>
<th>Pale yellow seeds sown at Rampur. 50% plants detasseled. Field selection. Lab selection; only white seeds selected to continue. Other colors discarded.</th>
<th>White seed continued by random mating. Good maize growers invited for plant selection. FAMPAR trials.</th>
<th>Upgrading continued. ditto</th>
</tr>
</thead>
</table>

- Female parent sown in alternate rows with other varieties.
- All female and undesirable and diseased plants from male rows detasseled.
- Good maize growers invited for field selection.
- Deep yellow and white seeds and other diseased grains discarded.
- Only pale yellow seeds (being hybrids) from yellow female parent continued.

Note: Two years on-farm testing to satisfy variety release committee is to be conducted before proposing variety to be released.

* Adapted local germplasm from various parts of the middle hills should be continuously collected, evaluated, and combined in local composite so as to make broad genetic base which could be used for future crossing programs. Recurrent selection of these composites (randomly mated) should be continued.
<table>
<thead>
<tr>
<th>Trait</th>
<th>Disease, Man-1</th>
<th>Lodging, Man-1</th>
<th>Drought tolerant, Man-1</th>
<th>Maturity, Man-1</th>
<th>Stay green, Man-1</th>
<th>LST. Liking, Man-1</th>
<th>Ear size, Man-1</th>
<th>Ear Compact, Man-1</th>
<th>Shade tolerant, Man-1</th>
<th>Stover yield, Man-1</th>
<th>Production, Man-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant disease</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
<td>Arun-1</td>
</tr>
<tr>
<td></td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
<td>BA-93</td>
</tr>
</tbody>
</table>

**Figure 1a. Farmers' perceptions of pre-harvest traits of four new maize varieties**

(Farmers' perceptions as to whether the test varieties were better or worse than the local varieties are indicated by lines. The shorter the line, the more similar the variety is to the local varieties.)
Preharvest traits. Farmers observed that the germinative ability of the new varieties was better than that of the local varieties since better quality seed was given to them. During the group discussion, one of the participating farmers said that if the quality of seed of the new varieties was as poor as the usual inferior (insect attacked) quality of the local varieties, then the germination percent of the local varieties would be higher under stressed situations (drought and soil capping). Additionally, the farmers said that when the maize was sown, there was sufficient moisture in the soil, and as a result, there were no germination problems this year.

Farmers also perceived that the new varieties had stronger stems and shorter plant height than the local varieties, resulting in reduced lodging. The test entries were better with respect to foliar diseases, particularly turcicum blight, but they had problems with ear rot. Within the new varieties, Population-22 was preferred. This was mainly because it had larger ears and lower rates of infection with turcicum blight. Farmers thought this was because it was less affected by tree shade. New varieties matured earlier than local varieties except for Population-22 (figure 1a). The new varieties had similar requirements for fertilizer and water as the local varieties; however, their drought tolerance was less. There were mixed responses from farmers on ear size, production estimates, shelling percent, and grain size. Despite the desirable thinner stems of the local varieties for livestock...
stover, farmers preferred the new varieties for this purpose because they had improved stay-green characteristics. Except for Population-22, the new varieties were not shade-tolerant.

**Postharvest traits.** Assessment of postharvest traits revealed that the local varieties were better with respect to grain color and type, taste, grit-to-flour ratio, stored-grain pest infestations, and cooking quality. The farmers who were able to comment on taste reported that Manakamana-1 was good but still inferior to the local varieties. The taste of Population-22 was inferior to local varieties and to Manakamana-1. However, these varieties all fetch good market prices compared with yellow types (figure 1b).

The overall ranking of the tested varieties from different sites with different groups of farmers revealed that despite its lateness, farmers liked Population-22 in field conditions (table 2). The traits farmers liked were higher yielding potential, taller plants with multiple ears, stay-green characteristics, freedom from foliar diseases, and tolerance to lodging. Because of the taller plant height, there was less shading of millet when the lower leaves are stripped by farmers to harvest fodder and reduce competition with the millet. However, at the Murtidhunga and Parewadin sites, farmers said it affects millet because of its larger leaves and late maturity.

### Table 2. Overall Rank of Varieties from Different Sites with Different Groups of Farmers (1999)

<table>
<thead>
<tr>
<th>CVs (sites)</th>
<th>Marga</th>
<th>Patle</th>
<th>Fakchamara</th>
<th>Mr/Dhumga</th>
<th>Tankhuwa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Mixed</td>
</tr>
<tr>
<td>Mana-1</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Pop-22</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>BA-93</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Arun-1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Locals</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

There was little distinction between the preferences of male and female farmers. It was rather surprising that the late variety Population-22 scored the highest (40), followed by Arun-1 (26). The score of Mana-1, local varieties, and BA-93 was similar (21). This was supported by the observed grain yield from FAMPAR trials, where Population-22 was found to be significantly superior \((p<.05)\) to local varieties (figure 2). Other entries were on par with local varieties for grain yield.

As in the FAMPAR trials, Population-22 was found to be the highest yielder in the multilocational varietal display trials, although this result was not statistically significant \((p=.38)\). The mean grain yield, irrespective of site, ranged from 2294 kg ha\(^{-1}\) to 2949 kg ha\(^{-1}\). Arun-1 was the lowest yielder. Most of the farmers who grew Arun-1 commented that because of its early maturity, birds and rodents were attracted to it. A further problem was the theft of ears. Thus, there was no seed to keep for the following year or to assess for postharvest traits. However, because of its earliness and other desirable traits, farmers were willing to continue to use it. Some farmers also expressed the opinion that it provided early food and that demand for it would increase in the future when green ears were marketed locally for roasting.

**Impact of FAMPAR varieties**

The impact of any variety is assessed by looking at the area covered by that variety in a particular location and how confidently farmers have taken to that variety. Although it is too early to assess
impact, most of the participating farmers stated that they had saved seeds from some of the FAMPAR varieties that they grew last year, thus confirming the potential of PVS to increase biodiversity. The amount of seed saved for this year’s sowing was 31 kg of Population-22, 29 kg of Manakamana-I, 24.5 kg of BA-93, and 13.5 kg of Arun-I across all sites. Most farmers stated that one or two years’ experimentation was not sufficient to fully understand the performance of a variety, so a few more years would be needed to have a more complete picture. According to the farmers, the seed demand from other farmers for FAMPAR varieties was limited except in a few cases (there was some demand for Population-22, Manakamana-I, and Arun-I) because of less exposure. A participatory seed-multiplication program for Manakamana-I and Population-22 has been launched. Farmers were briefed about the selection of maize seeds in the field and the relative advantages of the field selection techniques.²

Conclusions

The basis for farmers’ decisions to either accept or reject a variety is complex.

- Farmers’ interest in growing new maize varieties without replacing existing local varieties confirmed that participatory crop improvement is a means of increasing genetic diversity.

- No ideal variety that satisfies all the criteria set by farmers has been developed so far by research. Varieties generated by following the top-down approach provide only a few traits that farmers required, but the participatory approach is more satisfactory because it offers more choices and gives the new varieties more exposure.

². This refers to detasseling of 50% of phenotypically desirable maize plants from the terraces, which mostly lie in the central part of the field. Tassels from detasselled plants can be used as fodder. This operation is also expected to reduce the shading effect on the maize crop, reduce the degree of lodging, and stabilize yield through regeneration of heterosis. This operation also creates interest among farmers for testing the variety in the next season. This is a very simple and easy technique; however, care should be taken not to damage the flag leaf, which is important for photosynthesis.
• Farmers’ interest in taking an active part in the selection process indicated that the success of this approach could be sustainable in the future.

• Farmers who had only one year’s experience with a variety felt that this was not sufficient for precise feedback on a variety. This could have resulted in inconsistent opinions during the assessment of pre- and postharvest traits.

• Women farmers need to be encouraged to participate in the program because most of the field work in maize is carried out by women. It was noted that feedback received from women farmers was of better quality.

• The participatory approach provides a reciprocal educational experience between farmers and researchers because each recognizes the other’s opinions and taken them into account.

• Despite its lateness, farmers liked Population-22 in field conditions (table 2). The traits farmers liked were higher yielding potential, taller plants with multiple ears, stay-green characteristics, freedom from foliar diseases, and tolerance to lodging.

References


Goyal, S.N., A. Joshi, and J.R. Witcombe. Participatory crop improvement in maize in Gujarat, India. This volume.


Participatory Varietal Selection in Finger Millet

B.H. Halaswamy, B.T.S. Gowda, A. Seetharam,
D.S. Virk, and J.R. Witcombe

Abstract

Finger millet (Eleusine coracana [L.] Gaertn.) is an important small millet for rainfed areas in India. A dozen varieties have been released for cultivation but there is little adoption by farmers, particularly in the Chitradurga and Bellary districts of Karnataka state where the present study was conducted. Participatory rural appraisal (PRA) showed that all farmers wanted higher grain and fodder yields, while only 8% mentioned resistance to diseases. Varieties of 105 to 110 days duration with moderate to high tillering and compact-top, in-curved ears were more acceptable. The PRA also showed that there was a varietal monoculture of PR 202 from Andhra Pradesh state.

Six varieties were selected for testing with farmers. They were chosen from those released for Karnataka but not adopted, and from those that were promising in all India co-ordinated trials. Most of them performed well in two-year trials. Participatory varietal selection (PVS) trials were conducted with 150 farmers in seven villages. Pre- and postharvest focus-group discussions (FGDs) revealed that the two recently released varieties, GPU 26 and GPU 28, met several of the farmers' selection criteria. GPU 26 was found to be suitable for late sowing up to the middle of August if the onset of rain was delayed, but GPU 28 could be grown in the second week of July. Among the nonreleased varieties, the short-duration variety (85 days), VL 305, was identified to be suitable as a second crop for sowing in September after sesame or cowpea—an option not available to farmers with the released varieties or nonreleased cultivars.

Introduction

In India, finger millet occupies an area of around 2 million ha, and annual production is about 2.6 million tonnes. It is grown as a rainfed crop on marginal sloping lands, where moisture and plant nutrients are limited. The crop withstands a variety of biotic and abiotic stresses, and traditionally, it has been an indispensable component of the dryland farming system. It is a staple food in southern Karnataka and in Tamil Nadu, Andhra Pradesh, South Bihar, Maharashtra, Orissa, and Uttar Pradesh.

In Karnataka, a dozen high-yielding varieties were bred and released for cultivation during the 1970s, '80s, and '90s. These varieties were developed through hybridization between exotic (African) and native Indian germplasm. Farmers, particularly in areas where rainfall is more evenly distributed, have accepted some of these varieties, but their adoption is uneven in the major finger-millet-growing belts of Karnataka. Adoption is higher in districts and areas where annual rainfall is more evenly distributed than where rainfall is scanty and erratic. For example, in Chitradurga and Bellary, farmers still grow old varieties because of their specific adaptation to the local environments. The reasons for nonacceptance of new varieties in these districts could be a lack of traits farmers consider important in the new varieties, or a lack of location-specific adaptation, or both.

This paper reports results on farmer participatory varietal selection in finger millet in Karnataka. The major objectives of the study were to find out what traits farmers prefer to have in a new...
variety, to provide a basket of choices of recommended and nonrecommended varieties (the nonrecommended selected from those in advanced stages of formal varietal testing) to farmers for testing and selection, and to identify farmer-preferred varieties for dissemination.

The study was carried out in three major finger-millet-growing subdistricts (taluks): Chitradurga, Holalkere, and Hosadurga of Chitradurga district, Karnataka, India. The mean annual rainfall in Holalkere is 602 mm, in Chitradurga 590 mm, and in Hosadurga 463 mm.

**Participatory rural survey**

A household baseline survey for varietal preferences was conducted, involving 150 finger-millet-growing farmers categorized into upper, medium, and lower socioeconomic classes. The survey was made in 1999 in seven villages: Kathalli, Jalikatte, and Erajjanahatti of Chitradurga taluk, surveyed in May; Maddheru and Kumminagatta of Holalkere taluk, surveyed in June; and S. Roppa and Bansihalli of Hosadurga taluk, surveyed in July.

*What characteristics do farmers want in a new variety?*

Disregarding those farmers who did not respond, all farmers preferred a variety with higher grain and fodder yields. Among other traits, 67% farmers preferred varieties with compact ears, 65% wanted plants of medium height of around 100 cm, and 38% considered early maturity an important trait. Farmers did not express a specific preference for characteristics such as ear size, number of tillers per plant, or quality of fodder or grain (table 1).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Preference (percent, based on 150 farmers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher yield</td>
<td>100 (11 not responding)</td>
</tr>
<tr>
<td>Higher fodder yield</td>
<td>100 (11 not responding)</td>
</tr>
<tr>
<td>Ear compactness</td>
<td>67 compact, 8 semi-compact, and 25 loose</td>
</tr>
<tr>
<td>Ear size</td>
<td>69 medium, 31 large</td>
</tr>
<tr>
<td>Plant height</td>
<td>65 semi-dwarf, 15 medium, and 19 tall</td>
</tr>
<tr>
<td>Duration</td>
<td>38 early</td>
</tr>
<tr>
<td>Tillers per plant</td>
<td>16 high</td>
</tr>
<tr>
<td>Fodder quality</td>
<td>11 good</td>
</tr>
<tr>
<td>Grain color</td>
<td>11 red</td>
</tr>
<tr>
<td>Grain quality</td>
<td>1 good</td>
</tr>
<tr>
<td>Disease resistance</td>
<td>8 resistant</td>
</tr>
</tbody>
</table>

The farmers' ideal variety would be high-yielding, maturing in about 105 days, with a plant height of 100 cm, medium-sized compact ears, and moderate tillering ability (table 1). Farmers also required a suitable variety for late sowing (in the middle of August) as a second crop following sesame or cowpea in the rainy (kharif) season.

The baseline survey also showed that there was a varietal monoculture of PR 202, a selection from local cultivars from Andhra Pradesh. PR 202 is an old variety that was released for Andhra Pradesh in 1976 as a pure-line selection from a Mettachodi landrace of the Vishakapatnam area. Its plants...
are medium tall (110 to 120 cm) and ears are in-curved with six to eight fingers per ear. PR 202 has a good threshing ratio, and its orange-brown grains are medium bold (1000 grains weigh 2.8 g). However, PR 202 is highly susceptible to blast—a major disease of finger millet, and farmers wanted an alternative to this variety.

Selection of cultivars for farmer-managed participatory-research trials

Following the baseline survey, a search was undertaken to find varieties that would best match the farmers' selection criteria. Six varieties were chosen for testing by farmers in a participatory varietal selection program. Three of the selected varieties were released varieties, or identified for future release, i.e., GPU 28 and GPU 26 (released for Karnataka in 1998 and 1999, respectively), and VL 149 (nationally released in 1994). The other three varieties, VL 305, GPU 46, and 9002, were promising entries in advanced All-India co-ordinated finger-millet trials.

Conduct of the farmer-managed participatory-research trials

All the 150 farmers sampled in the baseline survey were involved in the conduct of farmer-managed participatory-research (FAMPAR) trials during the rainy season of 1999. There were two types of trials.

Single-variety trials

The 150 farmers were divided into six groups of 25 each across the seven selected villages; the number of participating farmers varied across villages. Each group was given one cultivar to grow side by side with their local variety in the same field under farmer-managed conditions, so there were 25 replicate-farmers for each variety. Each participating farmer was supplied with 1 kg of seed of the new variety (table 2).

Table 2. Details of the FAMPAR Trials Conducted in the Study Villages and Their Clusters, Chitradurga District, Karnataka, India

<table>
<thead>
<tr>
<th>Taluk</th>
<th>Cluster</th>
<th>Village</th>
<th>No. of trials</th>
<th>Mean distance from district headquarters</th>
<th>No. of trials</th>
<th>No. of successful trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chitradurga</td>
<td>1</td>
<td>Kathalley</td>
<td>30</td>
<td>10</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Erijanahalli</td>
<td>12</td>
<td>7</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Jalikatte</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holalkere</td>
<td>3</td>
<td>Maddheru</td>
<td>30</td>
<td>32</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Kumminagatta</td>
<td>30</td>
<td>38</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Hosadurga</td>
<td>5</td>
<td>Bansihalli</td>
<td>18</td>
<td>50</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S.Roppa</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Single-replicate all-variety trials

Two farmers in each village were given seed of all six varieties for growing together with the local variety in the same field in a single-replicate trial. These trials served two purposes: to compare the performance of all varieties and to serve as foci for demonstration and focus-group discussions. A
two-way analysis of variance with varieties as one factor and locations (villages) as the other provided significance of differences among location, varieties, and interaction of varieties with locations.

Farmers took a great interest in experimentation since only four FAMPAR trials out of 150 were unsuccessful. The variety GPU 28 yielded more than all other varieties in all clusters (table 3). Only variety GPU 46, in clusters 1 and 5, and variety GPU 26, in clusters 2 and 5, yielded on a par with GPU 28. All other varieties yielded less than GPU 28 in all five clusters.

Table 3. Mean Performance of Six FAMPAR Varieties over Five Village Clusters (Table 1), Rainy Season, 1999

<table>
<thead>
<tr>
<th>Variety</th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
<th>Cluster 4</th>
<th>Cluster 5</th>
<th>Mean</th>
<th>Increase over local (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPU 28</td>
<td>5.52 a</td>
<td>5.21 a</td>
<td>5.85 a</td>
<td>5.46 a</td>
<td>4.91 a</td>
<td>5.39</td>
<td>51</td>
</tr>
<tr>
<td>GPU 26</td>
<td>4.82 bc</td>
<td>4.76 ab</td>
<td>4.10 cd</td>
<td>4.82 b</td>
<td>4.66 abc</td>
<td>4.63</td>
<td>29</td>
</tr>
<tr>
<td>GPU 46</td>
<td>5.34 ab</td>
<td>4.34 bc</td>
<td>4.80 b</td>
<td>4.58 bcd</td>
<td>4.75 ab</td>
<td>4.76</td>
<td>33</td>
</tr>
<tr>
<td>VL 149</td>
<td>4.15 d</td>
<td>3.94 cde</td>
<td>3.87 cde</td>
<td>4.21 de</td>
<td>3.74 de</td>
<td>3.98</td>
<td>11</td>
</tr>
<tr>
<td>VL 305</td>
<td>4.29 cd</td>
<td>3.88 cde</td>
<td>3.41 e</td>
<td>4.25 cde</td>
<td>3.70 de</td>
<td>3.91</td>
<td>9</td>
</tr>
<tr>
<td>9002</td>
<td>4.72 cd</td>
<td>4.12 cd</td>
<td>4.12 c</td>
<td>4.68 bd</td>
<td>4.11 d</td>
<td>4.35</td>
<td>22</td>
</tr>
<tr>
<td>Local</td>
<td>3.44</td>
<td>3.41 e</td>
<td>3.41 e</td>
<td>3.57</td>
<td>4.05 de</td>
<td>3.58</td>
<td>—</td>
</tr>
<tr>
<td>LSD (t ha⁻¹)</td>
<td>0.61</td>
<td>0.55</td>
<td>0.55</td>
<td>0.44</td>
<td>0.53</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: Values followed by the same letter do not differ significantly from each other.

On average, GPU 28 yielded 5.39 t ha⁻¹—51% more than the local cultivar. All of the varieties showed some yield superiority to the local cultivar. GPU 46, the entry ranked second for grain yield, produced 33% more grain than the local variety, and GPU 26, the entry ranked third, yielded 29% more grain. Moreover, GPU 26 was significantly earlier to mature than either GPU 46 or the local variety, an important advantage as it allows the escape of terminal drought caused either by late sowing or early cessation of the rains.

Farmers’ perceptions were recorded in pre- and postharvest focus-group discussions (FGDs). Nine traits were scored in the FGDs: grain yield, stover yield, grain size, grain density, grain color, ear type, cooking quality, days to flowering, and disease resistance. The cultivar GPU 28 closely matched farmers’ criteria for a variety to grow under normal sowing in the second week of July. Early-maturing GPU 26 was the most preferred variety for late sowing. A nonrecommended variety, VL 305, was preferred by farmers for its 9% higher yield than the control and its extra-early maturity in 85 days, which allows it to fit in a double-cropping sequence. It can be sown in September after a crop of sesame or cowpea.

In the present study, farmers of Chitradurga district did not prefer the nationally recommended variety, VL 149. On the other hand, varieties GPU 26 and GPU 28, released by Karnataka state were accepted by farmers, although they still lacked the ear characteristics preferred by farmers. An important result of farmer-participatory varietal selection was the identification of variety VL 305 for growing in very specific niches as a second crop after sesame or cowpea. Farmers preferred this
variety because of its earliness even though this results in lower productivity compared to later-maturing varieties.

Participatory varietal selection in finger millet has been successful in identifying varieties for specific agroecosystems, which are difficult to reproduce on research stations. Our results confirm those of various workers in other crops and agroecological systems: farmers prefer to adopt varieties from a basket of choices irrespective of their recommendation domains (Sthapit, Joshi, and Witcombe 1996; Joshi and Witcombe 1996, 1998; Virk, Bhasker Raj, and Witcombe 1996; Thiele et al. 1997). The participatory approach is more effective than conventional on-farm adaptive research (Gowda et al. 2000) because it provides farmers multiple choices from among varieties that are selected for farmer-preferred traits.

Conclusions

The PVS approach in finger millet was a useful tool for the following reasons:

- understanding farmers’ criteria for selecting a variety
- analyzing reasons for nonadoption of a released variety
- identifying varieties for different sowing times and cropping systems from a basket of choices
- decreasing the gap between recommendation and adoption

References


Participatory Varietal Selection, Food Security, and Varietal Diversity in a High-Potential Production System in Nepal

K.D. Joshi and J.R. Witcombe

Abstract

A survey of nearly 1500 households in the high-potential production system (HPPSs) of the Chitwan and Nawalparasi districts of Nepal showed great physical and socioeconomic diversity. Varietal diversity was low in all the crops studied and varied according to location in main-season rice. Masuli was the predominant main-season rice variety, occupying over 65% of the area in the surveyed villages. Seventeen modern varieties of main-season rice were introduced to farmers to test in collaborative trials. Farmers identified 10 of the new rice varieties as having useful traits, and seven were adopted to a significant extent within three seasons. The new varieties occupied about 13% of over 800 ha of main-season rice in eight study villages and increased on-farm varietal diversity by partly replacing predominant varieties. The accepted varieties offered, on average, an 18% yield advantage without any requirement to change agronomy or increase inputs. Other advantages of the new varieties were their early maturity, drought tolerance, disease and insect tolerance, and better adaptation to different ecological niches such as areas of shallow water. Despite the commonly assumed uniformity of high-potential production systems, the new varieties occupied specific niches in the farming system from irrigated land with varying duration of retained standing water, and from partially irrigated to rainfed lowland conditions. Farmers preferred specific varieties for different niches, which should help to increase and maintain biodiversity on the farm. Overall production is expected to increase as each niche becomes occupied increasingly by the best-adapted variety. Participatory approaches are simple, powerful methods for identifying superior varieties and deploying them in specific niches for increasing food production in high-potential production systems.

Introduction

Favorable agricultural environments, known as high-potential production systems (HPPS), produce most of the world's grain. In the developing world, HPPS are often intensively cultivated irrigated areas. The terai of Nepal (the alluvial, low-altitude flat land on the southern borders of Nepal at about 150 m altitude) has seasonal or perennial irrigation, high crop yields, and produces 57% of the total cereal production of the country (AMDD 1994/95). For Nepal to feed its ever-increasing population without increased reliance on imports, higher production is required in the terai.

A description of the study area

The study area is located in the south of Nepal at a latitude of 27° N. The climate is subtropical to tropical, with warm, humid summers (max. 40°C) and cool, dry winters (min. 8°C). About 90% of the annual total rainfall of about 2000 mm falls between June and September. The research was carried out in 18 villages comprising 3000 households. The villages were located in parts of two districts, Chitwan and Nawalparasi, and grouped into three clusters of six villages in East Chitwan.
West Chitwan, and Nawalparasi. The villages were selected for the study using several criteria, such as having >80 households, good irrigation facilities, land suitable for double rice cropping, and good access to agricultural markets.

There are more than 53,000 ha of cultivated land in Chitwan and over 64,000 ha in Nawalparasi. Both districts have more than 72,000 ha of main-season rice. About 22% of the land is irrigated in Chitwan and about 36% in Nawalparasi. Farmers grow two or three crops per year. Main-season rice is the major crop in June to October and covers about 1600 ha in the study villages. Rice is followed by lentils or wheat in the winter, followed by maize and chaite rice in the spring. There is diversity in soil type, irrigation facilities, and production potential. Productivity is generally higher in East and West Chitwan than in Nawalparasi. There are also variations in the farming systems within clusters, e.g., some farmers in Chitwan grow maize and vegetables in the winter instead of wheat and lentils.

A survey of 1487 households in Chitwan and Nawalparasi conducted in 1997 showed high diversity in physical and socioeconomic conditions. In the study area, 23% of farmers were resource rich, 34% were classed as having average resources, and 43% were resource poor (Ranà et al. 2000). There was wide variation in the size of land holdings, access to irrigation, and the use of production inputs, which has resulted in different cropping patterns: rice-vegetables-maize or rice-maize-vegetables and rice-wheat-maize in East Chitwan and mostly rice-wheat-rice, rice-fallow-rice, or rice-lentil-maize in West Chitwan and Nawalparasi. There is wide variation in the rice ecosystem, from perennially irrigated land with varying durations of retained standing water, to seasonally irrigated land, to rainfed lowland conditions.

The production potential is high. Yields of the most commonly grown main-season rice variety were measured in farmer-managed participatory research (FAMPAR) trials in 1997. The average yield of the predominant main-season rice cultivar, Masuli, was 4.2 t ha\(^{-1}\) (Joshi et al. 1999).

**Participatory approaches**

Two approaches—participatory varietal selection (PVS) and informal research and development (IRD)—were used to provide a choice of varieties to farmers in Nepal. In PVS, introduced varieties were tested in intensively evaluated FAMPAR trials using the methods described in Joshi and Witcombe (1996). IRD uses less intensive evaluation and has been proven to be effective for popularizing new varieties by the Lumle Agricultural Research Centre, Nepal (Joshi and Shapit 1990). In each cluster of six villages, FAMPAR trials were conducted in three and IRD trials in three. In the IRD trials, the same ranges of varieties were used but there was no monitoring or participatory evaluation during the growing season. Instead, farmer’s perceptions were evaluated after harvest by informal interviews with a sample of farmers. Data were collected on subsequent adoption and farmer-to-farmer seed dissemination. There were 536 FAMPAR and 546 IRD trials from 1997 to 1998.

Twelve new varieties of main-season rice were first offered to farmers to experiment with in the main season of 1997 and five more varieties were given out in 1998 (table 1). In each village, for each variety a 1-kg bag of seed was given to two farmers in each of three wealth categories (see below). Plot sizes varied because of differences in nursery raising practices. Planting methods, use of manure and fertilizers, and intercultural operations were unchanged. The farmers grew the new variety alongside their existing variety, usually Masuli, as a control. Care was taken to avoid any
Table 1. Rice Varieties Included in the Participatory Varietal Selection Program, 1997–1998 (The first 12 varieties were first offered in 1997, the last 4 in 1998.)

<table>
<thead>
<tr>
<th>Name of variety</th>
<th>Entry name</th>
<th>Parentage</th>
<th>Country and year of release</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR51672</td>
<td>IR51672</td>
<td>—</td>
<td>India</td>
</tr>
<tr>
<td>Narendra 80</td>
<td>NDR 80</td>
<td>N22/IR36</td>
<td>1986</td>
</tr>
<tr>
<td>Radha 11 (India:Rajshree)</td>
<td>TCA 80-4</td>
<td>Local selection in India</td>
<td>1989</td>
</tr>
<tr>
<td>Rampur Maroli</td>
<td>AS781-1</td>
<td>Lalnakanda/IR30</td>
<td>1995</td>
</tr>
<tr>
<td>Pant Dhan 4</td>
<td>BG 90-2</td>
<td>IR262/Ramadja</td>
<td>1984</td>
</tr>
<tr>
<td>Pant Dhan 10</td>
<td>IR9763</td>
<td>IR32/Mahshuri/IR28</td>
<td>1993</td>
</tr>
<tr>
<td>PNR 381</td>
<td>—</td>
<td>Tainan 3 mutan/Vasmati 370</td>
<td>1992</td>
</tr>
<tr>
<td>PR 103</td>
<td>IR661</td>
<td>IR8/IR127-2-2</td>
<td>1976</td>
</tr>
<tr>
<td>PR 106</td>
<td>IR665-79</td>
<td>IR8/Peta/Bella Patna</td>
<td>1978</td>
</tr>
<tr>
<td>PR 111</td>
<td>—</td>
<td>IR54/PR106</td>
<td>1993</td>
</tr>
<tr>
<td>Pusa basmati-1</td>
<td>Pusa 615</td>
<td>Pusa 150/Karnal local</td>
<td>1989</td>
</tr>
<tr>
<td>Swarna</td>
<td>MTU7029</td>
<td>Vasista/Mahshuri</td>
<td>1982</td>
</tr>
<tr>
<td>Pusa 33</td>
<td>—</td>
<td>Improved Sabarmati/Ratna</td>
<td>1983</td>
</tr>
<tr>
<td>Pusa 44</td>
<td>Pusa 44-33</td>
<td>IARI 5901-2/IR 8</td>
<td>1993</td>
</tr>
<tr>
<td>Pusa 834</td>
<td>—</td>
<td>IR 50/Pusa 33/IR 50/Pusa 33</td>
<td>1995</td>
</tr>
<tr>
<td>Sarwati</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: NR = not released; PR = pre-release; (—) information not available.

chance of mixing the new variety with the existing farmer's variety from seed sowing through to post-harvest assessment. The area of the trial plots was measured by researchers, while farmers measured yield in local volumetric units, which were later converted to metric units. A paired t-test was used to test the significance of the difference for yield between the test entry and the existing rice variety.

To conduct the trials, each trial site was jointly identified and demarcated by the participating farmers and researchers. There were regular visits by researchers to the trial plots with the participating farmers to see the performance of the variety at different growth stages. A farm walk was organized in which researchers, participating farmers, and other interested farmers saw the standing crop in all or most of the plots when the crop was near to maturity. Immediately after each farm walk, a focus-group discussion was held, which included preparing a narrative summary of each rice variety, describing all its positive and negative traits, and preparing an overall preference ranking of all the varieties. A post-harvest evaluation of the rice varieties was done on the basis of farmers' perceptions two to three months after the harvest of the crop. This gave the farmers enough time to assess post-harvest traits. A structured questionnaire was used, which included questions on grain quality, market preference, and the farmers' intentions on whether to adopt or reject the variety. Questions were also asked on the distribution of the seed of the variety by farmers to monitor the adoption and spread of the new rice varieties through 1997 to 1999. In 1999, households that received seeds in 1997 and 1998 were visited first (purposive sampling) and then new adopters were interviewed based on the distribution list provided by each farmer.
The project mobilized existing farmers' groups in the project villages. These groups had been formed for different purposes, including agriculture, livestock/dairy, and water use. Distribution of the seed of the new varieties was done following discussions with the groups. Participatory well-being ranking was done to identify farmers from different resource categories. Through group consensus, an equal number of farmers from all three well-being categories were selected to participate in the trials. A brief overview of all the varieties included in the trials was given to farmers.

**Varietal diversity in the project area before PCI**

The baseline study showed that varietal diversity was low in *chaite* rice, wheat, and maize (Rana et al. 2000). In *chaite* rice, CH 45 covered over 97% of the *chaite* rice area in the project villages. In maize, varieties Arun 2 and Arun 4 occupied about 70% of the area, and Rampur Composite about 30%. In wheat, two varieties, UP 262 (50%) and RR 21 (20%), occupied most of the area.

For main-season rice, the greatest varietal diversity was in the East Chitwan cluster (ECC) of villages where 11 different rice varieties were grown by the farmers, of which Masuli and Ekhattar (a sister line of Sabitri) together occupied two-thirds of the rice area (figure 1).  

![Figure 1. Area under main-season rice varieties in three study villages of East Chitwan cluster, 1997 (Himali and Chaite 6 occupied an insignificant area and are not shown.)](image)

Six different rice varieties were grown by the farmers in the West Chitwan cluster (WCC) but Masuli alone covered 98% of the total rice area (figure 2). The narrow varietal diversity in this cluster could be attributed to a more uniform physical environment as the majority of the area is low lying and retains standing water during most of the rice-growing season. Another reason is that in WCC, in contrast to ECC, few vegetables are grown. Vegetable growing promotes diversity because farmers grow rice varieties of shorter duration than Masuli to allow timely sowing of the vegetable crops.
The varietal diversity at the Nawalparasi cluster (NPC) is closer to WCC than to ECC. The main differences are that in Nawalparasi there is more Masuli and Sabitri and no Ekhattar at all (figure 3).