ment, considering their resources (time), knowledge, and skills, were chosen by the farmers' group. There were mainly three types of activities: a mass-selection program, a crossing program, and a participatory variety selection (PVS) program.

## Refining the research process

The involvement of farmers in analysis of researchable problems helped change the researchers' perceptions of the problem (table 4) and redefine the goal of the maize-improvement program. The redefinition of the breeding goals of the maize-improvement program provided guidelines for refining the research process that had been proposed initially. A multiple approach (mass selection, crossing, screening of improved/pipeline varieties, and PVS) was taken to address the problems, some of which had not been considered before. Farmers liked the mass-selection technique because they perceived it as a simple method and as a possible option to improve specific traits, keeping the desirable traits of the variety intact. The crossing program was chosen in consideration of the slow genetic gain in the mass-selection method, particularly in farmers' fields. Considering the long gestation period of the variety-improvement program, which may delay the delivery of benefits to the farmers, the variety-selection program was planned. This would provide farmers with access to new, improved genetic materials to test in diverse farming situations.

A farmers' research committee was formed at each site in order to empower farmers and to ensure farmers' leadership in the project. It was decided that the committee would be equally responsible for the planning, implementation, and monitoring of project activities. The committee works as an interface between farmers and researchers. It is expected that involving farmers in the planning and

**Table 4. Changes in Researchers' Perceptions after Involvement of Farmers in Problem Analysis**

| | Researchers' perceptions | |
|---|---|---|
| **Parameters** | **Before farmers' involvement** | **After farmers' involvement** |
| Varietal intervention | Low | Low and limited |
| Landraces | Low yielding and inferior | Despite good yield potential–low production due to lodging |
| Problem | Low yield | Lodging |
| Extent of problem | Not known | Yield loss: 15%–85% depending upon severity |
| Contributing factors of the problem | Not known | Tall plant and ear height<br>Thin stalk<br>Wind pressure |
| Ethno-perception | Not known | Local landraces are well fitted in different niches<br>Widely grown *Thulo pinyalo* has all good traits but prone to lodging |
| Varietal requirement | HYV | Lodging-resistant variety |
| Objective | Increase access to genetic materials<br>Provide mass-selection training to farmers | Improve *Thulo pinyalo* for lodging resistance<br>Provide mass-selection training to farmers |

implementation process will help in capacity building and increase the farmers' sense of ownership in the program.

Farmers are very supportive and cooperative in the project area. However, in some technical matters farmers' had different perceptions and attitudes, which changed along with the time. For example, farmers perceived that plants with short height could not produce good yields, that detasseling leads to total sterility in maize, etc. In the beginning, this made it difficult for researchers to facilitate some of the field activities, such as crossing, demonstrating short-statured varieties, etc. Later, the farmers found that their perceptions were not correct, and their faith in the researchers increased, leading to better understanding, cooperation, and collaboration. Some farmers who were not positive about the program in the beginning are the strongest members of the team now.

## Conclusions

Involvement of farmers in the planning process resulted in the development of more specific breeding objectives, which were more focused on the farmers' perceived needs. It has helped to refine the context and process of the participatory plant-breeding program and has given farmers a leading role in the decision-making process.

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# Sensory Evaluation of Upland Rice Varieties with Farmers: A Case Study

*R.K. Singh, K. Prasad, N.P. Mandal, R.K. Singh, B. Courtois, V.P. Singh, and T. Paris*

**Abstract**

As part of a participatory plant-breeding project with methodological objectives to improve rainfed rice in eastern India, an evaluation of sensory characteristics was conducted with farmers in a village of Bihar. Twenty-four farmers (12 women and 12 men) evaluated 15 upland rice varieties as raw rice and parboiled rice for milled and cooked rice appearance, color, odor, texture, stickiness, taste, and overall acceptability. The rice samples were milled and cooked by the women farmers following their ordinary practices. One variety recorded good results with both raw and parboiled modes of preparation. The preferences of women and men farmers did not differ significantly. The rankings based on preferences were compared with the rankings of the varieties for various physico-chemical characteristics measured in the laboratory. Most correlations were not significant, indicating that, for the set of tested varieties, these parameters were poor predictors of farmers' preferences. The rankings based on preferences were compared with farmers' field rankings, and the correlation was positive for raw rice and negative for parboiled rice. Farmers' trade-off between field performance and grain quality is therefore important to assess for at least parboiled rice. The results of this first sensory evaluation experiment will be used to simplify the methodology and to improve varietal evaluation in the formal breeding process.

## Introduction

In eastern India, rainfed rice represents a major component in the diet and income of millions of resource-poor people. In these harsh environments, the rate of adoption of modern rice varieties is low. Subsistence agriculture is still quite important, although market integration is slowly progressing (Pingali 1997). In these transition systems, grain quality and taste strongly influence the adoption of modern varieties. The main source of variation in grain quality is the variety, although environment and genotype-x-environment interactions also affect grain quality. Different grain types, and therefore different varieties, are needed for self-consumption, market sale, and various preparations or to pay wages in kind. For plain rice, precooking practices influence the varietal choices. Among the most common is parboiling, which is an age-old practice in some regions of eastern India, where rice is partly cooked before being air-dried and then sun-dried to improve its nutritional, cooking, and storage attributes. Preferences may vary across income levels, various social groups requiring various varieties.

Quality tests for breeding lines are routinely conducted by scientists in the laboratory. In the frame of a participatory plant-breeding project with methodological objectives started in 1997 under the collaborative program with the Indian Council of Agricultural Research (ICAR) and the International Rice Research Institute (IRRI) (Courtois et al. 1999), we developed a methodology to evaluate the grain quality of rice varieties in collaboration with farmers. To test the methodology, the

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sensory evaluation of a set of upland rice varieties was organized in a village of eastern India. The objectives of this study were (1) to document the process of rice preparation at the farm level for raw and parboiled rice, (2) to estimate the influence of the two modes of preparation on rice quality and identify the best varieties in each case, (3) to collect information about quality characteristics that determine varietal acceptability by female and male farmers, and (4) to relate the preferences with the physico-chemical properties of the varieties determined in laboratory.

## Materials and methods

Fifteen modern upland rice varieties and a local check (Brown Gora, widely grown by upland farmers) were tested. The test was conducted in 1998 in the village of the Korahar district of Hazaribagh, Bihar, India. These varieties had been previously tested for their agronomic values in a participatory varietal trial conducted in the same village (Courtois et al., *submitted*).

### *Raw rice*

For each variety, two kilos of sun-dried paddy of good quality were used. The paddy was dehulled and milled using a *dhenki*, a big wooden bar moving up and down around an axis. The *dhenki* was operated by two women, one of them moving the *dhenki* with her leg, the other shuffling the paddy grain after every stroke of the *dhenki*. All the varieties were dehulled and milled by the same two persons under the same conditions. The times necessary for completion of dehulling and milling, and the milling recovery (percentage of milled rice weight on rough rice weight) were recorded. The head rice recovery (unbroken grains) was not quantified but estimated visually (milled rice appearance).

Before cooking, one kilo of cleaned rice was washed with water. Aluminum vessels called *bhudeli* were used to cook each variety separately. All *bhudeli* were of the same capacity. The women suggested using 3 liters of water to cook 1 kg of raw rice. The *bhudeli* with water was kept on the fire up to the boiling point, when the washed rice was added. The cooking test was done by pressing the cooked rice between thumb and index finger. The same woman did the cooking test for all varieties. The cooking time of each variety was recorded. The excess water was drained and the cooked rice was displayed on a *pattal* (leaf mat) for sensory evaluation.

### *Parboiled rice*

As decided by the women, 2.5 kg of paddy were soaked in 3 liters of water in a tin container for 18 hours. A common belief is that the soaking of paddy should be done in the evening rather than during daytime, with the excess water drained in the morning, to avoid the heat of the day. A temperature that is too high would induce the soaked paddy to ferment, leading to poor rice quality, high breakage, and bad odor (Bhattacharya 1985). The soaking of paddy in water started at 4:00 p.m. and the water was drained at 10:00 am the next day. After decanting the water, the soaked paddy was steamed on the fire. During the steaming process, the tin containing the soaked paddy was covered with a gunny bag to avoid loss of heat. When the husks of the paddy started cracking, the container was taken off the fire. The steamed paddy was spread in the shade on a mud floor for drying. The paddy was dried in the shade for 48 hours with intermittent mixing. It was then exposed to the sun for complete drying. An indigenous technique was used to test the proper drying of paddy. Twenty to 30 grains of paddy were dropped on a hard floor. The grains were crushed underfoot by rotating the heel. If this removed the grain husk, the rice was considered to be well dried and ready for

dehulling. For dehulling and milling, 2 kg of cleaned paddy were used and the same process as for raw rice was followed.

More water is needed to cook parboiled rice than to cook raw rice. The women suggested adding 7 liters of water to cook 1 kg of parboiled rice. For the subsequent operations, the same process was followed as for raw rice.

### *Sensorial evaluation*

A protocol for the practical organization of the sensory evaluation was designed following the recommendations of Amerine, Pangborn, and Roessler (1965) and Del Mundo (1991) and adapting them to the realities of an eastern Indian village.

Twenty-four farmers (12 women and 12 men) participated in the sensory evaluation. A hedonic scale was used. The farmers were asked to indicate whether they liked (score 1) or disliked (score 0) the varieties for milled grain appearance, cooked rice appearance, odor, color, texture (soft/hard), stickiness, taste, and overall acceptability. The samples were numbered and randomized to limit the "first-sample bias." The raw rice and parboiled rice were evaluated on different days to limit the testers' fatigue.

### *Physico-chemical characterization of the samples under laboratory conditions*

The tests were performed at the technology laboratory of the Central Rice Research Institute, Cuttack, India, for raw rice and in N.D. University of Agriculture and Technology, Masodha, Faizabad, India, for parboiled rice. The parameters measured for raw rice were milling recovery, head rice recovery, grain length and width, alkali value, volume-expansion ratio, kernel-elongation ratio, and amylase content. For parboiled rice, hulling and milling recovery and grain shape were measured.

### *Statistical analysis*

For rank comparison, Spearman's coefficient of correlation was used when only two rankings were compared. A Kendall coefficient of concordance was used, as described in Siegel (1956), when more than two rankers were involved. The mean comparisons were performed using a Student's *t*-test.

## Results and discussion

### *Milling*

No difference between the two modes of preparation was observed for milling time (table 1). Raw rice took significantly less time to cook as compared to parboiled rice. Milling recovery was significantly higher for parboiled rice in comparison to raw rice. There was no significant difference between farmers' practices and laboratory method for raw rice but recovery was higher with farmers' practices for parboiled rice. The lower coefficients of variation in the case of parboiled rice indicated a buffering effect of parboiling across varieties for recovery, which explains why parboiling is considered an excellent means to recover poor-quality samples.

### *Sensory evaluation*

The method of rice preparation had a great impact on the ranking of the rice varieties for all traits, as shown by the nonsignificant and sometimes negative rank correlations between the two sets of

**Table 1. Comparison of the Milling Properties and Cooking Time of Raw and Parboiled Upland Varieties Prepared by Farmers, Korahar, Bihar, India, 1998**

| Variety | Milling time (minutes) | | Recovery farmers' practices (%) | | Recovery laboratory (%) | | Cooking time farmers' practices (minutes) | |
|---|---|---|---|---|---|---|---|---|
| | Raw | Parboiled | Raw | Parboiled | Raw | Parboiled | Raw | Parboiled |
| Brown Gora | 19 | 30 | 70 | 71 | 58.5 | 75.0 | 11.0 | 23.0 |
| RR139-1 | 16 | 17 | 63 | 77 | 62.3 | 80.0 | 8.5 | 33.5 |
| RR151-3 | 18 | 19 | 69 | 72 | 67.3 | 75.0 | 10.0 | 17.0 |
| RR151-4 | 22 | 19 | 57 | 74 | 67.5 | 80.0 | 8.0 | 20.5 |
| RR166-645 | 15 | 23 | 65 | 74 | 59.5 | 76.3 | 11.0 | 23.0 |
| RR203-16 | 15 | 17 | 63 | 73 | 56.0 | 76.3 | 11.0 | 22.0 |
| RR2-6 | 27 | 18 | 70 | 72 | 60.5 | 76.3 | 13.0 | 33.0 |
| RR265-1 | 20 | 15 | 70 | 72 | 76.5 | 77.5 | 8.5 | 22.0 |
| RR347-166 | 20 | 17 | 66 | 74 | 73.5 | 7.38 | 15.5 | 23.0 |
| RR348-5 | 30 | 17 | 71 | 72 | 66.3 | 78.8 | 9.0 | 23.0 |
| RR348-7 | 13 | 16 | 69 | 74 | 51.0 | 77.8 | 13.0 | 32.0 |
| RR352-1 | 16 | 24 | 66 | 72 | 64.0 | 76.3 | 14.0 | 27.0 |
| RR354-1 | 20 | 23 | 59 | 75 | 69.8 | 77.5 | 16.0 | 29.0 |
| RR50-5 | 18 | 20 | 67 | 71 | 67.8 | 80.0 | 13.0 | 34.0 |
| RR51-1 | 19 | 18 | 66 | 72 | 58.8 | 75.0 | 10.0 | 26.0 |
| Vandana | 17 | 19 | 74 | 70 | 72.0 | 76.3 | 13.5 | 25.0 |
| Mean | 19.1 | 19.5 | 66.6 | 72.8 | 64.4 | 77.0 | 11.4 | 25.8 |
| SD | 4.4 | 3.8 | 4.5 | 1.8 | 6.9 | 1.9 | 2.5 | 5.1 |
| t raw/parboiled | 0.28ns | | 7.11** | | 4.29** | | 12.04** | |

Note: ** = significant at the 1% level; ns = not significant.

scores (table 2). The preferred varieties in terms of acceptability were RR151-3, RR352-1, and RR354-1 for raw rice, and RR50-5, RR352-1, and RR354-1 for parboiled rice. For breeding purposes, it was interesting to identify varieties that could perform well under both preparations. RR352-1 and RR354-1 scored quite well in this respect.

The farmers were also asked to indicate the four varieties they liked the most (high score indicated high preference) and the four varieties they liked the least (this time high scores indicated high dislike). By this means, only one variety, RR354-1 recorded a good score for both raw and parboiled rice (table 3), being liked by 67% of the farmers as parboiled rice and 58% of the farmers as raw rice. RR151-3 and RR352-1 were appreciated by the farmers as raw rice but not as parboiled rice. Inversely, RR2-6, RR166-645, and RR265-1 were liked by the farmers as parboiled rice but not as raw rice.

For raw rice as well as parboiled rice, the rank correlations among characteristics scored by farmers were very strong and positive (table 4) except for stickiness, for which they were also positive but more seldom significant. This means that there is probably no need to ask the farmers to score all these traits. The acceptability or the choice of the three or four most preferred varieties should be enough to represent the group of traits. A simplification of the testing procedure an important in order to facilitate the integration of participatory approaches in the formal breeding system and to sustain farmers' participation.

**Table 2. Sum of Scores Given by 24 Farmers for Cooking Quality Characteristics of Upland Rice Varieties, Korahar, Bihar, India, 1998**

| Variety | Milled rice appearance | | Cooked rice appearance | | Odor | | Color | | Texture (soft/hard) | | Stickiness | | Taste/ flavor | | Accept. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Raw | Par. | Raw | Par. | Raw | Par. | Raw | Par. | Raw | Par. | Raw | Par. | Raw | Par. | Raw | Par. |
| Brown Gora | 1 | 11 | 5 | 13 | 2 | 11 | 2 | 7 | 2 | 10 | 8 | 12 | 10 | 13 | 4 | 9 |
| RR139-1 | 4 | 10 | 18 | 19 | 13 | 18 | 17 | 21 | 13 | 17 | 11 | 20 | 15 | 20 | 12 | 16 |
| RR151-3 | 17 | 1 | 20 | 9 | 18 | 10 | 20 | 9 | 18 | 8 | 16 | 10 | 17 | 9 | 18 | 6 |
| RR151-4 | 17 | 16 | 16 | 19 | 12 | 23 | 17 | 19 | 13 | 15 | 10 | 22 | 18 | 18 | 16 | 19 |
| RR166-645 | 4 | 11 | 11 | 18 | 11 | 17 | 6 | 8 | 12 | 10 | 9 | 13 | 11 | 16 | 9 | 18 |
| RR203-16 | 8 | 6 | 13 | 14 | 9 | 16 | 14 | 15 | 5 | 12 | 8 | 15 | 13 | 15 | 13 | 11 |
| RR2-6 | 8 | 13 | 9 | 21 | 8 | 23 | 12 | 23 | 6 | 17 | 8 | 19 | 9 | 20 | 8 | 20 |
| RR265-1 | 19 | 18 | 13 | 18 | 10 | 16 | 13 | 21 | 12 | 18 | 9 | 19 | 13 | 16 | 9 | 18 |
| RR347-166 | 21 | 6 | 20 | 17 | 17 | 17 | 21 | 17 | 14 | 14 | 12 | 16 | 14 | 13 | 12 | 12 |
| RR348-5 | 1 | 22 | 19 | 20 | 13 | 17 | 16 | 20 | 15 | 16 | 15 | 15 | 17 | 14 | 15 | 16 |
| RR348-7 | 1 | 13 | 7 | 16 | 6 | 16 | 4 | 19 | 5 | 14 | 11 | 13 | 8 | 14 | 6 | 13 |
| RR352-1 | 22 | 10 | 20 | 21 | 20 | 20 | 18 | 20 | 17 | 17 | 16 | 21 | 21 | 20 | 17 | 22 |
| RR354-1 | 12 | 23 | 15 | 24 | 14 | 23 | 19 | 23 | 16 | 20 | 7 | 22 | 18 | 22 | 17 | 24 |
| RR50-5 | 21 | 16 | 14 | 24 | 15 | 21 | 15 | 22 | 10 | 22 | 11 | 19 | 14 | 22 | 14 | 21 |
| RR51-1 | 9 | 7 | 11 | 14 | 12 | 12 | 16 | 10 | 7 | 13 | 13 | 15 | 13 | 11 | 11 | 13 |
| Vandana | 12 | 2 | 15 | 9 | 15 | 11 | 19 | 5 | 16 | 8 | 11 | 8 | 12 | 9 | 12 | 6 |
| Rank correl. raw/parboiled | -0.12 | | 0.10 | | 0.12 | | 0.20 | | 0.06 | | -0.19 | | 0.26 | | 0.23 | |

*Notes*: Par. = Parboiled rice; Accept. = Acceptability; Varieties with high scores are the preferred ones.

**Table 3. Preferences of Farmers for the Various Varieties in the Sensory Evaluation Conducted in Korahar, Bihar, India, 1998**

| Variety | Most liked* | | Least liked* | |
|---|---|---|---|---|
| | Raw | Parboiled | Raw | Parboiled |
| Brown Gora | 0 | 0 | 13 | 5 |
| RR139-1 | 4 | 0 | 2 | 8 |
| RR151-3 | 16 | 0 | 1 | 15 |
| RR151-4 | 8 | 6 | 2 | 2 |
| RR166-645 | 1 | 10 | 10 | 1 |
| RR203-16 | 3 | 9 | 4 | 0 |
| RR2-6 | 1 | 11 | 14 | 0 |
| RR265-1 | 2 | 10 | 3 | 0 |
| RR347-166 | 8 | 2 | 1 | 7 |
| RR348-5 | 7 | 6 | 2 | 3 |
| RR348-7 | 3 | 2 | 15 | 11 |
| RR352-1 | 14 | 0 | 1 | 7 |
| RR354-1 | 14 | 16 | 2 | 1 |
| RR50-5 | 4 | 4 | 4 | 4 |
| RR51-1 | 3 | 3 | 1 | 3 |
| Vandana | 0 | 0 | 1 | 13 |

*Farmers were asked to give the codes of the four varieties they liked most and the four varieties they liked lease. However, some of them gave only 1 or 2 scores.

**Table 4. Correlations between Farmers' Ranks for Quality Traits of Raw and Parboiled Upland Rice Varieties (Women's and Men's Rankings Pooled Together), Korahar, Bihar, India, 1998**

| Trait | | Milled rice app. | Cooked rice app. | Odor | Color | Texture | Stickiness | Taste |
|---|---|---|---|---|---|---|---|---|
| **Milled rice app.** | Raw | | | | | | | |
| | Parboiled | | | | | | | |
| **Cooked rice app.** | Raw | 0.59* | | | | | | |
| | Parboiled | 0.55* | | | | | | |
| **Odor** | Raw | 0.72** | 0.85** | | | | | |
| | Parboiled | 0.68** | 0.88** | | | | | |
| **Color** | Raw | 0.60* | 0.84** | 0.88** | | | | |
| | Parboiled | 0.60* | 0.87** | 0.88** | | | | |
| **Texture** | Raw | 0.46 | 0.76** | 0.80** | 0.83** | | | |
| | Parboiled | 0.50* | 0.87** | 0.87** | 0.85** | | | |
| **Stickiness** | Raw | 0.18 | 0.47 | 0.45 | 0.29 | 0.20 | | |
| | Parboiled | 0.29 | 0.62* | 0.66** | 0.48 | 0.52* | | |
| **Taste** | Raw | 0.58* | 0.87** | 0.71** | 0.72** | 0.72** | 0.28 | |
| | Parboiled | 0.53* | 0.83** | 0.72** | 0.71** | 0.74** | 0.39 | |
| **Acceptability** | Raw | 0.67* | 0.81** | 0.82** | 0.79** | 0.75** | 0.23 | 0.90** |
| | Parboiled | 0.52 | 0.81** | 0.87** | 0.75** | 0.77** | 0.39 | 0.91 |

Opinions of women and men farmers were similar, with significant to highly significant correlations between their rankings for milled rice appearance, cooked rice appearance, texture, color, and taste (table 5). The only traits for which their agreement was weaker was stickiness and, to lower

**Table 5. Correlations between Women and Men Farmers' Mean Ranks for Cooking Characteristics of Raw Rice, Korahar, Bihar, India, 1998**

| Trait | Spearman rank coefficient of correlation |
|---|---|
| Milled rice appearance | 0.97** |
| Cooked rice appearance | 0.57* |
| Odor | 0.45 |
| Color | 0.75** |
| Texture | 0.55* |
| Stickiness | 0.22 |
| Taste/flavor | 0.54* |
| Acceptability | 0.83** |
| Most liked | 0.88** |
| Least liked | 0.95** |

*Note:* Sample size was 12 women and 12 men.
* = Significant at 5% level.
** = Significant at 1%.

extent, odor. In terms of overall acceptability, there was no difference in women and men farmers' opinions on the tested varieties nor in their final choices of the varieties they liked most and least.

### *Laboratory analysis versus sensory evaluation*

The ranks given by farmers for the various quality traits were compared with the ranks of the same varieties for the main chemical properties of raw rice measured in the laboratory: alkali value, volume expansion, amylase content, and elongation ratio. Elongation ability was negatively correlated with stickiness $r = -0.55$, significant at the 5% level) but that was the only significant case. In the samples tested, amylase content did not seem to have any link to farmers preferences for texture $r = -0.14$) or stickiness $r = 0.04$).

It is unexpected to see so few relationships between consumer preferences and measurable chemical properties, since these are standard parameters used by all chemistry laboratories. However, for the varieties included in the evaluation, the variability for some traits was limited and therefore consumers had difficulty assessing differences.

### *Field performance versus grain quality*

There was little relationship between farmers' field ranking and grain quality for parboiled rice, as shown by the very low coefficients of correlation for rank and a negative one for the ranking based on yield (table 6). The relationship was stronger and positive for raw rice. There was no particular reason why the rankings should be correlated, but a strong negative correlation would complicate the breeding work. These results confirm that participatory varietal selection should not stop after harvest. Since a compromise might be necessary, at least for parboiled rice, the trade-off between criteria for agronomic performance and cooking quality applied by farmers has to be assessed.

**Table 6. Correlation Between Field Ranking and Yield, and Farmers Preferences based on Grain Quality, Korahar, Bihar, India, 1998**

| Variety | Farmers field ranking | Ranks based on observed yield | Most liked * | | Acceptability *** | |
|---|---|---|---|---|---|---|
| | (1) | (2) | Raw | Parboiled | Raw | Parboiled |
| Brown Gora | 15.0 | 10.5 | 15.5 | 14.0 | 16.0 | 14.0 |
| RR139-1 | 12.0 | 16.0 | 7.5 | 14.0 | 9.0 | 8.5 |
| RR151-3 | 4.0 | 2.0 | 1.0 | 14.0 | 1.0 | 15.5 |
| RR151-4 | 2.0 | 10.5 | 4.5 | 6.5 | 4.0 | 5.0 |
| RR166-645 | 6.0 | 8.0 | 13.5 | 3.5 | 12.5 | 6.5 |
| RR203-16 | 10.0 | 12.0 | 10.0 | 5.0 | 7.0 | 13.0 |
| RR2-6 | 8.0 | 13.5 | 13.5 | 2.0 | 14.0 | 4.0 |
| RR265-1 | 13.0 | 13.5 | 12.0 | 3.5 | 12.5 | 6.5 |
| RR347-166 | 3.0 | 3.0 | 4.5 | 10.5 | 9.0 | 12.0 |
| RR348-5 | 11.0 | 6.5 | 6.0 | 6.5 | 5.0 | 8.5 |
| RR348-7 | 16.0 | 15.0 | 10.0 | 10.5 | 15.0 | 10.5 |
| RR352-1 | 7.0 | 5.0 | 2.5 | 14.0 | 2.5 | 2.0 |
| RR354-1 | 5.0 | 9.0 | 2.5 | 1.0 | 2.5 | 1.0 |
| RR50-5 | 9.0 | 6.5 | 7.5 | 8.0 | 6.0 | 3.0 |
| RR51-1 | 14.0 | 4.0 | 10.5 | 9.0 | 11.0 | 10.5 |
| Vandana | - 1.0 | 1.0 | 15.5 | 14.0 | 9.0 | 15.5 |
| Rank correlation with (1) | | | 0.35 | 0.03 | 0.57* | 0.06 |
| Rank correlation with (2) | | | .027 | -.034 | 0.45 | -0.28 |

* Ranked from 1 (most liked) to 16 (least liked); results of a participatory varietal trial conducted in Korahar in 1998 wet season.
** Ranked from 1 (highest yield) to 16 (lowest yield).
*** Ranked from (most acceptable) to 16 (least acceptable).

# Conclusions and recommendations

Grain quality is an important selection criterion (Juliano and Villareal 1993). Sensory evaluation with farmers allows us to assess varietal preferences under conditions of food preparation very close to that of the final consumer. For the set of varieties tested, men and women seemed to share the same opinions. The physico-chemical analysis did not indicate much power to predict the results of farmers' rankings. The methodology was satisfactory although quite costly in terms of organization time. It is important to define which of the two modes of preparation (raw rice or parboiling) is most prevalent in the target area, since they lead to different varietal choices. A simplification of the ranking system by reducing the number of ranked traits is possible.

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# Incorporation of Users' and Gender Perspectives in Farmer-Led Participatory Plant Breeding on Maize: Experiences from the Western Hills of Nepal

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**Abstract**

Maize production is the main source of livelihood for the farmers of the western hills of Nepal. However, farmers have very limited access to improved varieties of maize, suitable to their local requirements. They cultivate a number of maize varieties maintained locally through continuous selection for preferred traits. An initial survey of the two project sites in the Gulmi district of western Nepal suggests that farmers apply a number of criteria to the selection of a particular maize population to suite their production environment and to meet their family requirements for different uses of maize. However, the survey results show that the differences among farmers in the preference for and selection of a particular maize variety are not very strong. The report discusses the ways these differences have been analyzed and incorporated into the design of participatory plant breeding for the improvement of local maize varieties by the farmers.

## Introduction

Maize is the first most important food crop in the hills of Nepal in terms of both area and its contribution to household food security. It occupies about 0.8 million hectares (about 35% of the total cultivated area); 78% of this is in terraced hill farming, which produces over 1.3 million tonnes per annum (CBS 1999). The productivity of maize, however, is quite low (1.7 tonnes/hectare) and, as a result, there is high incidence of food-deficit households in the hills of Nepal. One of the major contributing factors to this low yield is the poor performance of farmer-maintained maize varieties. Farmers' access to new seeds and varieties is extremely poor and, at the same time, a majority of farmers tend to keep their own seed without replacing it for years. It is estimated that nearly 90% of the total seed requirements for cereals and other food crops in the country is met by the traditional seed-supply system (Cromwell et al. 1993; Joshi 1995). Since maize is an open-pollinated crop, even new varieties rapidly get contaminated with the undesired traits of local varieties. On the other hand, most of the new varieties developed so far neither fit well with local environments nor meet farmers' diverse needs. Therefore, it is increasingly being realized that breeding must be carried out in the target environment with the full participation of farmers so that the users' perspective is well reflected in the new varieties developed.

The environments where maize is produced in the hills of Nepal are very diverse in terms of topography, soil types, and use of production resources. There are also differences between farmers and farming communities in terms of access to resources (i.e., wealth) and food culture, which is governed largely by ethnicity. These differences exist not only between wider agroecological zones but also between farming families in the same village. For these reasons, farmers require a large number of varietal options to fit into diverse production niches and to meet the varied consumption

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requirements of the farming families. Similarly, because of differences in gender roles and gender needs, there are also requirements for different maize varieties within the same household. Previous studies (Acharya and Bennet 1981; Bajracharya 1994; Shrestha 1998) suggest that women play important roles in agricultural activities and are responsible for major farming decisions. Because of these gender differences, different family members usually have different varietal needs and behave differently toward new crop varieties. The consideration of users' and gender perspectives in the process of variety development, therefore, is vital.

Local Initiatives for Biodiversity Research and Development (LI-BIRD), in collaboration with the Systemwide Program on Participatory Research and Gender Analysis (PRGA), is conducting research on a farmer-led participatory maize-breeding approach that incorporates users' and gender perspectives in developing farmers' preferred maize varieties. The two research sites, namely Darwar Devisthan and Simichaur, are located in the Gulmi district of the western hills of Nepal. This paper draws upon the work and experience of researchers in this collaborative project and discusses the findings regarding the analysis of this research and its subsequent incorporation into the research process.

## Methods and sources of information

Various sources of information have been used in the report. These include focus-group discussions (FGDs) conducted during participatory rural appraisals, participatory gender analysis, and household baseline surveys undertaken at the Darwar Devisthan and Simichaur research sites at the inception of the project. Separate FGD sessions were held with different groups of farmers, categorized by gender, wealth, and ethnicity. There were two categories under gender—male and female; three categories under wealth—rich, average, and poor; and three categories under ethnicity—Brahmin/Chhetri/Jogi (BCJ), Gurung/Magar/Newar (GMN), and Kami/Damai/Sarki (KDS). The categorization of farming-household wealth was done by the farmers themselves, using their own perceptions and knowledge of wealth of these households. The ethnic categorization was done by researchers on the basis of sociocultural similarities.

The participatory gender analysis involved the analysis of gender roles and decision-making patterns in the production and utilization system for maize. A sample of 30 selected households was facilitated in doing their own gender analysis by using a pictorial set of a man, woman, and child, and maize grains, to indicate their roles. Similarly, a detailed household baseline survey was conducted to collect detailed and widely representative information, which also served as a major source of information for this report. It involved a questionnaire survey of 100 households (40 at Darwar Devisthan and 60 at Simichaur) selected using a stratified random sampling technique.

## Analysis of users' and gender perspectives in maize farming

### *Users' perspectives in maize production and utilization*

The perspective of users in maize production and utilization was analyzed using two socioeconomic variables: ethnicity and the wealth categories derived from participatory wealth ranking. The analysis of gender perspectives, on the other hand, utilized information from male- and female-headed sample households that were included in the household baseline survey. Of the total sample households surveyed, 19% were female headed. These are mostly *de facto* household

heads, i.e., women have taken charge of managing the farm while men work off-farm away from home for several months, mostly in India.

### *Characteristics of heads of households*

The characteristics of the heads of maize-growing households are presented in table 1. The family members who make major farming decisions are mature, with an average age of 50 years. Their literacy rate is much higher (81%) compared to the national literacy rate (39.6%). However, a majority of them (47%) are either barely literate or have a primary-level school education. The family member making the main farming decisions is younger and more illiterate in the average and poor wealth categories, in the KDS and GMN ethnic households, and in female-headed households.

### *Characteristics of maize-growing households*

The characteristics of the maize-growing households are presented in table 1. The maize-farming families are relatively larger than nonfarming families, with an average of seven members per family. The family size is, however, relatively smaller in the average and poor wealth categories and in the KDS and GMN ethnic households than in other households. This implies that the family labor available to these households is less than in other households. Though farming is the major occupation for the households of the two research sites, family members of 72% of the farming households are engaged in off-farm activities to earn additional cash income for the family. The percentage distribution of these households across wealth categories and male- and female-headed households is similar. The percentage of households with family members engaged in off-farm activities, however, is slightly higher in the GMN and KDS households than in the BCJ households.

Maize is the main livelihood crop for the farmers of the research sites. The maize production in the area is subsistence-oriented and production is largely for self-consumption. The self-produced food, however, is not adequate to meet household food requirements. About 86% of the farming household experiences food deficits from less than one to 11 months of the year, and the average length of food self-sufficiency is only about seven months. The degree of food deficiency varies among the different household categories. The average time of food self-sufficiency is lower in average and poor households, in BCJ and KDS ethnic households, and in female-headed households. Only a small proportion of the households (10.4%) sell maize. The proportion of households selling maize is similar across households of different ethnic categories but is lower in the average and poor households and in male-headed households. A high proportion of the households (61%) purchase maize to offset their food-grain deficit. The differences in the proportion of households purchasing maize is highly significant ($p < .0001$) across wealth categories but not significant across ethnic categories and across male- and female-headed households. There is virtually no market influence on farmers' choice of maize varieties.

### *Access to farm resources*

In general, farmers are smallholders with an average maize-growing *bari* land holding of 0.4 hectare, scattered over an average number of 2.3 parcels (table 1). (*Bari* represents rainfed upland where a maize-based cropping system is dominant.) The average holding size and the number of parcels of *bari* land decrease with the wealth of the farming household. The differences in *bari* land holdings are highly significant across wealth categories ($p < .0001$). Similarly, the variation in number of parcels of *bari* land per household is also significant ($p < .05$) across wealth categories. These differences in *bari* land holdings and the number of *bari* parcels per household are not statistically significant across either ethnic categories or male- and female-headed households.

**Table 1. Characteristics of Maize Growing Households at Darwar Devisthan and Simichaur in Gulmi District, Nepal**

| Characteristics | All | Gender categories | | Wealth categories | | | Ethnic categories | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Rich | Medium | Poor | BCJ | GMN | KDS |
| Age of household head (years) | 50.1±1.1 | 51.4±1.7 | 44.4±2.1 | 52.6±2.4 | 49.3±2.4 | 48.1±2.8 | 49.6±1.6 | 56.4±5.1 | 47.6±5.0 |
| Education of household head (% ) | | | | | | | | | |
| Illiterate | 19.0 | 12.3 | 47.4 | 6.0 | 23.3 | 29.0 | 15.0 | 10.0 | 60.0 |
| Just literate/primary education | 47.0 | 48.1 | 42.1 | 57.1 | 43.3 | 40.0 | 45.0 | 80.0 | 30.0 |
| Secondary education | 21.0 | 24.7 | 5.3 | 14.3 | 23.3 | 26.0 | 24.0 | 10.0 | 10.0 |
| University education | 13.0 | 15.0 | 5.3 | 22.2 | 10.1 | 6.0 | 16.3 | 0.0 | 0.0 |
| Food self-sufficiency (month) | 7.2±0.3 | 7.3±0.4 | 6.8±0.6 | 8.9±0.5 | 7.6±0.5 | 5.3±0.4 | 7.5 | 9.3 | 3.3 |
| Wealth class (% household) | | | | | | | | | |
| Rich | 35.0 | 26.0 | 32.0 | 35.0 | 0.0 | 0.0 | 40.0 | 30.0 | 0.0 |
| Medium | 30.0 | 29.6 | 32.0 | 0.0 | 30.0 | 0.0 | 31.3 | 40.0 | 10.0 |
| Poor | 35.0 | 34.6 | 37.0 | 0.0 | 0.0 | 35.0 | 29.0 | 30.0 | 90.0 |
| Family size (number) | 6.7±0.4 | 7.2±0.4 | 4.9±0.5 | 7.8±0.5 | 6.1±0.5 | 6.2±0.7 | 6.9±0.4 | 5.4±0.9 | 6.7±1.0 |
| Resource ownership | | | | | | | | | |
| Bari land (ha/household) | 0.4±0.04 | 0.4±0.1 | 0.3±0 | 0.6±0.1 | 0.4±0 | 0.3±0 | 0.4±0.1 | 0.4±0.1 | 0.2±1 |
| Parcel of bari land (Mean) | 2.3±0.1 | 2.4±0.2 | 1.9±0.3 | 2.8±0.3 | 2.2±0.2 | 2.0±0.1 | 2.4±0.1 | 2.5±0.7 | 1.6+0.3 |
| Buffalo (number) | 2.6±0.1 | 2.7±0.2 | 2.05±0.2 | 3.2±0.2 | 2.6±0.2 | 1.2±0.1 | 2.7±0.2 | 2.2±0.3 | 1.6±0.2 |
| Cattle (number) | 2.4±0.2 | 2.4±0.3 | 1.5±0.5 | 2.7±0.4 | 2.1±0.4 | 2.2±0.4 | 2.5±0.3 | 1.8±0.4 | 2.0±0.0 |
| Goats (number) | 2.5±0.2 | 2.6±0.3 | 2.2±0.2 | 2.6±0.4 | 2.1±0.2 | 2.7±0.4 | 2.7±0.2 | 2.0±0.5 | 1.2±0.2 |
| Poultry (number) | 5.5±0.6 | 6.0±0.7 | 2.3±0.6 | 5.4±1.2 | 6.5±1.5 | 5.1±0.9 | 4.3±0.7 | 8.1±1.5 | 6.0±1.6 |
| Livestock unit per household | 2.8±0.2 | 3.0±0.2 | 1.9±0.2 | 3.8±0.4 | 2.7±0.2 | 1.8 | 3.0±0.2 | 2.4±0.4 | 1.4±0.2 |
| Off-farm labour (%) | 72.0 | 71.6 | 74.0 | 71.4 | 73.3 | 71.4 | 70.0 | 80.0 | 80.0 |
| Sell maize (%) | 10.4 | 9.1 | 16.0 | 20.0 | 3.4 | 6.3 | 12.0 | - | 11.1 |
| Purchase maize (%) | 61.0 | 60.3 | 64.3 | 31.0 | 74.0 | 84.0 | 60.3 | 44.4 | 100 |
| Cultivation of improved variety (%) | 13.0 | 8.3 | 39.0 | 13.3 | 12.0 | 13.3 | 16.2 | 0.0 | 0.0 |
| Changing seeds for the last 5 years (%) | 38.6 | 38.0 | 42.0 | 35.0 | 35.0 | 44.4 | 37.3 | 40.0 | 44.4 |
| Participated in training (%) | 8.2 | 8.8 | 6.0 | 15.2 | 7.0 | 3.0 | 10.4 | 0.0 | 0.0 |
| Participated in educational tours (%) | 6.0 | 7.4 | 0.0 | 9.0 | 7.0 | 3.0 | 7.5 | 0.0 | 0.0 |
| Received information on improved technology for maize production (%) | 15.1 | 16.0 | 12.0 | 23.0 | 21.0 | 3.0 | 19.0 | 0.0 | 0.0 |

*Note*: Ethnicity is represented as BCJ = Brahmin/Chhetri/Jogi; GMN = Gurung/Magar/Newar; KDS = Kami/Damai/Sarki.

Livestock forms an important and integral part of the farming system and, among other things, provides a major source of nutrients (i.e., manure) for plants. Buffalo, cattle, goats, and chickens are the main kinds of livestock in the area, with an average livestock unit of 2.8 per household. The average livestock unit is highest among households in the rich and BCJ categories and lowest in poor and KDS households. This difference is significant across wealth ($p < .0001$) and ethnic ($p < .01$) categories. Similarly, the female-headed households have lower livestock units per household than the male-headed households, but this difference is not statistically significant. The resource analysis thus indicates that BCJ households have the most resources, followed by GMN households, while KDS households have the fewest resources. Similarly, female-headed households have comparatively fewer resources than male-headed households.

### *Access to information and technology*

The access farmers have to improved maize varieties suitable to local environments and their own needs is quite limited (table 1). Only 13% of the farmers reported growing improved varieties of maize; however, they know the value of changing their old seeds. About 39% of the households reported exchanging their seeds during last five years with other farmers. The users' and gender analysis showed that access to new maize seeds is similar across all wealth categories. However, GMN and KDS households have a complete lack of access to new maize seeds, and a lower proportion of male-headed households reported cultivating improved varieties than did female-headed households. The proportion of households changing seeds over the last five years, however, is greater in the poor wealth category, suggesting that farmers in this category change seed more frequently than do the others. Since these households are also highly food deficit, they may be consuming the seed and, therefore, borrowing seeds from other farmers. The proportion of households changing maize seeds is, however, similar across ethnic categories and between male and female-headed households.

Similarly, farmers' access to technical services and information on technology is also poor. Only about 3% of the maize-growing households reported participating in agriculture-related training, and only 6% participated in educational tours. Likewise, about 15% of the households reported receiving information on improved technology for maize production. This reveals that external technical support to farmers in their attempts to develop better maize varieties is quite limited. The proportion of households participating in agricultural training and tours is lower in the average and poor households than in rich households. A chi-square analysis shows significant differences ($p < .05$) in access to information on improved technology for maize production across wealth categories. Similarly, only BCJ households reported having participated in agricultural training and tours or receiving information on improved maize production. The proportion of female-headed households participating in agricultural training and tours and receiving information on improved maize production is lower than male-headed households.

### *Maize varieties and their uses*

Farmers have been found to grow about eight different types of maize varieties, which they broadly categorize into two maize types: one is a large type (*Thulo makai*) with tall plants, big cobs, large grains and long maturity, while the other is a small type (*Sano makai*) with short plants, small cobs and grains, and short maturity. A majority of the farmers grow large-type maize, and it covers about 87.7% of the total maize area. Among the large varieties, *Thulo pyanlo* alone covers about 80% of the area planted to this type, which reflects that, although farmers grow a large number of varieties, a large portion of the maize-growing area is covered by a relatively small number of varieties.

A majority of the households grow one to two varieties of maize (46.5% to 45.5%, respectively) in a season (table 2). Only about 8% of the total maize-growing households grow more than three varieties per season. The varietal diversity maintained at household level, therefore, is low (figure 1). The ANOVA result shows that the difference in the number of maize varieties grown at household level is significant ($p < .05$) across wealth categories but not significant across ethnic categories and between male- and female-headed households. A higher proportion of poor households grows one variety of maize, compared to rich and average households. This is contrary to the currently held view that small farmers maintain significant amounts of crop genetic diversity (Jarvis et al. 1997) and agrees with the findings of other studies (Rana and Kadayat 1999). Similarly, though not significant, a very high proportion of KDS households (90%) grows only one variety of maize.

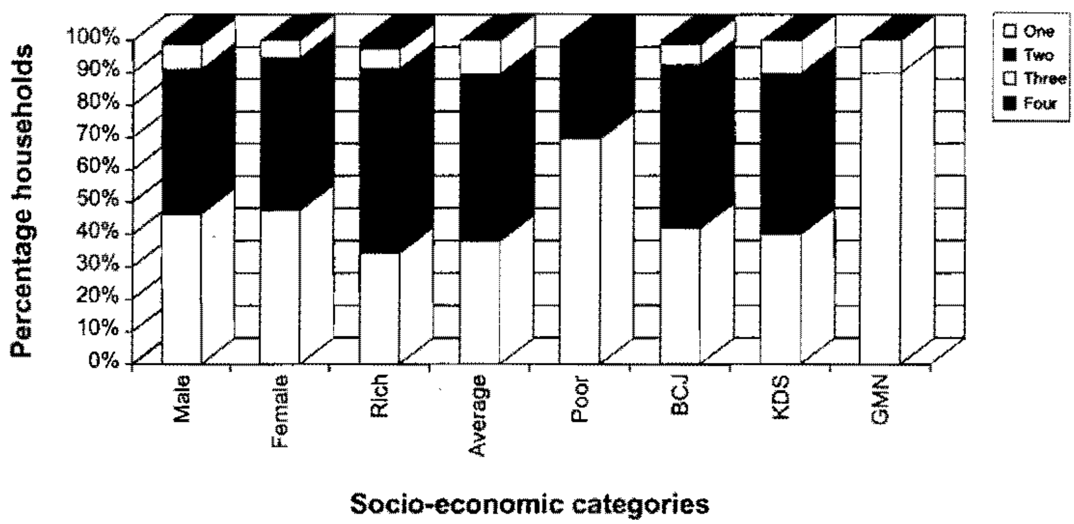


**Figure 1. Number of maize varieties per household across gender, wealth and ethnic categories**

Farmers who grow more than one variety mentioned various reasons for this (table2): to prepare different food items, to harvest at different times, to suit different land types, to use as animal feed, and to meet fodder requirements. However, a majority of the farmers (67.9%) grow to suit different types of land, and this is true across all wealth and ethnic categories and between male- and female-headed households. The ANOVA result suggests that the number of maize varieties grown at household level is not significantly related to the size of the *bari* land but is highly significantly related to the number of parcels of *bari* land the farmer is planting to maize ($p < .0001$). This indicates that with the increase in the number of parcels of *bari* land, the number of maize varieties grown at household level also increases. This also confirms the PRA finding that farmers in the area grow large-type maize on more fertile land while small-type maize is grown on less fertile soil. The number of *bari* parcels, therefore, appears to be the strongest determining factor in deciding the number of maize varieties to be grown per season. It is, however, true that farmers use multiple criteria to select maize varieties for their household production.

The gender differences in the use of some criteria to choose maize varieties are striking. A large proportion of female-headed households (more than three times the number of male-headed households) mentioned growing more than one variety to meet fodder requirements for their livestock. This is also confirmed by the PRA findings. During the focus-group discussions, women farmers

**Table 2. Maize Varieties and Their Uses as Reported by Farmers at Darwar Devisthan and Simichaur in Gulmi District, Nepal**

| Characteristics | All | Gender categories | | Wealth categories | | | Ethnic categories | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Rich | Medium | Poor | BCJ | GMN | KDS |
| No. of varieties grown per year (% households) | | | | | | | | | |
| One variety | 46.5 | 46.3 | 47.4 | 34.3 | 38.0 | 66.0 | 42.0 | 40.0 | 90.0 |
| Two varieties | 45.5 | 45.0 | 47.4 | 57.7 | 52.0 | 29.0 | 51.0 | 50.0 | 0.0 |
| Three varieties | 7.1 | 7.5 | 5.3 | 5.7 | 10.3 | 6.0 | 6.3 | 10.0 | 10.0 |
| Four varieties | 1.0 | 1.3 | 0.0 | 2.9 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 |
| Reasons for more varieties (% households) | | | | | | | | | |
| Prepare different food items | 41.5 | 41.9 | 40.0 | 43.5 | 27.8 | 41.7 | 32.6 | 100.0 | — |
| Harvest at different time | 34.0 | 37.2 | 20.0 | 34.8 | 33.3 | 33.3 | 28.3 | 83.3 | — |
| Suit different types of land | 67.9 | 67.4 | 70.0 | 69.6 | 55.6 | 50.0 | 69.6 | 50.0 | — |
| For use as animal feed | 32.0 | 30.2 | 40.0 | 17.4 | 22.2 | 75.0 | 26.1 | 66.7 | — |
| Meet fodder requirements | 20.8 | 14.0 | 50.0 | 21.7 | 11.1 | 33.3 | 21.7 | — | — |
| Usage of maize (% households) | | | | | | | | | |
| Grit (*makai ko bhat*) | 76.6 | 76.2 | 78.6 | 73.7 | 78.5 | 81.0 | 76.3 | 81.3 | 72.0 |
| Bread (*roti*) | 2.3 | 2.3 | 2.4 | 2.5 | 1.6 | 2.6 | 2.4 | 0.6 | 4.4 |
| Poridge (*dhindo*) | 0.9 | 0.85 | 1.1 | 1.5 | 0.23 | 0.2 | 1.0 | 0.0 | 0.0 |
| Roasted | 13.5 | 13.2 | 15.0 | 13 | 15.0 | 13.3 | 13.2 | 17 | 10 |
| Others | 6.7 | 7.4 | 3.0 | 9.4 | 5.0 | 3.1 | 7.0 | 0.9 | 13.3 |

*Note*: Ethnicity is represented as BCJ = Brahmin/Chhetri/Jogi; GMN = Gurung/Magar/Newar; KDS = Kami/Damai/Sarki.

strongly expressed their preference for tall varieties of maize like their local varieties because taller varieties produce more fodder than short varieties. Women appear to be more concerned with this issue because managing livestock fodder is largely their responsibility. Similarly, women farmers are very particular about the suitability of maize varieties for intercropping, especially with legumes (cowpeas and beans), because these help them meet the vegetable and pulse requirements of their families. The latter sometimes leads to conflicts with their male counterparts because intercropping with cowpeas and beans makes maize plants vulnerable to lodging and can cause big losses in the maize yield.

Maize is the staple food for farming households in the study area. Different preparations of maize are made for household consumption, of which steamed grit (*makai ko bhat*) is the most common preparation, reported by 77% of total production (table 2). Farmers, therefore, prefer maize varieties that have high grit recovery. They perceive that yellow (colored) maize has higher grit recovery and, therefore, prefer colored varieties over the white ones. The food preparation of maize is similar across households of different wealth, ethnic, and gender categories, and a majority of households use it in grit form. Users' and gender differences in the choice of variety, therefore, do not appear to be influenced by differences in the use of maize.

The analysis discussed above indicates that farmers' choices for maize varieties are not greatly influenced by their differences in wealth, ethnicity, and gender, i.e., different categories of farmers have preferences for similar types of maize varieties. Farmers across all wealth, ethnic, and gender categories grow only one or two maize varieties per household and, therefore, their varietal needs are not very diverse. However, farmers use multiple criteria in selecting the varieties they grow. They prefer to have as many traits of their preference as possible in one to two maize varieties. In this way, they are able to maintain and manage the variety of their preference for a long duration. Since maize is an open-pollinated crop, a large number of varieties is difficult to maintain and manage. This analysis is also confirmed by the findings of the PRA conducted at the project research sites. The participatory breeding program, therefore, should focus on developing fewer maize varieties with multiple traits that reflect farmers' preferences. Priority should be given to the maize varieties that have higher grit recovery, grow well under different land conditions, produce high biomass for use as fodder, and allow good intercropping with legumes.

### *Gender roles in maize production and utilization*

The information on gender roles in maize production and utilization is based on a participatory gender analysis done with 30 maize-growing households selected for that purpose. The results show that there are distinct gender roles for men, women, and children in the production and utilization of maize in the hills of Nepal.

Women supersede men in their involvement in all three major functions of maize production and utilization: namely, (1) production, (2) household utilization and marketing, and (3) seed management (table 3). Their involvement is particularly high in the application of compost and farmyard manure to the maize field; seed processing, treatment, storage, and preparation for sowing in the next season; and intercropping of maize with beans, cowpeas, pumpkins, and other crops.

The results of the gender analysis show that women are also the prime decision makers in the family and their contribution to decision making in activities related to maize production and utilization is higher than that their male counterparts in the family (table 4). Their contribution to decisions is particularly high in the selection of crops for intercropping with maize, deciding on date and time of weeding and earthing-up in the maize fields, and in most of the activities related to utilization and