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

Table 3. Gender Roles in Maize Production and Utilization (Percentage Time Contribution)

Activities	Male	Female	Children
A. Maize production activities			
1. Seed preparation (shelling cobs, drying and storage)	24.8	61.1	14.1
2. Carry compost/FYM to the field	17.4	63.5	19.1
3. Land preparation	54.8	36.5	8.7
4. Seed sowing	11.7	42.8	45.5
5. Field supervision for seed germination	43.4	52.1	4.5
6. Weeding and earthing up maize crop (first)	34.1	49.4	16.5
7. Weeding and earthing up of maize crop (second)	41.0	54.5	4.5
8. Intercrop sowing of beans, cowpeas, pumpkin etc.	11.9	74.3	13.7
9. Relay transplanting of fingermillet in maize field	30.8	56.0	13.2
10. Field supervision of lodging of maize plants	41.3	52.1	6.6
11. Harvesting and transporting	35.9	50.3	13.8
12. Making bundles of maize stover and transporting	53.9	39.5	6.6
13. Processing (*khostyane/jhuto parne*) and storage of cobs	33.8	45.5	20.7
Total	**33.5**	**52.1**	**14.4**
B. Consumption and marketing activities			
1. Shelling cobs	24.2	57.1	18.7
2. Processing (cleaning and drying) grains for milling	15.3	76.6	8.1
3. Carrying grains to processing mills	27.2	52.0	20.7
4. Carrying grains to market for selling	49.7	50.3	—
5. Purchase	55.1	44.3	0.6
Total	**34.1**	**56.2**	**9.7**
C. seed management activities			
1. Selection of cobs for seed	37.3	57.1	5.6
2. Shelling grains from the selected cobs	31.1	52.4	16.5
3. Seed processing and treatment (cleaning, drying and treatment) and seed storage	21.7	74.4	3.9
4. Preparing storage pot/structure for seed storage	26.3	72.5	1.2
Total	**29.1**	**64.1**	**6.8**

marketing and seed management. The gender analysis thus suggests that women have important roles and a stake in the varietal-improvement programs designed to develop farmers' preferred varieties. Their participation in the whole process of variety development should be ensured and properly utilized.

Distribution of breeding knowledge

Participatory plant breeding seeks to use the knowledge and experiences farmers have accumulated over generations. It also creates an environment for mutual learning and sharing, which closes the knowledge gap and sets the stage for a working partnership between the farmers and researchers.

Table 4. Gender Differences in Decision Making in Maize Production and Utilization (Percentage Contribution in Decision Making)

Activities	Male	Female
A. Maize production activities		
1. Selection of maize variety for next season planting	49.2	50.8
2. Selection of land selection according to the variety	46.1	53.9
3. Date/time of sowing	51.5	48.5
4. Selection of crops for intercropping with maize	27.0	73.0
5. Date/time of weeding and earthing up of maize	36.2	63.8
6. Date/time of maize harvest	44.6	55.4
Total	**42.4**	**57.6**
B. Consumption and marketing activities		
1. When and how much grains to shell	30.6	69.4
2. Quantity of grits/flour to be milled at a time	23.2	76.8
3. When to carry maize grains to the mill (for milling)	27.6	72.4
4. Food items to be cooked daily	33.0	67.0
5. Whether to sale maize or not	44.8	55.2
6. Quantity of maize grains to sold	37.7	62.3
7. Whether to purchase maize or not	41.5	58.5
8. Quantity of maize grains to purchased	36.1	63.9
Total	**36.1**	**63.9**
C. Seed management activities		
1. Selection of maize varieties for next season	46.2	53.8
2. Quantity of seeds of different varieties for next season	39.9	60.1
3. Ways/methods of storing seed	35.3	64.7
4. Number of sun-drying of stored seeds and using other treatments	30.7	69.3
5. Whether to change old seeds or not	48.0	52.0
6. Type and quantity of seeds of new variety to be planted	48.8	51.2
7. Giving self-produced seeds to other farmers	36.1	63.9
Total	**36.3**	**63.7**

Facilitating and supporting farmers in their plant-breeding activities then becomes easy and smooth. Based on this understanding, farmers' breeding knowledge was assessed by surveying a sample of 113 households selected randomly. An analysis of the influence of gender, wealth, and ethnicity on the distribution of such knowledge was also done and is presented in table 5.

The majority of the households (more than 90%) separate seed and grain in advance, but the seed selection is almost entirely done from the cobs, and generally right after the harvest. Farmers virtually do not practice seed selection on standing crops. The majority of the households select big, good-looking cobs with big, bold grains for seed. Similarly, almost all farmers follow the practice of discarding grains on the tips of the cob when the cobs are shelled for seed. Only about a quarter of the farmers are knowledgeable about the role of seed replacement in maintaining varietal purity and vigor. Farmers' knowledge on the more technical side of breeding, such as identification of male

Table 5. Distribution of Breeding Knowledge by Gender, Wealth and Ethnicity (% Households)

		Gender categories		Wealth categories			Ethnic categories		
Characteristics	All	Male	Female	Rich	Average	Poor	BCJ	GMN	KDS
Separate seed and grain in advance	96.2	97.0	93.9	97.7	94.1	94.1	97.2	90.0	91.7
Stage of seed selection									
a. On standing crop	0.1	10.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
b. Immediately after harvest	100.0	96.0	97.0	44.0	32.0	3.8	10.8	8.0	12.0
c. From stored cobs	0.8	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
Basis of cob selection for seed									
a. Cobs with big and bold grains	67.2	63.6	67.6	30.0	32.0	26.0	72.0	7.0	7.0
b. Big and good looking cobs	83.6	75.7	79.4	32.0	31.0	32.0	5.0	8.0	9.0
c. Matured cobs	36.0	30.3	47.0	18.0	10.0	8.0	43.0	1.0	2.0
d. Healthy cobs without insect and disease damage	35.2	32.3	38.2	17.0	12.0	14.0	37.0	4.0	4.0
d. Cobs not damaged by birds and rodents	1.6	1.0	2.9	0.0	2.0	0.0	2.0	—	—
f. Uniform grain colour	0.0	4.0	2.9	1.0	0.0	0.0	3.0	—	2.0
Practice of discard grains on either tips of the cob while selecting seeds	97.7	98.0	97.0	95.3	97.1	100.0	98.1	100	91.7
Knowledge about the need for seed re-placement to maintain varietal purity and vigour	24.2	24.0	25.0	27.9	23.5	13.5	28.0	0.0	8.3
Knowledge about male and female maize flower									
a. Male flower	6.0	8.0	0.0	8.7	3.0	0.0	7.2	0.0	0.0
b. Female flower	6.0	8.0	0.0	8.7	3.0	0.0	7.2	0.0	0.0
Knowledge about the use of tassel and silk									
a. Tassel	12.0	13.1	9.0	17.1	6.7	5.7	12.6	0.0	16.7
b. Silk	9.0	11.1	3.0	11.4	6.7	0.0	9.0	0.0	16.7
Knowledge about the reason of varietal mixture	10.5	13.1	3.0	14.3	6.7	2.8	10.0	1.0	16.7

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

and female plants and their functions, was found to be very poor. Similarly, a majority of the farmers also do not know the actual mechanism that causes new maize varieties to rapidly deteriorate, compared to other cereal crops like rice and wheat. The survey thus revealed that there is good scope and a need for sharing scientific breeding knowledge prior to the inception of a participatory plant breeding program in order to enhance farmers' confidence and thereby increase their interest and participation.

Incorporation of the users' perspective in the research process

Considerations made in the research process

The project on farmer-led participatory plant breeding of maize has just completed one season of work. A number of considerations have been made, as suggested by the analysis of the users' and gender perspective of maize production and utilization. These are briefly discussed below.

Breeding objective and selection of breeding materials

The breeding objective has been redefined to improve the production performance of a widely grown maize variety, *Thulo pyanlo,* rather than creating a large diversity of maize varieties in order to improve the productivity of the niche environment. This variety has all the traits preferred by the farmers except one, i.e., lodging resistance. Reducing lodging in this variety is now the main objective of the breeding program. In addition, the selection of improved maize varieties to be used as one of the parents for crossing with *Thulo pyanlo* was done in a way that ensured that they met most of the farmers' preferences for different traits. These included relatively taller, stout plant varieties like Ganesh 1 and 2, Rampur composit, Rampur 1, Khumal yellow, and Pop 22. This would help to combine good traits from a large number of varieties into a few farmers' preferred maize varieties. At the same time, attention has also been given to meeting the specific needs of the niche environment through a participatory variety-selection program, which provides farmers with a choice from a large number of maize varieties.

Selection of research farmers

Farmers have formed their own research committee at both the research sites to ensure their participation in and influence on the research process. These research committees are well represented by different categories of farmers and 41% of its members are women. The Farmers' Research Committee, in consultation with the farmers at large, decide the breeding objectives and the research process. They also select research farmers to participate in the farmer-led maize breeding programs implemented at the research sites. Since farmers themselves select research farmers, it is envisaged that this will lead to the development of maize varieties preferred by a large number of farmers. Similarly, under participatory variety-selection program, care is taken to distribute the seed of new maize varieties to different categories of farmers.

Selection of trainees and contents

Based on the findings of the survey on the distribution of maize-breeding knowledge among farmers, field-based training was provided to the research farmers in order to supplement farmers' knowledge with practical scientific breeding knowledge. Attention was given to representation of different categories of farmers, including women. Forty-five percent of the total trainees were women. This consideration will also be made in future farmers' training programs.

Collection and analysis of users' and gender-differentiated data

The initial survey indicated that farmers use multiple criteria for the selection of a particular maize variety. Farmers may give different weights to these criteria to suite their individual needs and resources. With this in mind, the collection and analysis of users' and gender-differentiated data have been built into the research process to ensure that users' and gender perspectives are incorporated into the participatory breeding program. Data are collected in a form that allows users' and gender-differentiated data to be analyzed, which will facilitate the drawing of inferences about whether users' and gender differences make a significant difference in the process and product of participatory plant breeding in open-pollinated crops like maize.

Conclusion

The users' and gender analysis indicates that the differences among maize-growing households in regard to wealth, ethnicity, and gender do not have any significant influence on their choices for different maize varieties. Similarly, farmers across all wealth, ethnic, and gender categories grow only one to two maize varieties per household; therefore, their varietal needs are not very diverse. This is contradictory to what has been found in the case of self-pollinated crops. This appears to be largely because a large number of varieties is difficult to maintain and manage in open-pollinated crops like maize. Farmers, however, use multiple criteria in selecting the maize varieties they grow and prefer to have as many traits of their preference as possible in one to two varieties. It is, therefore, important for the participatory breeding program to focus on developing fewer maize varieties with the multiple traits that farmers prefer. Women farmers have strong preferences about the quantity and quality of the fodder by-products of maize and the suitability of new maize varieties for intercropping with legumes. The research process should allow farmers of different categories to use their criteria in developing and selecting new maize varieties. Farmers of all categories generally lack adequate practical breeding knowledge, and they are specifically poor in scientific reasoning, regardless of whatever breeding knowledge they have. Supplementing farmers' knowledge with practical scientific breeding knowledge is, therefore, necessary to empower farmers to sustain their breeding initiatives.

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Understanding Farmers' Selection Criteria for Rice Varieties: A Case in Madhya Pradesh, Eastern India

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Abstract

This paper presents information from a participatory breeding project initiated in 1997 at the International Rice Research Institute (IRRI) in collaboration with plant breeders and social scientists from six national agricultural research institutions located in eastern India. The Indira Gandhi Agricultural University (IGAU) in Raipur, Madhya Pradesh, is one of the collaborating centers. The information given here is based on a sample survey of 75 rice-farming households in three villages of the Raipur district, Madhya Pradesh. Surveys were conducted to characterize farmers' cropping/farming systems, rice varietal diversity, degree of market orientation, gender roles, as well as socioeconomic differences, and to relate these to farmers' rice varietal preferences. The focus is on methodologies for improving understanding of farmers' (including women farmer's) criteria for selecting specific rice varieties and how these criteria are considered in participatory breeding strategies for rainfed lowland conditions in Madhya Pradesh, eastern India.

Introduction

Rice is the principal crop grown during the wet season (June-October) and is the staple food in Madhya Pradesh, eastern India. In this region, rice is cultivated on 5.35 million hectares, with an annual production of 6.46 million tons. This state contributes 9% to the national production from 12.8% of the national acreage. Eastern Madhya Pradesh, known as Chhattisgarh is considered the rice bowl of the state. Of the total rice area, 80% is rainfed, and drought, which occurs every two years, is a major constraint in increasing rice productivity in the region. The rice yield in the region is low (about 2.3 tons per hectare) and is below the national average. Because of the frequent droughts, the majority of farmers are not willing to risk investing in farm inputs to increase productivity. Sustainability and yield stability are the most important considerations of farmers in the management of their farming systems. Rural poverty still persists in this region, and about one-third of the total poor in Madhya Pradesh depend on rice production as the basic source of livelihood. Therefore, improving rice production and productivity could directly lead to a substantial reduction in the rural poverty in the region (Janiah et al. 2000).

For the last four decades, a total of 512 modern rice varieties have been released in India. However, hardly 10 to 20 of the released varieties are in the seed-production channel. For example, the average age of cultivars for which there is a demand for breeder seed is 11 years. The average age of cultivars in certified seed production ranges from 12 to 17 years in the states of Gujarat, Madhya Pradesh, and Rajasthan (Virk, Packwood, and Witcombe 1996). Only a few modern varieties have been successfully adopted in the irrigated ecosystem.

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One of the main reasons for low adoption of released varieties in the rainfed environments is that farmers have inadequate exposure to new cultivars. If adoption rates are to be improved, farmers need to try a wide range of novel cultivars in their fields in participatory varietal-selection (PVS) programs. The cultivars should include prereleased cultivars, advanced lines, and already released cultivars from other regions or countries (Whitcombe et al. 1996). This would give farmers a 'basket of choices' of varied genetic material (Chambers 1989). Another reason for low adoption of modern varieties is that the breeding process does not meet farmers' diverse needs. Released rice varieties are not suited to the complex and heterogeneous rainfed agroecological environment or to the diverse uses and needs of different socioeconomic groups of farmers. In Uttar Pradesh, India, Maurya et al. (1988) tested advanced lines of rice in villages and successfully identified superior material that was preferred by farmers. Understanding farmers' preferences and needs is crucial for successful adoption and dissemination of improved rice cultivars.

In 1997, a farmer participatory breeding project was initiated at the International Rice Research Institute (IRRI) and conducted in eastern India (Courtois et al. 2000). This is a collaborative project among plant breeders and social scientists from IRRI and six national agricultural research institutions located in eastern India. The Indira Gandhi Agricultural University (IGAU) in Raipur, Madhya Pradesh, is one of the collaborating centers. The main objectives for pursuing farmer participation in plant breeding are as follows:

- to test the hypothesis that farmer participation in rainfed rice breeding can help develop suitable varieties more efficiently
- to identify stages along the breeding process where farmers' participation has the most impact and to develop and test a methodology for effectively involving farmers in the breeding program
- to improve understanding of male and female criteria for selecting specific rice varieties
- to differentiate between the influence of farmer participation and decentralization of the breeding program
- to develop rice varieties suitable for heterogeneous rainfed environments and which meet farmers' preferences

This paper focuses on methodologies for improving our understanding of farmers' (including women farmers') criteria for selecting specific rice varieties and how these criteria were considered in participatory breeding strategies for rainfed lowland conditions in Madhya Pradesh, eastern India.

Methodology

This study is based on a sample survey of 75 rice-farming households in three villages of the Raipur district, Madhya Pradesh. Surveys were conducted to characterize farmers' cropping/farming systems, rice varietal diversity, degree of market orientation, gender roles, as well as socioeconomic differences, and to relate these to farmers' rice varietal preferences. Farmers were interviewed in regard to the positive and negative attributes of the traditional and improved varieties they grow and other seed-related information. A method of participatory weighted ranking was used to elicit male and female farmers' criteria for selecting rice varieties according to specific land elevations and information on how they trade off between traits. Basic information (name, age, sex, caste, size

of landholding, elevation of rice plots, etc.) was collected from male and female heads of separate households who are actively involved in rice farming. Twenty cards that illustrate traits of rice cultivars were shown and explained to the farmers. Referring to a particular land elevation (*upland*, for example), each farmer was asked what traits he/she considered when selecting rice varieties for that elevation. The traits that the farmer did not consider important were discarded. With the remaining cards representing the chosen traits, the farmer was then asked how much weight he/she gave to each trait out of 16 ana (16 ana=100 paise, 100 paise = 1 Rs). For this process, a total of 16 pieces of stone were provided to the respondent to assign the weights according to his/her choice. An average weight was then computed by getting the sum of all the values assigned per trait, divided by the number of respondents, after which the proportion of each trait to all traits was calculated. This methodology in eliciting farmers' perceptions also provides room for trading off between traits (Sharma et al.1998; Paris et al. 1999)

Farmer participatory approaches for the identification or breeding of improved crop cultivars can be usefully categorized into participatory varietal selection (PVS) and participatory plant breeding (PPB). PVS is a more rapid and cost-effective way of identifying farmer-preferred cultivars, if a suitable choice of cultivars exists. A successful PVS program has four phases: (1) a means of identifying farmers' needs in a cultivar, (2) a search for suitable material to test with farmers, (3) experimentation on its acceptability in farmers' fields, and (4) wider dissemination of farmer-preferred cultivars (Whitcombe et al. 1996). In all of these phases, understanding farmers' local knowledge, perceptions, and criteria for varietal selection is important in improving rice varieties for rainfed ecosystems.

Two approaches were used to strengthen farmers' involvement in the project: (1) farmers were invited to the research station to view a broad range of genetic materials, and (2) farmers were asked to grow a set of diverse materials in their own fields using their own level of management and inputs. Two farmers in each village volunteered to evaluate 16 rice genotypes on their fields using their own labor and level of management. Two sets of medium-duration rice genotypes were planted in two farmers' fields in Tarpongi, which has comparatively lighter soils. One set each of late-duration varieties was planted in Saguni and Khairkut villages, which have heavy-textured soils. The set of rice genotypes include prereleased genotypes (F7-F8), advanced lines from the Shuttle Breeding Project, and a local check. During specific phenotypic stages of rice production, farmers and plant breeders, using a visual method, evaluated and ranked the same set of rice genotypes on the station and on farmers' fields. Kendall's coefficient of agreement was used to measure the agreement among farmers, among plant breeders, and between farmers and breeders. Farmers recorded the reasons for their ranking in their diaries. This was done for consecutive years from 1997 to 1999. In 2000, the number of rice genotypes was reduced to five choices (plant breeder, farmer, one common, and a local check). These genotypes will be evaluated before harvesting, both at the station and on farmers' fields by plant breeders and farmers.

Results and discussion

Characteristics of the research sites and the farm households

This research is being conducted in three villages in the Raipur district located on the Chhattisgarh plains of Madhya Pradesh. On the Chhatisgarh plains, rice is grown mostly in the lowlands in a drought-prone ecosystem. Drought is a major climatic constraint for rice crops in this region. The general climate of the region is dry sub-humid, where annual potential evapotranspirational losses

are higher than the annual rainfall, which is about 1300 mm. Over 90% of the rainfall is received during the period from June to October. The monsoon sets in by 15 June and withdraws around 15 September. Winter conditions set in by mid-November, when the average minimum temperature reaches around 15°C. Hence, the rice crop should mature before this time. Sometimes winter conditions set in early—by the third week of October—and this results in increased sterility and, thereby, low productivity. Under such fragile conditions, the identification of suitable genotypes should be based both on climatic and edaphic characteristics (IRRI-IGAU 2000).

The research sites are located in three villages: Tarpongi, Saguni, and Khairkut in the Raipur district. Tarpongi is 29 km in the north of Raipur; Saguni and Kharkut are 5 km to the west of Tarpongi. These villages are located within 50 km of IGAU. There are 200 to 250 households in each village. More than 90% of the farming households in these villages belong to the other backward caste with small and marginal landholdings (owning less than a hectare), of which the majority are Hindus. Male heads of households have an average of four years in school, while the majority of the women have lower levels of education and did not go to school. All of the farmers interviewed owned their own land. In each village, 25 farmers were interviewed with regards to their farming and cropping systems, rice diversity, and their criteria for varietal selection. The survey was conducted in 1997 and 1998.

The areas for rice production in these representative villages are heterogeneous. Farmers in these villages classify their land according to the topography/slope, such as upland, midland, and lowland. The light soils in the uplands are classified by farmers as *bhata* (entisols), while the sandy loam in the midlands are referred to *matasi* (inceptisols). The heavy-textured soils in the lowlands are referred to as *kanhar* (vertisols). Most of the drought-prone areas have light-textured soils, whereas the more favorable areas have heavy-structured soils. Tarpongi has light-textured soils while the other two villages have heavy-structured soils. The length of the rice-growing season is primarily dependent on moisture availability, which is dependent on slope and soil type.

Rice is grown mainly in the rainy season (*kharif*) in a *biasi* system. Land preparation is done by bullocks and rice is dry-seeded at the beginning of the rainy season in June. When enough rain has accumulated in the field, 25- to 30-day-old seedlings are wet-plowed, laddered, and redistributed. This traditional practice, called *beushening* or *biasi*, is common in many rainfed areas of eastern India, particularly in Madhya Pradesh. Farmers continue this practice with the belief that it helps to control weeds and stimulate root growth (Fujisaka et al. 1993; Singh, Singh, and Singh 1994). Farmers grow purple-colored rice varieties as a strategy to identify and eradicate wild rice (which is prevalent in this region) at an early stage of crop growth.

Family members provide the major source of labor for rice cultivation. While male family members do most of the land preparation, rice broadcasting, and application of chemicals, females are predominantly responsible for weeding, applying farmyard manure, harvesting, threshing by hand, winnowing, and managing seeds for storage. Seed selection is done by both husband and wife. Other post-harvest activities, such sun drying, dehusking, and parboiling are exclusively done by women. Caring for livestock and, consequently, daily collection of green fodder for the livestock is done mostly by women (Sharma et al. 1997). Thus, women's criteria for rice varietal choices may be influenced by their roles and responsibilities in farming and their social and religious obligations, and may differ from those of men. The majority of the farmers obtain new seeds from their neighbors and from extension workers. Only 24% obtain new seeds from IGAU. This indicates a lack of awareness among farmers about the new technologies developed at the university. Weeds are prevalent in farmers' fields, and roguing the rice fields to protect the purity of seeds is not

commonly practiced in these villages. Rice mixtures and weed seeds are commonly found in the seed stocked for the next season.

The cropping intensity in these villages is low because of the lack of supplementary irrigation water during the *rabi* season. The cropping systems in the villages are rice-fallow, rice-lathyrus, or rice-chickpea (table 1). The chickpea and lathyrus crops are grown as relay crops (locally called *utera* in rice).

Table 1. Characteristics of the Rice Land in the Research Sites in Raipur, Madhya Pradesh, Eastern India

Slope	Upland (ndulating)	Midland (gently undulating)	Lowland (leveled and gently undulating and terraced fields)	Lowland (leveled)	Lowland (low lying)
Soils	*Bhata* (entisols)	*Matasi* (inceptisols)	*Dorsa* (alfisols)	*Kanhar* (vertisols)	*Nala* (vertisols)
Texture	Gravely course loamy to sandy	Sandy loam	Silty clay	Clayey	Clayey
Depth (cm)	Very shallow (5–30)	Moderate (30–80)	Moderate to deep (80–150)	Deep (>150)	Deep (>150)
Internal drainage	Rapid	Moderate	Moderate to slow	Slow	Slow (surface flooding)
Mechanical composition (%)					
a. Sand	60–80	30–50	25–35	20–30	20–30
b. Silt	15–22	30–40	25–30	20–30	20–30
c. Clay	9–20	20–33	33–45	>45	>45
Cropping patterns	Rice-Fallow	Rice-Fallow	Rice-Lathyrus or Chickpea	Rice-Lathyrus; Dikes are planted with pigeon pea	Rice-Lathyrus
Duration of rice varieties suited to these land	Short (90–110 days)	Intermediate (110–130 days)	Long (130–145 days)	Long (> 145 days)	Long (> 145 days)

Adoption of rice varieties

A high diversity of rice varieties exists in these villages. The names of the varieties grown by farmers in these villages are shown in table 2. Of the total area grown to rice in the lowlands of Tarpongi, 73% is grown with traditional varieties, while the rest (27%) has modern varieties. Twenty years ago, there were about 20 traditional varieties; however, this number has declined. In contrast, in the uplands of Saguni and Kharkut, the adoption of modern varieties is slightly higher than thethe adoption of traditional ones. Traditional varieties such as Safri-17 and Chepti gurmatia are popular in the lowlands. The main reason for adoption of traditional varieties in the lowlands with heavy soils is because all the traditional varieties are tall and can sustain even late *biasi* operations.

According to the rainfall pattern and soil types of Chhattisgarh, farmers grow varieties according to the land elevation, hydrology, and soils. Rice varieties with a growth duration of less than 110 days are grown on the upper (undulating) portion of uplands with loamy to sandy soil *bhata* (entisols). Rice varieties with a growth duration of 110 to 130 days are allocated mainly to the midland (gently undulating) sandy loam *matasi* (inceptisols). Varieties with a growth duration of up to 140 days are best suited for light soils, such as those found in Tarpongi village. Late-maturing varieties (140 to 155 days) are ideal for low-lying, heavy-textured *dorasa* and *kanhar* soil types, such as those found

Table 2. Area (Hectares) Planted to Modern and Traditional Rice Varieties by Sample Farming Households, Elevation of Rice Land, and Village, Raipur, Madhya Pradesh

Varieties	Tarpongi (n = 25)		Saguni (n=50)		Khairkut (n=50)		
Modern	**Upland**	**Lowland**	**Upland**	**Lowland**	**Upland**	**Lowland**	**Duration (days)**
Swarna	0.8	7.82	27.64	9.86	38.66	5.0	Late (150)
Mahamaya		2.6	2.22	1.4	6.6	1.0	Medium (130)
Kranti	6.8	6.9	8.8	1.8	4.9		Medium (130)
262	7.5	2.1		0.1	0.8		Medium, (125)
H.M.T.					0.4		Medium (130)
Purnima	2.4	0.4					Late (145)
IR36						0.6	Early (120)
Culture		0.8	1.86	1.2			Medium (130)
Others				0.7			
Total MVs	17.5	20.62	40.52	15.06	51.36	6.6	
Traditional							
Safri-BD	2.9	**28.4**	7.7	4.04	**40.62**	5.2	Late (150)
Safri-17	1.2	**10.7**	12.3	3.64	0.44		Late (155)
Chepti gurmatia	**10.8**	7.0	3.2	3.8	0.64	5.0	Medium (130)
Ranikajar	1.8	1.4	6.3	1.84	5.68	0.4	Medium (130)
Bhata safri	4.44	7.8		0.4	2.12	1.6	Medium (130)
Anjan safri	0.5	0.1					Late (145)
Ganga safri	0.3						Late (145)
Nankershar	0.2						Late (135)
Dubraj		1.6					
Chepti				4.7			Medium (130)
Total Traditional	20.14	57.0	29.5	18.82	49.50	12.2	
Total of all varieties	37.64	77.62	70.02	33.88	100.86	18.8	
%MV	**46.49**	**26.57**	**57.87**	**44.45**	**50.92**	**35.11**	
%Traditional	**53.51**	**73.43**	**42.13**	**55.55**	**49.08**	**64.89**	

Note: Modern = semi-dwarf, high-yielding varieties. Traditional = tall in stature whether improved or not improved by selection. Upland = no bunds between plots.

in Saguni and Khairkut. Crops are grown chronologically with the lowland fields planted first and the upland fields planted last. Lowland fields are submergence-prone and need to be sown early so that seedlings are already established before the fields are flooded.

Farmers' perceptions of traditional and modern rice varieties

After identifying the modern and traditional varieties farmers grew, questions were asked about positive and negative attributes. These questions were open-ended and no attempt was made to impose *a priori* categories of answers. Table 3 shows the list of positive traits of popular traditional varieties such as Safri-17 (late duration) and Chepti gurmatia (medium duration). Although these traditional varieties have lower yields, farmers prefer them because of their combined positive

Table 3. Farmers' Assessment of Popular Traditional Varieties

Variety	Positive traits	Negative traits
Safri-17 (late maturing)	• stable yield every year • resistant to pests and diseases • drought tolerant • good for heavy-textured soil • good for *beushening* method of land preparation • tall (157 cm) and submergence tolerant • competes with weeds • requires less water and fertilizer • photosensitive • good taste and eating quality • good grain quality (slender, fine, shining) • commands high market price • high milling recovery • good quantity and quality of straw for making rope • matures near religious festival (*Diwali*)	• has lower yields (2–3 t/ha) than Swarna and Kranti • susceptible to lodging due to height (157–168 cm) • can't be used to distinguish wild rice (*karaga*) • too much straw and less grain
Chepti gurmatia (medium duration)	• good grain yield (3 t/ha) • competes with weeds • tolerant to drought • ideal for light soil or *Matasi dorsa* • medium duration and can be harvested early, allowing *rabi* crop • purple pigmentation helps in eradicating wild rice • has good taste and eating quality • commands a high price in the market • good for other rice products (e.g., *basi* and *pulao*) • preferred as wage by agricultural laborers due to its bold, coarse grains: can last longer in the stomach	• yields lesser than Swarna • susceptible to lodging because it is tall (137–142cm) • susceptible to bacterial blight and stemborer • has more straw than grain

qualities. *Chepti gurmatia*, for example, has purple pigmentation that helps farmers distinguish and eradicate wild rice (*karaga*).

Swarna and Mahamaya are two modern varieties that have the positive qualities present in the traditional varieties. Swarna is a high yielder, late maturing and semi-dwarf. Farmers perceive that these varieties can tolerate drought. Mahamaya, similar to Chepti gurmatia, also has the purple leaf sheath and purple auricle, which help to distinguish it from wild rice. It has potentially higher yields than the traditional varieties; however, the modern varieties are more susceptible to diseases (bacterial blight and gall midge). Mahamaya is also susceptible to lodging because of its short stature (table 4). Actually, Swarna was released in 1982 from Andhra Pradesh and was tested by the plant breeders. However, it was not recommended to farmers before 1992. The adoption of Swarna has been fast and it has replaced local varieties such as Safri and Dubraj and improved varieties such as Mashuri. However, since 1992, not a single variety with these positive combined characteristics could be released by the local breeders in IGAU.

Table 4. Farmers' Perceptions of Traits of Popular Modern Varieties

Variety	Positive traits	Negative traits
Swarna (late duration)	• high yield (4–5 t/ha), which is 1.5 tons higher than Safri • responsive to fertilizer • high number of medium-slender, fertile spikelets (150–200) • dark green color helps in distinguishing wild rice • can withstand drought • heavy tillering (8–10 tillers) • semi-dwarf (93 cm) and resistant to lodging • suitable to heavy-textured soils and retains moisture • requires low inputs • commands high price in the market • preferred for *basi* (leftover rice from dinner that is dipped in water and eaten the following day for breakfast or lunch) • good eating quality—remains soft after cooking for a long time compared to the other varieties • high milling recovery	• susceptible to diseases (bacterial blight, gall midge) • susceptible to brown plant hopper • poor weed competition due to its short stature, which requires early weeding • duration too long when *rabi* crops need to be grown • requires more water to mature • low yields of straw • less yield than Mahamaya • not photosensitive
Mahamaya (medium duration)	• higher yield potential • resistant to diseases (gall midge) and pests (brown plant hopper) • dark green color helps distinguish wild rice • purple leaf sheath and purple auricle help identify wild rice • early to medium duration—can harvest sooner and grow *rabi* crops • commands high market price • has bold, heavy grains • good quantity and quality of straw • more fertile spikelets • resistant to lodging—intermediate height • responsive to fertilizer • preferred by millers and traders for beaten rice (unbroken *poja*) and for puffed rice (*murmura*) because it expands easily • preferred by poor farmers and agricultural laborers because it remains soft after cooking and makes them feel full even when consumed in small quantity	• susceptible to stemborer • susceptible to sheath blight • not good eating quality • poor milling recovery—has more broken grains after milling

Mahamaya was only released in 1997. Both Swarna and Mahamaya were released for irrigated rice ecosystems, but because of their perceived ability to tolerate drought and their high market demand by traders, these two varieties have become very popular. Millers and traders prefer Mahamaya for making beaten rice and puffed rice. Poor farmers and agricultural laborers who are paid in terms of

rice prefer Mahamaya because they feel that it satisfies their hunger. Mahamaya has bold, coarse grains that they believe last longer in the stomach. Farmers also prefer Swarna for *basi* (leftover rice from dinner, dipped in water with a little salt and eaten the following day for breakfast or lunch).

Male and female farmers' criteria in selecting rice varieties

Despite the active involvement of women in rice production, post-harvest, and seed-management activities, scientists, who are mostly men, often talk with male farmers only. Ignoring women's knowledge and preferences for rice varieties may be an obstacle to adoption of improved varieties, particularly in areas with gender-specific tasks and in farm activities where women have considerable influence. For example, a released variety such as Pant-4 is high yielding but is rejected by women farmers because it is difficult to thresh by hand. In contrast, traditional varieties that are low yielders are still grown because of their desirable taste and their eating and cooking qualities that make them well-suited for rice products that women prepare. Knowing men's and women's criteria in rice varietal selection and access to and control of new seeds, information, etc., will lead to more efficient dissemination of improved rice varieties for rainfed conditions and their subsequent adoption. Thus, in 1998, a team of scientists from the Directorate of Extension, IGAU, conducted focused research in the same villages. Our objective was to test and develop a methodology for eliciting male and female farmers' criteria and to determine whether there are gender differences in these criteria in rice varietal choice.

The majority of the women farmers are illiterate and are less exposed to household surveys; therefore, we used a simple participatory method of eliciting their perceptions regarding the useful traits they consider when selecting rice varieties. Men and women were separately involved in this activity. This method, which is like a game of cards (see methodology section), gave the farmers more time to think as well as to enjoy the process. Tables 5 to 7 show the important traits that male and female farmers consider when selecting rice varieties according to land elevation and size of landholding. The results show that grain yield was the most important criterion for both men and women farmers in selecting rice varieties for all land types and sizes of landholding. Both men and women gave more value to eating quality (taste) and duration/maturity for rice varieties grown on upland fields. However, women were more concerned with market price, drought tolerance, pest and insect resistance, and competitiveness to weeds. On the other hand, men gave more importance to grain size and shape than women did. For midland conditions, women gave higher values to eating quality and market price, while men gave more importance to duration and maturity. For lowlands, eating quality and market price were considerations for both men and women. Women consistently gave higher values to the multiple use of straw for varieties grown in all land types.

We also assessed whether there were differences in criteria between men and women from marginal and large farms. Table 6 shows that there is not much difference between the criteria across size of landholding. Both men and women with large farms gave the highest value to grain yield. Aside from grain yield, both men and women from the same economic category gave more importance to eating quality and market price. Duration/maturity was more important to male farmers from large farms than to women of the same category, similar to marginal farmers. Women from both large and small farms gave a higher value to the multiple use of straw than men did.

In summary, the most important traits that both men and women value in selecting rice varieties are grain yield, eating quality (taste), market price, duration/maturity, drought tolerance, and resistance to pests and diseases. Women placed higher weights on multiple uses of straw across all land types and for both large and small landholdings. Men did not consider this as important, obviously

Table 5. Men's and Women's Perceptions of Useful Traits of Rice Varieties by Land Elevation, Raipur, Madhya Pradesh

Traits	Uplands		Midlands		Lowlands	
	Men	Women	Men	Women	Men	Women
Grain yield	19	19	27	25	30	27
Eating quality (taste)	16	11	6	17	11	19
Market price	3	10	8	13	9	13
Duration/maturity	13	10	13	6	7	3
Drought tolerance	6	11	5	3	3	1
Pest/insect resistance	6	10	8	6	6	4
Multiple use of straw	0	8	5	11	6	11
Grain size and shape	16	0	2	2	4	3
Milling recovery	9	0	2	2	4	4
Lodging resistance	3	0	3	4	2	3
Fertilizer responsiveness	6	3	5	3	4	2
Weed competitiveness	7	7	3	1	2	2
Submergence tolerance	5	5	1	2	2	2
Good for rice products	0	0	2	2	1	0.5
Disease resistance	0	0	3	<0.5	3	0.5
Adaptation to soils	3	0.5	2	1	2	1
Adaptation to land level	0	0.5	2	1	0.5	1
Storage quality	0	2	1	<0.5	2	1
Fullness in stomach	0		1	<0.5	1	1
Cooking time	0	3	1	1	0.5	
	100	100	100	100	100	100

Note: Values have been rounded off. Values were computed by weighted-ranking method.

because women are more responsible than men in caring for the livestock. Rice straw is used as feed for the livestock and also mixed with cowdung to make a cake for household fuel. Thus, women consider both grain yield and rice biomass in selecting rice varieties according to their specific environments. A rice variety that has high grain yields but low quantity and quality of rice straw has a lower chance of adoption by women farmers. Men gave more importance to grain size and shape for varieties grown on the uplands. Men owning small farms considered adaptation of the variety to specific soil conditions as being extremely important (second to yield) but were the only group to rank this highly. This may be because poorer farmers cultivate more marginal land (explaining the need for adaptation of the variety to soil type). Women did not rank this characteristic highly, probably because of their role in production (men tend to choose the varieties and clear the land).

Logically, drought tolerance was more important for upland and midland areas than for lowland areas. Women weighted this more highly than men.

While the participatory ranking method was useful in assessing the trade-offs between traits valued by farmers, this method could be improved by including traits mentioned in the open-ended

Table 6. Perceptions of Useful Traits of Rice Varieties, by Size of Landholding and Gender, Raipur, Madhya Pradesh

Traits	Large farmers		Marginal farmers	
	Men	Women	Men	Women
Grain yield	36	34	19	21
Eating quality (taste)	13	12	9	18
Market price	8	12	6	13
Duration/maturity	10	3	7	8
Multiple use of straw	4	7	3	10
Drought tolerance	4	8	4	4
Pest/insect resistance	7	5	6	7
Grain size and shape	8	<0.5	5	2
Milling recovery	1	2	9	6
Lodging resistance	3	2	4	2
Fertilizer responsiveness	3	2	7	3
Weed competitiveness	1	2	2	1
Submergence tolerance	1	5	1	1
Good for rice products	1	<0.5	1	1
Disease resistance		1	2	<0.5
Adaptation to soils		1	12	<0.5
Adaptation to land level		1	1	<0.5
Storage quality		1	1	1
Fullness in stomach		0	1	<0.5
Cooking time		2	1	2
		100	100	100

questionnaires. The cards shown by the researcher limited the choice of desired traits—other traits based on specific cultural practices, such as a preference for purple-colored rice varieties or for varieties suited to the *beushening* method of land preparation, were not mentioned at all. Moreover, other social considerations, such as a preference for late and medium varieties to coincide with a religious festival such as *Diwali* were not captured. Farmers usually harvest rice only after the *Diwali* festival. During this festival, families give special rice as gifts to relatives.

Participatory varietal selection

Although scientists accept that farmers are careful managers and possess a wealth of knowledge about their production systems, this knowledge is not sufficiently used in the formal breeding process (Kshirsager et al. 1998) Several strategies were used to involve farmers in PVS. Farmers volunteered to grow 16 early- to medium-duration group varieties and late-duration varieties on their own fields for three consecutive years. The early/medium-duration group varieties were tested at Tarpongi village on two farmers' fields that have light soils. The late-duration varieties were tested on two farmers' fields at Saguni village under heavy soils. The new varieties had some of the preferred criteria mentioned by farmers obtained in the interview and participatory-ranking activities. Farmers and breeders ranked the rice lines on the station and on farmers' fields in the research sites.

Table 7. Comparison between Ranks Attributed by Farmers and Breeders at Different Growth Stages in the PVS Trials, Raipur Villages, Eastern India, and IGAU Station, 1997–99

Trial location	Year	Trial code[2]	Stage[1]	No var.	No F.	No B.	Agreement among farmers W	Agreement among breeders W	Correlation between farmers' & breeders' rankings r
Station	97	1	F	16	8	1	0.34**	–	–0.20
	97	1	M	16	8	1	0.51**	–	0.11
Tarpongi	97	1	F	16	5	–	0.51**	–	–
	97	1	M	16	4	2	0.55**	0.47	013
	97	2	F	16	5	–	0.50**	–	–
	97	2	M	16	7	2	0.34**	0.53	–0.03
Saguni	97	1	F	16	7	–	0.30**	–	–
	97	1	M	16	6	2	0.44**	0.30	–0.18
	97	2	F	16	5	–	0.79**	–	–
	97	2	M	16	5	2	0.54**	0.56	–0.06
Station	98	1(M)	F	16	8	2	0.32**	0.77	0.16
	98	1(M)	M	16	6	2	0.26	0.60	0.50*
	98	2 (L)	F	16	8	2	0.31**	0.54	–0.04
	98	2 (L)	M	16	6	2	0.67**	0.70	0.28
Tarpongi	98	1(M)	F	16	5	1	0.55**	–	0.46
	98	1(M)	M	16	4	1	0.30***	–	0.20
	98	1(M)	CROP FAILURE						
Saguni	98	2 (L)	F	16	4	1	0.56**	–	0.07
	98	2 (L)	M	16	4	1	0.59**	–	0.02
Khairkhutt	98	2 (L)	F	16	6	1	0.38**	–	0.51*
	98	2 (L)	M	16	4	1	0.44*	–	–0.01
Station	99	1 M)	M	16	7	3	0.49**	0.91**	0.33
Station	99	2 M)	M	16	7	3	0.65**	0.89**	0.62*
Tarpongi 1	99	1 M)	M	16	6	3	0.65**	0.94**	0.61*
Tarpongi 2	99	2 M)	M	16	5	3	0.62**	0.84**	0.46
Station	99	1 (L)	M	16	7	3	0.53**	0.81**	0.15
Station	99	2 (L)	M	16	7	3	0.34**	0.76**	0.11
Saguni 1	99	1 (L)	M	16	7	3	0.50**	0.93**	0.66**
Saguni 2	99	2 (L)	M	16	6	3	0.66**	0.91**	0.64**
Station	99	1	V	20	5	3	0.98**	0.94**	0.90**
Station	99	1	F	20	5	3	0.98**	0.98**	0.91**
Station	99	1	M	20	5	3	0.96**	0.97**	0.89**
Khairkhut	99	2	V	20	5	3	0.98**	0.95**	0.87**
Khairkhut	99	2	F	20	5	3	0.94**	0.99**	0.92**
Khairkhut	99	2	M	20	5	3	0.90**	0.97**	0.41**

Note: – = not tested. W = Kendall's coefficient of concordance. r = Spearman's coefficient of correlation. F = farmers. B = breeders.

1. Stage: V = vegetative stage, F = flowering, M = maturity.
2. Trial code: L = late, M = medium.

Farmers' rankings were compared with breeders' rankings during different stages of crop growth (vegetative, flowering, and maturity) as shown in table 7.

Correlation between breeders and farmers at all sites and in all the years was consistently low. Very few of the trials showed significant or highly significant agreement between farmers and breeders (trials that showed any significant agreement were mainly in 1999). In general, agreement was insignificant or even negative (although not strongly so). It was impossible to make an assessment of agreement between farmers and breeders in 1997 and 1998. However, in 1999, although there was high agreement in varietal ranking among farmers and among breeders, there was generally low agreement between farmers and breeders, which may indicate that farmers and breeders consider different criteria. Farmers' rankings are not correlated with yield, indicating that farmers consider other criteria in their rankings.

Assessment of late-duration varieties included in PVS in Saguni, Raipur

The breeders' top five favorite late-duration varieties in the 1999 trials included Swarna, BKP-232, R650-1817, R304-34, and R738-1-64-2-2 (all modern varieties). These varieties also ranked in the top five in yield. The farmers' top five favorite varieties included Swarna, Safri-17, R738-1-64-2-2, Mahsuri, and R650-1817. These were not always the highest yielding varieties—in fact, Mashuri gave one of the lowest yields and Safri-17 (a traditional variety) was somewhere in the middle. These varieties were likely selected for other reasons than yield. Varieties preferred by both groups (ranking on average in the top 5) included Swarna (first choice of both farmers and breeders, and also high yielding), R650-1817, and R738-1-64-2-2. These are all modern varieties, and are also the three varieties that had the highest yields in the trials (table 8).

Table 8. Assessment of Late-Maturing Varieties Included in PVS, Saguni, Raipur, Madhya Pradesh, Eastern India

Variety	Ranking
Swarna (check)	Favorite of both farmers and breeders Consistently ranked highly in the top 5 by both groups in the field sites and on-station
Safri-17 (check)	Always ranked in the top 5 by farmers, but not so well ranked by breeders
R738—64	**This is ranked in the top 5 by farmers and breeders in the farmers' fields, but less well ranked in on-station trials.**
R304-34	**Ranked first by breeders, but not liked by farmers, even though yield is quite good (5 t/ha)** **Ranked low by both groups in field sites** **Bold grains, not susceptible to disease, commands high market price**
Mahsuri	On-station, ranked within top 5 by farmers, on station and in one farm site, although yield is consistently low Ranked consistently low by breeders
IR54896	On-station, ranked highly by breeders Yield is good, but farmers don't like it (one of their least favorites) Ranked low by all in farm trials

Assessment of medium-duration varieties in Tarpongi, Raipur, Madhya Pradesh

In Tarpongi, the top ranking medium-duration varieties for breeders were R574-11, IR42342, Chepti gurmatia, BG380-2, R703-1-52-1, and OR1158-261. All of these were also the top six

yielding varieties. All are modern varieties except for Chepti gurmatia. For farmers, the top ranking varieties included BG380-2, OR1158-261, R714-2-9-3-3, IR63429, and R574-11. These are all modern varieties, but not always top yielding. R714-2-9-3-3 gave medium yields, while IR63429 gave relatively low yields when compared with the other varieties. Farmers and breeders agreed only on R574-11, BG380-2, and OR1158-261 as their favorite varieties (table 9).

Table 9. Assessment of Medium-Duration Varieties Included in PVS, Raipur, Madhya Pradesh

Variety	Ranking
R714-2-9-3-3	Ranked highly by farmers on farmers' fields and in 2nd on-station replication, and is among the farmers' favorites Consistently marked low by breeders
R574-11	**Top ranked by farmers and by breeders in station trials. Also, highest yield** **On-farm, is still in top 1-2 for breeders but drops to 8-10th rank for farmers** **Yield on farm is less (4th and 6th rank)**
OR1158-26	Ranked about 5-6 (on average) in all sites except in one field, where it was #1 among farmers Yield ranges from 3-8 t/ha Among the top varieties for farmers and breeders
IR63429	**Ranked well by farmers in all sites but consistently ranked low by breeders** **Lower-yielding variety compared to others, but farmers seem to like it in any case** **Early, long grain, intermediate height**
IR42324	Consistently highly ranked by breeders, but given low rank by farmers in all sites except station replication #1 Consistently high yield, but even with highest yield on farm, farmers don't like it
Chepti gurmatia (local check)	Consistently ranked well by breeders, also one of the top 5 yielding varieties However, it ranks in the middle with farmers
BG380-2	**Ranked highly by breeders and farmers in field and on-station** **Generally has good yield**

During the *kharif* season 2000, the medium-duration varieties that were further evaluated on-station and on farmers' fields were IR4234 (breeders' choice), R574-11 (farmers' choice), BG380-2 (common choice), and Chepti gurmatia (best local choice). The late-duration varieties were BKP-232 (farmers' choice), R304-34 (breeder's choice), R650-1817 (common choice), and Swarna (local check).

The challenge facing plant breeders in IGAU and IRRI is to develop new cultivars that are better than Swarna and Mahamaya, while also meeting the other requirements and criteria that farmers have for their given rice environments. While it is impossible to combine all the requirements in one single variety, giving farmers (both men and women) an opportunity to test the performance of different rice genotypes on their own fields and to evaluate their cooking and eating qualities can lead to more efficient rice varietal improvement in the Chhattisgarh region in Madhya Pradesh.

Conclusions

This paper focused on methodologies for improving our understanding of the criteria used by farmers (both men and women) in selecting specific rice varieties and of how these criteria are considered in participatory breeding strategies in the rainfed lowland environments of the Chhatisgarh region in Madhya Pradesh, eastern India. Different methods for understanding farmers' criteria in

selecting rice varieties were used. These methods were (1) a questionnaire with open-ended questions eliciting positive and negative attributes of the most popular modern and traditional varieties, (2) a participatory weighted-ranking method, disaggregating the perceptions of men and women by land types and size of landholdings, and (3) participatory varietal selection, where farmers evaluated several prereleased and local varieties on their fields as well as on-station. The results of the study highlight the importance farmers attach to characteristics other than grain yield: eating quality (taste), market price, duration/maturity, drought tolerance, and pest and insect resistance.

Both men and women have similar criteria in choosing rice varieties. However, straw quality for multiple uses is an important consideration for women farmers but not for men. Farmers, particularly women who do most of the weeding, prefer rice varieties that are inherently dark green or purple to distinguish them from wild rice and enable the farmer to eradicate the wild rice at an early stage of crop growth. Wild rice is a prevalent pest and a constraint to high rice productivity in the Chhattisgarh region. The attributes considered by men and women farmers, however, are not generally used as screening criteria in most formal breeding programs, where the emphasis is mainly on grain yield. Quality attributes should be emphasized more than they have been in the past in breeding programs for rainfed areas. Because of the proximity of the villages to the market, farmers prefer to grow varieties that not only meet their own consumption needs but also those of consumers, including millers and traders. Therefore, farmers maintain their rice diversity and grow both traditional and modern varieties that meet their varied interests and needs. Using approaches like farmer participatory breeding and varietal selection from many rice lines provides an opportunity to farmers to choose varieties suitable to their environment and needs as well as access to new seeds.

Breeding lines R574-11, BG308-2, and IR42342 performed well over the three years of the project in the medium-duration group and showed tolerance to drought. Breeding lines R304-34 and IET-14444 (R738-1-64) also proved promising. A large quantity of seeds have been multiplied by one of the farmers of Saguni village where blight is a problem.

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Seed Security in Badakshan, Afghanistan

Iqbal Kermali

Abstract

Badakshan is located in the extreme northeastern corner of Afghanistan and has not yet come under Taliban control. The province is virtually cut off from the rest of the country and is traditionally food deficient. The 20-year-old conflict in the region has further aggravated the situation, causing massive population displacement and almost complete destruction of civil institutions and infrastructure. The situation has become so serious that food aid has to be distributed in the period of grain deficit, starting from before the harvest. Simultaneously, efforts are being made to rehabilitate and improve the agricultural systems of these farming communities.

In all formal and informal surveys in the area over the last three years, the farmers have identified good seed of wheat cultivars and fertilizer as being their main priority. Currently the seed of high-yielding cultivars acquired from the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) are available, but such varieties do not always perform well under farmer's conditions. The potential of these varieties can not be realized without the use of fertilizers. Almost all the available animal dung is used to as fuel and little is available for use as manure. The small amounts of chemical fertilizer available are totally inadequate in quantity and exorbitant in price. In response to these needs, improved varieties of wheat, potatoes, and vegetables are being provided to over 100 villages in five isolated districts bordering Tajikistan. Three to eight farmers in each village are testing the new planting materials under their local conditions. These farmer-led, on-farm evaluations are also serving as demonstration plots for the remainder of the farmers in the village. The farmers will compare the performance of the varieties provided with their existing varieties. Cultivation of the better of the two will be encouraged through farmer-to-farmer exchanges and credit through village organizations for the inputs. This procedure will be repeated every growing season whenever new potential materials, including varieties, landraces, and different crop species are available. A secondary goal is to enhance on-farm genetic diversity among and within different crop species. These activities will be gradually transformed into participatory breeding, allowing the community to gain full control over the type and amount of varieties being produced and exchanged with their neighbors. Participation in the management and decision making for seed security by the farming community will contribute to reestablishing local food security and peace in the area.

Introduction

Focus Humanitarian Assistance (FOCUS) is an international group of agencies established in Europe, North America, and South Asia to complement the provision of emergency relief, principally in the developing world. It helps people in need reduce their dependency on humanitarian aid and facilitates their transition to sustainable, self-reliant, long-term development. FOCUS is affiliated with the Aga Khan Development Network, a group of institutions working to improve opportunities and living conditions for people of all faiths and origins in specific regions of the developing world. Underlying the establishment of FOCUS by the Ismaili Muslim community is a history of successful initiatives to assist people struck by natural and man-made disasters in South and Central Asia, and Africa.

Assisting farmers in disaster situations to restore agricultural systems was identified as a priority in the Global Plan of Action for the Conservation and Sustainable Utilisation of Plant Genetic Resources for Food and Agriculture. The plan was adopted by over 150 countries at the International Technical Conference on Plant Genetic Resources (Leipzig, Germany, June 1996). The conference

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recognized that disasters, civil strife, and war pose challenges to agricultural systems. Often, adapted crop varieties are lost and cannot be recuperated locally. Food aid, combined with the importation of often poorly adapted seed varieties, can undermine food security and increase the costs of donor assistance. In such situations, the goal is to deliver seed of adapted varieties and landraces as needed to help reestablish indigenous agricultural systems in areas affected by disaster. In turn, this can play a major role in restoring local food security.

Afghanistan

Afghanistan is one of the poorest countries in the world. This millenium, the country passed the mark of 21 years of conflict, which has brought complete destruction and immense suffering to its people. After the fall of the Soviet-backed government in 1992, the prospects for peace have receded, with continuing civil war fragmenting the country into struggles between the various political and military groups in shifting alliances. Currently, more than 80% of the country is under the Taliban, while the remainder is under a united front. However, the Taliban movement is not yet recognized by the international community, except for Pakistan, Saudi Arabia, and the United Arab Emirates.

The nation's agricultural system has suffered from physical damage to irrigation structures, from mines, and from the disruption of normal markets and input-delivery mechanisms. Security concerns, high transport prices, and continual currency depreciation all combine to cause shortages of agricultural inputs such as seeds, fertilizers, chemicals, credit, and labor, resulting in increased food scarcity. The civil unrest has caused the country to move from near self-sufficiency in the mid-1970s to a dependency on imports in recent years.

Badakhshan

Badakshan, one of the most remote areas in Afghanistan, is located in the northeastern corner bordering Kunar, Lagham, Kapisa, and Thakar provinces. In addition, the province borders Pakistan in the southeast, China in the east, and Tajikistan in the north. It is one of the two major areas not under the control of the Taliban. The Panj River (Amu Darya) separates its long border with Tajikistan. The province is normally linked with the rest of country a by narrow, drivable road through the province of Takhar on the West. Currently, after Takhar the road intercepts the frontline with the Taliban. The province is thus virtually cut off from the rest of the country. On the eastern side, the road is linked with the Gorno-Badakshan province of Tajikistan through a narrow bridge over the Panj River at Ishkashem.

Badakshan lies in the Hindu Kush mountain range with the Wakhan rising up into the Pamir Mountains. The Hindu Kush mountain system is characterized by young, rugged ranges with sharp peaks and deep valleys. The eastern half of the province lies between 1,300 meters (Darwaz) to 3,000 meters (Wakhan). The western half is at a lower elevation, with Keshem, the lowest point, at 960 meters. Inside the province, most of the districts are isolated from each other for a greater part of the year by heavy snowfall in the winter, landslides in spring, and floods in the summer. Because of the rugged mountain terrain, much of the land area is uninhabitable. Connecting dirt roads are either very rough or do not exist. Donkeys, horses, and walking constitute the major means of transport. It is common for villagers to walk three to four days to the nearest market. There is virtually no effective government operating in the province at the current time. The villages and larger towns in

the province have no electricity, no running water, no sanitation facilities, few medical facilities, and poor schools.

Badakshan province has historically been isolated and neglected. It has always been considered a poor province; even before the war, local agricultural production met only 50% of the needs. The few development initiatives ever started were abandoned after the communist takeover and the subsequent fight between the Taliban and the Northern Alliance. It is estimated that agricultural production is down by at least 40% as a result of the war (UNIDATA 1966).

Agriculture

The province has a highly diversified cropping system. Crop production, horticulture, and livestock are the main sources of income for most households. It is difficult to obtain reliable statistics on agricultural production. Figures on land holdings provided by farmers during interviews tend to be grossly underestimated for fear of government taxation and to qualify for humanitarian assistance. The majority of households own less than one hectare, and further fragmentation of land holdings occurs because of the traditional inheritance laws. Smaller farmers usually sharecrop the land owned by farmers with relatively larger holdings (more than two hectares). Many districts do not produce enough food, for example, surveys have shown that food deficits in Sheghnan, Ishkashem, and Wakhan range from two to six months.

Autumn and spring wheat is the main grain crop. Other crops include pulses (broad beans, vetches, field peas, grass peas) often grown as a companion crop with spring barley. Finger millet and chickpeas are also planted in spring. Small quantities of oil-seed crops such as sesame and flax are occasionally grown for oil, but the wild mustard that grows as a weed in the wheat fields is harvested by women and children for oil and cooking. Maize is grown at lower elevations (below 1600 m) from Darwaz through Shekay as a second crop after wheat. Cotton is also grown in small quantities in some villages from Darwaz downstream, where it is used for stuffing quilts and pillows, and the oil extracted from the seed is used for lamps.

Vegetables include spinach, onions, beans, occasionally tomatoes, carrots, squash, and a variety of herbs. Several kinds of potatoes of varying lengths of maturity are grown. These vegetables provide a supplementary diet during the hungry months of spring and early summer before the harvest. Fruit trees, particularly mulberries, are important. Other common trees include fruit trees such as walnut, apricot, plum, sour cherry, apple, and grape, and timber trees such as poplar, willow, and walnut. Several wild plants play an important role and include wild mustard, wild rhubarb, wild orchid tuber, black cumin, licorice, and mushrooms, in addition to the wild herbs of medicinal value. Opium poppy is not cultivated on a commercial basis, although small patches may be planted by addicts for their own use.

Livestock are a main source of the household economy in rural areas. The sale of livestock is the primary means for much of the population to earn income for purchase of other food and essential items, especially wheat, during the spring months when they run out of food stock. The province has huge common grazing areas that support herds of livestock belonging to the local people as well as to nomads.

Humanitarian assistance

The chronic food-deficit situation in the province results in a cycle of poverty leading to hunger, and hunger leading to even greater poverty, which is very difficult to reverse. Because of its remoteness, very few assistance agencies are able to work in the province.

In response to the food deficit in the region, FOCUS is implementing a relief program. The program has included the distribution of 10,000 tons of food aid to 250,000 people over the last years. Food rations were provided for every household in about half of the province. In some districts, food was provided in a food-for-work program. FOCUS is able to carry out its activities in Badakshan for several reasons: FOCUS is affiliated with the Aga Khan Development Network, which has been active in Tajikistan and Pakistan on the northern and southern borders of Badakshan. During the last three years, good working relationships have been established with local leaders and with international organizations. A participatory model for rehabilitation comprising situation assessment, health, food assistance, village organization, agriculture, physical infrastructure, education, and economic initiatives is being considered.

Agricultural interventions

Agricultural interventions by FOCUS have been initiated this year in the districts along the Panj River (Darwaz, Sheghnan, Ishkashem, Zebak, and Wakhan). Although Zebak is not strictly along the river basin, its farming systems resemble those of Ishkashem. These districts are among the most food-deficient areas in the province. FOCUS is able to access these areas across the river from Gorno-Badakshan in Tajikistan where the Aga Khan Development Network has a comprehensive development program, of which agriculture is an important component.

The populated areas of the Sheghnan, Ishkashem, Wakhan, and Zebak districts are at an altitude of 2200 to 3000 meters. Population densities are low. Although there is a comparatively large area of land per capita, low temperatures, short growing seasons, low rainfall, and poor soils combine to lower productivity. Darwaz, on the other hand, is at a lower altitude (minimum 1300 meters) and has a longer growing season with higher rainfall and temperatures.

Table 1. Characteristics of the Target Areas

	Ishkashem	Zebak	Wakhan	Sheghnan	Darwaz
Number of villages	30	14	16	17	54
Households (farms) per village	39	45	68	160	132
People per household	9.0	9.3	8.7	8.3	8.7
Land resources: ser* per household	21	11	25	12	6
Number of animals per household	15	10	12	14	6
Number of households surveyed	1200	635	1084	2555	2648

* A *ser* is a local measure of land area based on seeding rate, ranging from 20 to 35 *sers* of wheat seed per hectare.

Needs assessment

Only 2% of eastern Badakshan is suitable for agriculture, and its soil quality is often poor and deficient in nutrients. A large portion of the agriculture is based on irrigation from rivers and torrents. Extensive systems of irrigation channels have been developed by the communities over centuries, bringing water long distances along the mountainsides. There is also a considerable amount of farming that depends on moisture from rainfall and melting snow, which is less productive.

The general constraints on crop and livestock production in the area include the following:

- lack of access to good, pure seed for cereal crops
- lack and/or cost of inputs such as fertilizers and plant-protection materials
- diseases, pests, and weeds
- lack of irrigation water and the state of the water system
- remoteness of markets and lack of transport facilities
- lack of agricultural and livestock services
- taxes (generally as a part of their crop yield)
- displacement of technical staff and farmers and destruction of institutions

In all formal and informal agricultural surveys, the farmers' priorities have always been fertilizers and good seed of improved varieties. Most farmers are aware of the possibilities of increasing their production through these inputs, especially fertilizers. The soil is generally very shallow and lacks sufficient nutrients to support intensive crop production. With shortages of fuel, especially firewood, most of the available animal dung is used for cooking and for heating in winter. The population of trees remaining is barely sufficient for watershed purposes and needs to be replenished. Lack of sufficient fodder for feeding livestock during the winter also limits the amount of animal dung available for the household. Small amounts of fertilizers are sometimes available in the markets but are usually of poor quality and very costly. Most farmers lack resources at planting time and have to pay high interest to borrow money for purchasing small amounts of fertilizer against the expected harvest.

The attitude of farmers towards weeds is rather tolerant, as many are also seen as serving a useful purpose. At a certain level, weeds in the wheat are considered to improve the quality of the straw as fodder. The presence of some wild rye is said to improve the quality of bread. Wild mustard is harvested separately by the women and processed for lamp and cooking oil. Some families consume plants of edible species weeded in the fields, such as *Chenopodium* spp.

Wheat is a staple food in all the communities of eastern Badakshan and is grown on both irrigated and rain-fed land. Altitude and snow cover tends to dictate whether wheat is sown as a spring or an autumn crop. Wakhan, Ishkashem, Zebak, and southern Sheghnan grow mostly spring wheat, while northern Sheghnan and Darwaz grow winter wheat.

Overall, wheat yields per hectare vary from 0.5 to 2.0 tons under irrigation and from 0.3 to 0.7 tons in rain-fed areas. The yields vary enormously with location, altitude, soil quality, the availability of farmyard manure (chemical fertilizer in the area is a rarity), susceptibility to fungal diseases such as rust and smut, pests such as locusts, weeds, and the genetic origin and purity of the seed planted.

Little or no introduction of improved varieties had taken place in eastern Badakshan prior to 1979. AfghanAid has recently established demonstration plots of improved varieties from the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) as part of an integrated development program in Badakhshan, including the districts of Ishkashem and Zebak. Almost all farmers grow a number landraces that are of local origin and of very mixed appearance, often heavily infested with weeds, particularly wild wheat, wild oats and mustard. *Sorkhak,* an indigenous red-grained wheat, is generally planted in the autumn, while safidak, an amber/light-grained wheat, is planted in the spring. A few farmers have part of their fields under seed from other districts, including from Pakistan and Tajikistan. Some of this is of improved origin but by now very mixed with other varieties and weeds.

In Darwaz, different types of wheat are cultivated with different lengths of straw, some with awns and some awnless. Winter-wheat types clearly owe their origin to Russian varieties and to the facultative varieties introduced elsewhere in the province under various United Nation and aid programs. Local cultivars are almost exclusively sown on rain-fed land.

Participatory seed-security strategy

Seed security (farmers' access to adequate, good-quality seed of the desired type at the right time) is the first defense for food security (the access by all people at all times to enough food to maintain an active and healthy life). This is especially true for war-torn Afghanistan in general and for neglected Badakhshan in particular. As recognized at the World Food Summit held in Rome (FAO 1996), poverty and impoverishment precondition people to a state of vulnerability—vulnerable to life-cycle hunger, vulnerable to seasonal hunger, and vulnerable to the impact of disaster. This also describes the state of food security today in eastern Badakshan.

The loss of access to seeds and food are often interconnected. While seeds are crucial to agricultural recovery, human energy is equally important. Seed relief is being viewed as an integral part of the emergency package. There are several examples from other parts of the world that show that the action taken to restore seed security quickly after disaster is an effective way to help restore food security in an area. During the 1991/92 drought in Southern Africa, an emergency seed-production project, jointly coordinated by the Southern African Development Community (SADC) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), was highly successful compared to the projects in which seed was imported. Their success was due to the distribution of better-quality adapted varieties. The Seeds of Hope initiative helped rebuild domestic food security through the rehabilitation of seed security following the civil war in Rwanda in 1994. Adapted varieties and landraces were assembled and multiplied in neighboring countries and reintroduced into Rwanda.

The seed program aims to ensure availability of the right kind of seed in the right place. Adapted varieties are obtained from similar agroclimatic conditions in Tajikistan and delivered across the Panj River to several distribution points. Transportation within Afghanistan is mostly by volunteers, by donkeys made available by the communities for this purpose. This helps to keep the costs of introducing the varieties to a minimum. The amounts being distributed have been minimized to enable the local seed-production and -distribution systems to continue functioning smoothly.

Early in spring of this year, seeds of high-yielding varieties of wheat, maize, other cereals, potatoes, and vegetables appropriate to the agroecological conditions of the area were introduced through

on-farm, farmer-managed observation sites in the target districts. All the villages in the Wakhan, Ishkashem, Zebak, Sheghnan, and Darwaz districts are participating. The farmers are selected through village committees, traditionally known as *shuras*. Attempts are being made to involve as many different farmers as possible by restricting the distribution of only one kind of crop commodity to each participating farmer.

Initially, for each kind of crop, varieties that are widely adapted and available in sufficient quantity are being introduced. This will be followed by varieties and landraces with superior traits such as higher yield, better adaptability, improved disease and pest resistance and stress tolerance, and more consumer acceptability. In future, different kinds of lentils, forages, fruit and timber trees, and herbs of medicinal value will also be introduced into the farming systems. It is expected that the introduction of useful germplasm will be repeated every growing season whenever new potential materials are available and the farmers—through their village committees—are in favor of it. Rather than replacing existing germplasm, the goal is to increase the range of germplasm available on-farm. This will contribute to enhancing on-farm genetic diversity among and within different crop species.

The emphasis is on farmer and community empowerment. Participating farmers and their neighbors will judge the usefulness of the materials being introduced and their subsequent multiplication and distribution. Farmer-to-farmer seed exchange forms the basis of the local seed system in the region. It is a part of the local culture that anyone with seed of improved varieties is obliged to share the seed produced at the first harvest with his extended family. Such acts of cooperation reinforce family ties with distant blood relatives. In some cases, extra amounts of seed will be distributed on credit if the demand for the varieties introduced cannot be met by the local seed systems. Credit systems in which farmers pay for the inputs at harvest are also being used for supplying fertilizers.

These activities will be gradually transformed into participatory breeding, allowing the community to gain full control over the type and amount of varieties being produced and exchanged with their neighbors. Participation in the management and decision making for seed security by the farming community will contribute to reestablishing local food security and peace in the area.

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Involving Farmers in the Development Process to Improve Adoption of Varieties Developed by National Maize-Breeding Programs

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Abstract

Developing maize varieties that will be readily adopted by subsistence farmers is challenging as there are numerous characteristics in addition to agronomic performance that are important to these farmers. Furthermore, these preferences vary from location to location. It may be logical to conclude that because of these location-specific requirements, maize breeding that targets subsistence farmers should be done at a localized level. National maize-improvement programs have an important role to play in developing improved maize genotypes for these farmers because they have access to a wide range of genetic materials that allows for the identification of genes for disease resistance and high yield that may not be available in local germplasm. Furthermore, they have the expertise required to incorporate these genes efficiently into genotypes that meet the farmers' other requirements. To increase the impact of genotypes developed by national maize-improvement programs, however, farmer input into their activities is essential. A balance between on-station breeding activities and interactions with farmers is needed in order for the process to be efficient. Therefore, the National Maize Research Program within Nepal's National Agricultural Council (NARC) has developed the following procedures for developing maize genotypes for subsistence farmers with their input. First, through on-farm surveys, the required grain (i.e., flint, dent, yellow, or white) and plant (i.e., tall, leafy, early, or late, etc.) types are determined. Second, exotic and locally developed genotypes are screened for the desired characteristics and general adaptation on-station using local varieties from the targeted environment as checks to ensure that maturity duration matches that already used by farmers. Promising materials are initially tested on-station for yield and disease resistance. Elite materials (approximately six to eight genotypes) are then tested in on-farm trials under farmers' conditions. Farmers who grow these materials observe their agronomic performance and provide input about which entries they prefer. Only those varieties that have proven to be high yielding and stable, and which have the characteristics preferred by farmers, will be released and made available on a more national scale. Maintenance of released genotypes and seed multiplication is a resource-intensive activity that must be limited to genotypes that are the most likely to have an impact. We believe that this varietal-development scheme will efficiently provide new and desirable options to small-scale subsistence maize farmers in Nepal.

Introduction

Maize is one of the three most important cereal crops in the world. Global annual maize production now exceeds 550 million tons. Of that, approximately 100 million tons are used directly for human food (CIMMYT 1999). Maize is growing in importance in Asia, primarily as a feed for animals. Nevertheless, there are significant areas of the region where maize is still the dominant cereal in the human diet. In Nepal, for example, of the 1.4 million tons produced annually, it is estimated that 86% is used directly as human food (CIMMYT 1999). The development of hybrids is one of the main reasons for the phenomenal advances in maize productivity throughout the world in the past few decades. In most developed countries, the area planted to hybrids approaches 100% of all land planted to corn. Growth in the use of hybrids has been impressive in areas of the developing world as well. For example, 60% and 46% of the area planted to maize is sown to hybrids in Thailand and

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Vietnam, respectively. Both within Asia and globally, there is a significant negative correlation between the percent utilization of maize for human food and the use of improved varieties (CIMMYT 1999). This can partially be explained by the fact that subsistence farmers have limited cash and are reluctant to pay the premium price associated with improved seeds, particularly hybrid seed, which must be purchased each year. Single-cross hybrid seed in Asia costs on average US $3.12 per kg, in comparison to US $0.69 per kg for open-pollinated varieties (OPVs) (Gerpacio 1999).

The development of OPVs for areas of the world where maize is grown as a subsistence crop makes good sense. Compared to hybrids, OPV seed is more readily produced, it can be made available to farmers at a lower cost, and it can be generated by farmers themselves. Nevertheless, in large areas of the world where maize is a subsistence food crop, a large percentage of the area is not planted to improved varieties (OPVs or hybrids) even though modern varieties with excellent adaptation are available from both the public and private sectors. The poor adoption of improved maize varieties can be attributed to many factors, primary among which may be the lack of viable seed enterprises. Other factors, such as the varieties' lacking the characteristics that are important to farmers, also constrain adoption. Farmers in Nepal for example, prefer their own varieties because they are earlier, have better husk cover and culinary characteristics than improved OPVs. In order to improve adoption of modern varieties, there is a need for greater farmer input into the development of genotypes that take these preferences into account. This paper discusses issues relative to developing and providing improved maize genotypes to farmers and describes a germplasm-improvement scheme adopted by the National Maize Research Program in Nepal to ensure that the products they develop are better targeted to the requirements of farmers.

Fixing favorable alleles—the numbers game

Maize is cross-pollinated under normal circumstances. Therefore, a crop or plot of a desired genotype must be carefully managed if the seed it produces is to be genetically pure. Furthermore, in relation to participatory approaches to plant breeding it means that seed of genotypes that are tested or demonstrated in farmers' fields in a typical small plot are likely to be contaminated or genetically altered through the inflow of foreign pollen. Saved seed will, therefore, not produce a phenotype identical to that observed the previous season. In a varietal-improvement program, be it through informal farmer selection or through a formally organized plant-breeding program, success is determined by the ability of the breeder to find desirable characteristics and fix them in the population so that they can be expressed in subsequent generations. For traits that do not exist or that have little expression in an otherwise desirable population, conventional breeding programs have a substantial competitive advantage over farmer-led approaches. In order to find favorable alleles for stress tolerance, for example, many thousands of lines and populations might need to be screened in order to identify a few genotypes with the desired characteristics. Similarly, for alleles that are found in a very low frequency in a population, breeding techniques that include selfing and extensive testing with recombination of best lines can be used to increase their expression relatively quickly.

Developing OPVs through conventional methods requires both time and land resources. As an example, the following steps are required to develop a superior experimental variety using full-sibs developed from an improved population (which itself may have been improved through many cycles of selection). First, 250 full-sib progenies are generated by hand-pollination. These are tested in up to six locations, including sites where a stress of interest is present. Next, eight to 10

superior families are selected and recombined using remnant seed. The progeny of these crosses are then allowed to intermate for one further cycle. The favorable alleles in these EVTs are now more or less fixed and these varieties are ready for testing.

In order to maintain these materials (produce breeder seed), at least 1500 plants need to be grown if they are hand-pollinated (bulked pollen). Foundation and certified seed can be produced from this breeder seed. Using these procedures, the greater the number of materials tested and the lower the experimental error of the experiments, the greater the likelihood that superior materials can be identified. Seed production requires isolation, and minimum standards of isolation are set for different classes of seed. As mentioned, this process is expensive and requires substantial areas of uniform land to ensure adequate testing. Nevertheless, it is very effective in identifying and fixing favorable alleles for the traits of interest. It is very effective in identifying resistance or tolerance to stresses that are prevalent in the testing environments and in developing materials with high yield potential. High yield potential and stress tolerance in OPVs, however, does not mean that they will be acceptable to farmers or will be adopted by them.

Adding farmer participation to the conventional breeding program

The rates of adoption of improved genotypes developed through the conventional methods described above have not been high in many areas of the world. Including traits that farmers prefer in OPVs may help improve rates of adoption in some of these regions. We propose that (1) input in the beginning of the development process, (2) coupled with more intensive on-farm testing of the materials that are developed, are two ways to improve the rates of adoption of newly developed genotypes that farmers desire. Moreover, we believe that identifying and fixing farmer-desired traits is most effectively carried out through conventional, tried-and-tested breeding methods, like those briefly referred to above.

Input at the beginning of the development process

Before a breeding program begins, the target environment and the basic requirements of the farmers in that particular environment must be clearly understood. In Nepal, the National Maize Research Program is currently developing materials that target the mid-hills, the high hills, the *terai*, and areas in both the *terai* and valley bottoms that require early-maturing varieties. Generally speaking, the biotic stresses differ significantly between the various agroecologies—enough that material developed for one ecology will not do well in another, and vice versa. Some extremely important farmer characteristics that must be ascertained at the beginning stages are length of growing period and grain type. This input can be obtained through farmer interviews (rapid rural appraisals [RRAs] and more formal surveys) and by soliciting farmers' reactions to on-going trials either on-farm or on-station. In Nepal, using an RRA approach, we found that farmers in different areas of the country preferred different characteristics (table 1). Furthermore, by having farmers view trials, they provided valuable feedback on the length of maturity they desired.

Farmer feedback during testing

After the on-station work of identifying and the fixing favorable alleles has been concluded, the experimental varieties need to be tested widely. Multilocational testing, usually on-station where experimental error can be controlled, allows researchers to identify high-yielding genotypes that are stable and adapted across environments (including having resistance to the prevalent diseases).

Table 1. Grain Characteristics Desired by Farmers in Maize Varieties in Various Regions of Nepal, Based on Results of Rapid Rural Appraisals Conducted by the National Maize Research Program, October 1999

Region	Grain type	Reason for preference
Eastern	White flint	Good storage, high grit yield
Central	Yellow flint	Good storage, taste, grit yield
Far western	White dent	High flour yield—used in *rotis*
Terai	Yellow dent or flint	Used for animal feed

Farmer input into the selection of experimental varieties can be obtained by allowing them to visit trials being conducted on-station. Generally, however, on-station yield trials contain a relatively large number of entries. Furthermore, a single visit to the research station would not allow farmers to select entries for grain type, unless farmers visited trials at the time of harvest. In the Hill Maize Research Project, the top four to six entries of the coordinated varietal trial are tested further on-farm, in what is termed a farmer field trial (FFT). These trials are conducted as widely as resources allow, and in addition to yield, feedback from farmers on varieties that they prefer is obtained and used in determining which varieties are released. This process allows farmers to evaluate fewer materials, and since plots are larger, a good evaluation of seed characteristics can be obtained.

A novel approach to allow farmers' input at an earlier stage of testing is being used by Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) in southern Africa (CIMMYT 2000:12–14). It is called the mother-daughter testing scheme. Within a given agroecology, a complete set of experimental varieties is tested on an experiment station, on a substation, or on-farm (with researcher management). The complete set can contain as many entries as desired by the breeder. These are grown in a lattice design with replications. The complete set is referred to as the "mother." In farms in the area represented by the mother trials, four to six entries that represent a block within a rep of the lattice are grown. These smaller on-farm trials are referred to as "daughters" and these daughter trials may be managed by nongovernmental organizations (NGOs), extension programs, community-based organizations, or farmers themselves.

Yield and farmer preferences are obtained from each of these on-farm trials. The results from all of these daughter trials can be combined and statistically analyzed as components of the complete trial. Although each farmer only sees a subset of the complete mother trial on his or her own farm, with sufficient replication, this approach should allow researchers to obtain yield data that can be analyzed statistically, as well as information from the farmers as to which materials are preferred. The approach allows for more effective farmer input at an earlier stage of testing. With the assistance of extension officers and NGOs, nearly 300 on-farm daughter trials were conducted in 1999/2000 in Zimbabwe.

A note on seed production and maintenance

Developing improved varieties is only part of the process of getting them into production in farmers' fields. Distinct from the cases of rice and wheat, seed production in maize is more complicated. Plots must be isolated to eliminate genetic contamination from foreign pollen. Furthermore, the

number of plants grown must be sufficiently large to ensure that the genetic variability of the population is well represented and inbreeding effects are reduced. Seed enterprises rely on a good source of foundation seed, which is usually produced from breeder seed maintained by the organization that develops the genotype. A lack of resources universally limits the number of varieties that can be maintained by public institutions. Due to the lack of involvement of the public and private sectors in seed production (certified seed) within Nepal, the Hill Maize Research Project supports seed production at the community level. This should allow quality seed of improved varieties to be available to farmers at a reasonable cost, even in relatively inaccessible areas.

Furthermore, farmers who use improved seed and retain their own seed for subsequent plantings must be trained in how to select seed if they are to continue to benefit from the "fixed favorable alleles" in the improved varieties. This training should emphasize that seed should be from plants in the field and not cobs in the store, that it should be selected from the center of their larger fields so as to avoid contamination from pollen from adjacent fields, and that it should be dried well and stored in such a way that it is protected from insect pests and will maintain a high level of germination.

Conclusion—the strategy of the Hill Maize Project

Based on the need to have greater input from farmers in the variety-development process and the efficiencies in finding and fixing favorable alleles inherent in station-based breeding programs, the following breeding strategy has been adopted by the Hill Maize Project for the development of OPVs for the hill areas of Nepal.

1. Based on information from RRAs and other survey instruments and feedback obtained from farmers from on-farm and on-station trials, breeding activities will focus on incorporating traits desired by farmers (i.e., grain texture and color, maturity length, plant stature, etc.) into new varieties.
2. Exotic and locally generated germplasm will be evaluated to determine source populations with which to work.
3. Tried-and-tested breeding procedures will be used to identify desirable traits and fix them into experimental varieties.
4. Promising genotypes will be identified through multilocational on-station testing.
5. Elite material will be evaluated in farmers' fields for both agronomic performance and farmers' preferences in either FFTs or mother-daughter trials.
6. Only varieties that are desired by farmers will be released.
7. Community-based seed production will be used as one mechanism for making seeds available to farmers at a reasonable price.
8. Farmers will be trained in techniques that can be used to ensure the maintenance of genetically pure seed.

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Participatory Plant Breeding and Property Rights

Project of SWP PRGA

Abstract

Participatory plant-breeding (PPB) efforts have proliferated within the last 10 years; however, other key aspects have yet to be explored. As in many other fields, the property rights and ethical issues of participatory plant breeding are lagging far behind technical advances. The urgency to define property-rights issues for PPB arises at an opportune time. This paper introduces incipient work (including development of a state-of-the-art paper) on property rights (i.e., legal issues, best-practice options to guide field programs, and ethical concerns in PPB work) and participatory plant breeding. Steps for development of the state-of-the-art paper and the types and issues to be covered are listed.

Introduction

Participatory plant-breeding (PPB) efforts have proliferated within the last 10 years, with some 65 examples identified worldwide (McGuire, Manicad, and Sperling 1999; Weltzien/Smith, Meltzner, and Sperling 2000). A range of international agricultural research centers (IARCs), national agricultural research systems (NARS), nongovernmental organizations (NGOs), and universities are experimenting with varied approaches (about 50 institutions belong to the plant-breeding group of the Systemwide Program on Participatory Research and Gender Analysis [SWP PRGA] alone), with the research paradigm increasingly being framed as a mainstream or strategic activity. Yet while work is mushrooming on certain aspects of PPB—for example, development of farmer-friendly breeding schema, analysis of possible cost efficiency, and testing of models to promote varietal diversity (SWP PRGA 1996)—other key aspects have yet to be explored. As in many other fields, the property rights and ethical issues of participatory plant breeding are lagging far behind technical advances. This is serious for an approach that pivots around the tenets of "trust" and "collaboration" among different groups—most often among poor farming communities and formal-system researchers.

Joint collaboration should mean joint benefit sharing. At this point, there are no ready-made arrangements or "best practices" to suggest for the processes and materials that emerge from PPB collaborations. Most of the PPB work to date has simply skirted the issues of property rights with two very diverse strategies: materials jointly developed by formal breeding and farming communities have been fed into the formal system for variety release and seed multiplication (completely ignoring farmers' input), or the PPB-developed materials have been "released," "let go" into farming communities—with no official launch of any kind. This has had a positive impact among farmers with mostly self-pollinated crops where issues of seed increase and quality are relatively easy for farmers to manage at their own level.

The urgency to define property-rights issues for PPB arises at an opportune time. The debate over farmers' rights seems stalled in many quarters on political, legal, and practical levels. Further, The legislation on plant breeders' rights makes varied assumptions about how much formal breeders control the process (to the exclusion of farmers)—assumptions that have rarely been placed under closer scrutiny. Exploration of property rights, and related issues within the field of participatory

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