and to meet their household needs. *Thulo pinyalo* is the most popular variety of the region and occupies as much as 80% of the maize area in some villages. Farmers liked most of its traits. This variety has good taste in all recipes, good grain and fodder yield, the biomass (both green and dried) is very much liked by the livestock, and it is easy to sell and barter because it has bold, flint grain with an attractive grain color. However, farmers had lodging problems with this variety, leading to as much as 85% production loss in the worst season (table 1). Lodging problems are equally high in other local varieties (viz. *Thulo seto* and *Amrikane*); however, the area under these varieties is very low. It was reported that the low production of *Thulo pinyalo* has more significant implications for the food security of the region than any other variety. So, the lodging in *Thulo pinyalo* was considered a major problem.

Resistance to lodging from thick stalks and strong, stout plants has been perceived by the farmers of the surveyed villages as the most desired characteristic in a recommended improved variety (table

Table 1. Desirable and Undesirable Traits of Local Varieties of Maize Grown in Surveyed Villages, 1999

	Surveyed villages					
Parameters	Digam, Gulmi	D/Devisthan, Gulmi	Simichaur, Gulmi	Chaun bari, Palpa	Banjha, Palpa	Kaule, Arghakhanchi
Desirable traits						
High yield potential	*	*	*	*		*
High fodder yield	*	*	*	*		*
High flour recovery		*				
Good taste	*	*	*	*		*
Undesirable traits						
Lodging	*	*	*	*	*	*
Head smut						*

2). The least desired characteristics were a relatively low grain and fodder yield compared to that of large local varieties, followed by inferior taste. Low fodder yields have been found to be associated with the low height of improved maize varieties, compared to local varieties. Farmers of Banjha reported that all the improved varieties under cultivation in the village were introduced nearly six years before, and now there is no difference between local and improved, due to heavy and recurrent cross-fertilization with local varieties.

Farmers of the surveyed villages reported that high-yield potential and resistant to lodging were the most preferred traits for maize, followed by good taste and high stover yield (table 3). Farmers perceived that grain yield is closely associated with the extent of lodging; they felt that these two parameters are highly interrelated and essentially synonymous. Farmers of Darbar-Devisthan reported that lodging problems are due to tall plant height, and therefore, they perceived relatively shorter plant height as one of the most preferred traits to be considered in the maize improvement program.

Revisiting farmers to discuss maize-production problems in the targeted area and to verify research hypotheses with farmers revealed that causal relationships in poor maize performance were not properly established. Earlier, a new research hypothesis surfaced, which explained that the poor

Table 2. Desirable and Undesirable Traits of Improved Varieties of Maize Grown in Surveyed Villages, 1999

	Surveyed villages					
Parameters	**Digam, Gulmi**	**D/Devisthan, Gulmi**	**Simichaur, Gulmi**	**Chaun bari, Palpa**	**Banjha, Palpa**	**Kaule, Arghakhanchi**
Desirable traits						
Nonlodging/thick stalks	*	*	*	*		
Early maturity	*					
Strong /stout plants			*			
Undesirable traits						
Lodging						*
Low yield	*	*	*	*		*
Low fodder yield	*	*	*	*		*
Inferior taste			*			*
More insect problems				*		

Table 3. Ranking of Preferred Traits of Maize in Surveyed Villages, 1999

	Surveyed villages					
Traits	**Digam, Gulmi**	**D/Devisthan, Gulmi**	**Simichaur, Gulmi**	**Chaun bari, Palpa**	**Banjha, Palpa**	**Kaule, Arghakhanchi**
Higher grain yield	1	2	2	1		1
Nonlodging	3	1	1	2		2
More stover yield	5	3	3	3		
Need for less soil fertility	6					
More grit recovery		5	5			
dctlparGood taste	2	4	4			3
White grain color				4		
Early maturity	4					
Short plant height		1				
Good husk cover				5		

performance of maize in the area is not due to yield traits but to lodging tendencies, and this, in turn, leads to poor production (figure 2).

Redefining breeding goals

In light of the new research hypothesis that emerged during the site-selection survey, a one-day village workshop was organized with the farmers at each research site selected for the implementation of the program. Farmers at the research sites opined that the local variety *Thulo pinyalo* has good yield and meets their requirements. They strongly suggested improving *Thulo pinyalo* for lodging resistance rather than just introducing new varieties. The underlying causes of lodging in *Thulo*

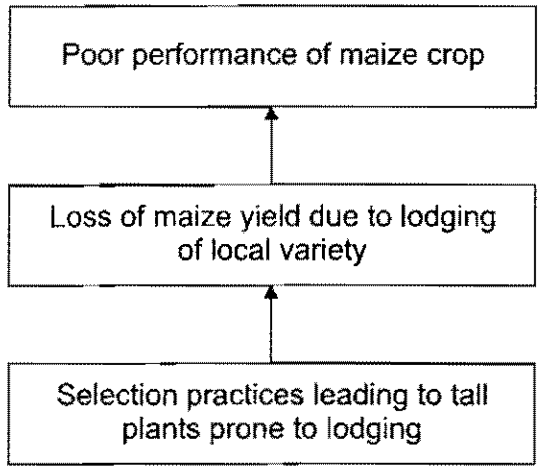

Figure 2. Farmers' perceptions of causal relationships for low productivity of maize in the mid-hill region of Gulmi and Arghakhanchi districts, Nepal

Pinyalo were explored with the farmers' group in order to understand and tackle the problem. Farmers perceived the following as the causes of the problem:

- The very tall plant stature of this variety is the main reason for lodging. Farmers reported it having as high as 27 leaves in one plant. In field observations, the plant height of *Thulo pinyalo* was found to be as high as 5.1 meters. Ear height has been found to be more than two meters under good growth conditions. The weight of the tassel and cob at such a height contributes to the extensive lodging of the thin-stalked *Thulo pinyalo*, even under mild wind pressure.
- *Thulo pinyalo* attains luxurious growth in fertile land, which is one of the reasons for lodging.
- Disease and insects attack the stem.
- The lodging is greater after prolonged rainfall followed by winds. According to farmers, they face substantial yield reductions even with mild winds, as very weak plants lodge under such conditions and fall on other, nonlodging plants. This phenomenon occurs in cycles and can affect large areas.
- The plants are more prone to lodging during the tasseling stage because of the increased weight at the top of the plant.
- Yield is inversely related to lodging. Yield losses due to lodging in this variety are as high as 85% in the worst season. *Thulo pinyalo* produces more grain than high-yielding varieties (HYVs) in a normal season and less if there is a lot of rain and wind.
- Lodging is greater in wet areas at lower elevations than in flat areas at the top of the hills.
- Lodging does not occur every year. However, there is no distinct pattern. High winds during tasseling contribute to severity of the problem.

Several possible options were discussed with the farmers to achieve the goal. The options that could be implemented within the project framework and which farmers considered possible to imple-

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 Thin stalk Wind pressure
Ethno-perception	Not known	Local landraces are well fitted in different niches Widely grown *Thulo pinyalo* has all good traits but prone to lodging
Varietal requirement	HYV	Lodging-resistant variety
Objective	Increase access to genetic materials Provide mass-selection training to farmers	Improve *Thulo pinyalo* for lodging resistance 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

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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.