Listening to Farmers' Perceptions through Participatory Rice Varietal Selection: A Case Study in Villages in Eastern Uttar Pradesh, India

Thelma R. Paris, Abha Singh, Joyce Luis with Hari Nath Singh, Omkar Nath Singh, Sanjay Singh, Ram Kathin Singh, and Surapong Sarkarung

Abstract

This paper presents a case study based on the findings in two villages in eastern Uttar Pradesh, India, part of a project started in 1997 to develop, test, and refine methodologies of participatory research and gender analysis as they apply to the development of new technologies in germplasm and natural resource management. The two villages occupy different agroecological areas and also differ in sociocultural characteristics. Both male and female farmers were included in the study, and details of their preferences for the rice varieties studied are presented in this paper.

Introduction

Decisions about the adoption of technology are conditional to farmers' perceptions of the performance of a new technology relative to that of the technology currently being practiced. Farmers may assess a new technology, such as an improved variety, in terms of a range of attributes, such as grain quality, straw yield, and input requirements, in addition to grain yield (Traxler and Byerlee 1993). In Orissa, eastern India, farmers indicated preference not only for the visual appearance of rice grain, but also for attributes such as cooking quality, taste, keeping quality, and straw quality (Kshirsagar, Pandey, and Bellon 1997). If farmers perceive an improved variety to be inferior to traditional varieties in terms of one or more attributes, they are unlikely to adopt such a variety (Adesina and Zinnah 1993, as cited by Kshirsagar, Pandey, and Bellon 1997). Crop improvement could potentially benefit from farmers' assessments of the relative performance of different varieties under farmer management. Information on the traits desired by farmers and their knowledge of the production system could be invaluable in setting the goals of a breeding program, delineating the target environment, identifying the parents for breeding and defining the management treatment for breeding work (Sperling et al. 1996; Eyzaguirre and Iwanaga 1996).

Varietal preferences may differ, not only between socioeconomic groups but also by gender. In a farmer-participatory breeding (FPB) project on pearl millet in the Jodhpur district, Rajasthan, India, grain yield, early availability of grain, and the ease of harvesting by hand (lower panicle number and lower plant height) were the main considerations for making selections by women. For the men, yield and quality appeared to be a stronger concern (Weltzien, Whitaker, and Anders 1996). While women have traditionally been seed selectors and managers of germplasm in low-input farming systems, scientists have not given enough attention to their local knowledge, criteria for selection, and perceptions regarding new seeds until recently. For instance, the criteria for selecting seeds, practices of animal care and food processing, and the consequent preferences for different kinds of blending various food materials are useful starting points for building on women's

Thelma R. Paris and Joyce Luis are with the Social Sciences Division and Surapong Sarkarung is in Plant Breeding, Genetics & Biochemistry at the International Rice Research Institute (IRRI), Los Baños, Philippines. Abha Singh, Hari Nath Singh, Omkar Nath Singh, and Sanjay Singh are with Narendra Deva University and Agricultural Technology (NDUAT), Kumarganj, Faizabad, eastern Uttar Pradesh, India. Ram Kathin Singh is at IRRI's New Delhi Office.

perspectives in participatory research (Gupta et al. 1996). Another example is when high labor demands for manual threshing may create incentives for women to adopt varieties that are easier to thresh (Adesina and Forson 1995). Including women in the early evaluation of varieties ensures that new seeds can be adopted rapidly. Thus, men's and women's criteria and preferences for rice varieties should be well understood and considered in plant-breeding strategies.

In March 1997, a farmer-participatory plant-breeding program for rainfed rice was developed at the International Rice Research Institute (IRRI) in collaboration with the Indian Council of Agricultural Research (ICAR). This project includes six research sites representing different rice ecosystems in eastern India. The project is under the umbrella of the CGIAR's Systemwide Initiative on Participatory Research and Gender Analysis. The goal of this initiative is to develop, test, and refine methodologies of participatory research and gender analysis as they apply to the development of new technologies in germplasm and natural resource management. This FPB project aims to test the hypothesis that farmer participation in rainfed rice breeding can help develop suitable varieties more efficiently. It is also designed to identify the stages in a breeding program where farmer interfacing is optimal. The project has two components: the first is a plant-breeding component, which aims to develop and evaluate a methodology for participatory improvement of rice for heterogeneous environments, and to produce and improve adoption of material suiting farmers' needs. The second is a social-science component (including gender analysis) that aims (1) to characterize cropping systems, diversity of varieties grown, and the crop-management practices of rice farmers, (2) to analyze male and female farmers' selection criteria and their reactions to a range of cultivars and breeding lines, and (3) to enhance the capacities of national agricultural research systems (NARS) in participatory research and gender analysis in plant breeding and rice varietal selection (Courtois et al. 2000). This paper focuses on farmers' selection criteria and their reactions to a range of cultivars and breeding lines under participatory varietal selection conducted on farmers' fields.

Characteristics of the villages

The results of the socioeconomic and gender analysis in the FPB project includes only two villages (table 1): Mungeshpur in the Faizabad district and Basalatpur in the Siddathnagar district, eastern Uttar Pradesh. These sites are among the research sites under the FPB project. A similar study was conducted in the other FPB research sites in Orissa and Madhya Pradesh.

Basalatpur represents favorable (but submergence prone) lowland, rainfed areas. Mungeshpur represents shallow, submergence-prone areas that are favorably rainfed during years of low rainfall. Basalatpur and Mungeshpur have a higher proportion of lowland fields (70% and 60%, respectively) with heavier soil and good water-holding capacity. The flow of natural resources like rainwater (field hydrological conditions) throughout the season has also had a major impact on varietal selection in these villages. Farmers in Mungeshpur have more access to supplementary irrigation, which enables them to diversify into other crops, particularly vegetables and fodder crops. Only one diesel pump exists in Basalatpur and this limits crop diversification. The importance of livestock between the two villages also differs. Livestock in Mungeshpur is more important than in Basalatpur. In Mungeshpur, bullocks continue to be used for land preparation, and threshing is done manually. In contrast, land preparation and threshing in Basalatpur is mechanized with the use of tractors. The degree of market orientation is higher in Basalatpur (nearer the city) where more rice is sold.

Table 1. Village Characteristics, Basalatpur (Siddathnagar District) and Mungeshpur (Faizabad District), India, 1997

Agroecology	Basalatpur, Siddathnagar	Mungeshpur, Faizabad
	Favorable lowland	Shallow, submergence-prone, favorable rainfed during years of low rainfall
Total no. of households	140	133
Sample size for surveys	50	50
No. of male farmers	30	30
No. of female farmers	20	20
Land types (%)		
Lowland	70%	60%
Medium land	0	20%
Upland	30%	20%
Irrigation source (private pump)	1%	10%
Importance of livestock	Low	High
Degree of market orientation	High	Low

The socioeconomic characteristics of the sample households are shown in table 2. Households are classified by official social categories of caste. Muslims dominate in Basalatpur (55%), followed by scheduled and backward castes. In Mungeshpur, the backward and scheduled castes dominate (89%). The Yadavs, a subcaste of the backward caste in Mungeshpur, take care of milch animals. The majority of the farming households are owner-cultivators, and share cropping is of limited importance. Female labor participation in rice production is four times higher than that of males in Basalatpur and three-fourths in Mungesphur. There is wide disparity in terms of access to education between men and women. In general, females have lower literacy rates than men. The differences in resource endowments, socioeconomic status, importance of livestock, degree of market orientation, gender roles and responsibilities in rice production, and family size may determine the choice of rice varieties/cultivars and agronomic management practices.

Cropping systems

Rice followed by wheat + mustard is the predominant cropping pattern in all villages. In Basalatpur, wheat and oilseed are grown mainly for domestic use, but rice is grown for consumption as well as marketing. On the other hand, in Mungeshpur, rice is mainly grown for consumption because of low yields and low marketable surplus. Rice is followed by wheat + mustard, which are grown for both domestic consumption and sale. Land preparation for rice is started in June after the arrival of the monsoon. Transplanting and broadcasting are done in July; weeding, in August; and harvesting and threshing, in October to December. During the *rabi* (dry) season from November to April, crops such as wheat + mustard, peas, grams, lentils, *berseem* as green fodder, and vegetables are grown. A few farmers, who have their own irrigation sources, grow crops like mung, maize, vegetables, and green fodder during the *zaid* season (late April to June) in Mungeshpur. Growing crops during the *rabi* and *zaid* seasons is not common in Basalatpur because of the lack of irrigation facilities.

Table 2. Socioeconomic Characteristics of Sample Households, 1997

Characteristics	Basalatpur, Siddathnagar	Mungeshpur, Faizabad
Caste composition (% of households)		
Upper caste	6%	9%
Backward caste	18%	49%
Scheduled caste	21%	42%
Minority	55%	0
Area by tenure (% of households))		
Share-in	3%	0
Share-out	0	1%
Owner-cultivated	97%	99%
Labor inputs in rice (days/ha)		
Male farmers	25 days/ha (19)	45 days/ha (25)
Female farmers	105 days/ha (81)	130 days/ha (75)
Categories of farmers (%)		
Marginal (<1 ha)	68%	80%
Small (1–2 ha)	24%	16%
Large (>2 ha)	8%	4%
Ave. operational size	1.00 ha	0.70 ha
Literacy rates (%)		
Male head	72%	51%
Female head	40%	14%
Average family size	7	7

Note: Figures in parentheses are percentages of total male and female labor inputs in rice production.

The gender division of labor in rice production

The majority of the respondents belong to the lower social class, with small-sized landholdings. Females are younger and have lower literacy rates, compared to males, and have over 20 years of farming experience. The extent of female participation in rice production is high in both villages. Some tasks in rice production and postharvest operations are gender specific. Land preparation and the application of chemicals are men's responsibilities in both villages (10% of fertilizer application is done by women in Basalatpur). In Mungeshpur, women from the lower social status dominate in the work of pulling seedlings (100%), transplanting (70%), weeding (80%), applying farmyard manure (60%), harvesting (82%), and threshing (82%). In Basalatpur, more men than women participate in pulling seedlings and harvesting. Women do the transplanting of seedlings (100%) and most of the weeding (75%), with men doing most of the spraying (90%). Women are also mainly responsible for postharvest activities such as cleaning and selecting the seeds for the next season, storage, and processing rice into other food products for home consumption and for sale. They are the primary end-users of rice byproducts and biomass for livestock and other farm use. A village study in eastern India revealed that women from the lower castes provided 60% to 80% of the total labor input in rice production (Paris et al. 1996). Aside from their significant contributions in rice production, women also provide labor in non-rice crops, collect green animal

fodder, and feed and tend livestock. Thus, men's and women's preferences for specific traits in rice varieties may differ, based on gender-specific roles and responsibilities. With increasing male migration to cities, women are taking on more responsibilities as farm managers, aside from their normal household and childcare responsibilities (Paris et al. 1996).

Rice varieties

Varieties grown by farmers

The rice varieties currently grown by farmers are shown in table 3. Traditional varieties are more common in Basalatpur than in Mungeshpur. Although modern varieties (MVs) show higher adoption rates in Mungeshpur, these varieties often suffer from submergence, drought, and stress at reproductive and ripening phases when the crop is planted late. Most farmers felt that traditional varieties are more tolerant to drought, submergence, pests, and diseases, while MVs performed well under irrigated conditions. The majority of the farmers indicated that they felt that MVs needed better management than traditional varieties. Modern varieties need more labor, higher levels of fertilizer, and more irrigation, but more farmers prefer to grow MVs because of their higher yields.

Table 3. Popular Rice Varieties Grown by Farmers According to Land Type

Land type	Variety	Basalatpur	Mungeshpur
Upland/midland	Traditional	Bengalia, Sarya, Kuwari Mashuri, Oriswa, Malwa	Ari, Bagri, Balbagra, Chaini
	Improved	NDR-97, Sarju-52, PNR-381	Saket-4, NDR-80, 97, 118 NDR-359, Pant-4, Pant-10, Pant-12, Sarju-52
Shallow lowland/lowland	Traditional	Kalamanak, Motibaddam, Malwa, Malasia	Bilaspuri, Indrasan
	Improved	Mashuri, Rajshree, Sambha Mashuri	Mashuri, Madhu, BKP-246, Dwarf Mashuri

Topographical adaptations

Farmers generally match varieties with their environment. For rainfed rice, this means an adaptation to the hydrological conditions of their fields. Each field position in the topo-sequence corresponds to a risk of drought or submergence. The drought risk increases from the bottom to the top of the topo-sequence, while submergence risk decreases along the same path, associated with progressively lower water depths and earlier recession of the water. This translates into different ideotypes for the different situations. Table 4 shows varietal diversity according to land type/topography. In Basalatpur, varieties such as *Bengalia, Sarya, Oriswa, Kuwari Mashuri, Malwa,* and *Ghanbhanan* are the major traditional rice cultivars grown in the uplands, and *Kalamanak, Malasia, Motibaddam,* and *Malwa* are the major varieties grown in the lowlands. Improved varieties, such as NDR-97, PNR-381, and Sarju 52 are grown in the uplands by a few farmers, but the improved variety, Mashuri, occupied more area in the lowlands. In Mungeshpur, the common local varieties grown on upland fields are *Ari, Bagri,* 90 days, *Sonia, Lalmati, Punjab, Lalbagra, Ashwani, Indrasan,* and *Bilaspuri*. The improved varieties are Saket-4, NDR-80, and NDR-118 in upland and medium fields and Sarju 52, Mashuri, and dwarf Mashuri mostly in lowland fields.

Table 4. Farmers' Perceptions of Useful Traits in Selecting Rice Varieties According to Land Type

	Mungeshpur							
	Upland		Lowland		Upland		Lowland	
Traits	Male	Female	Male	Female	Male	Female	Male	Female
Grain yield	36.67	39.50	48.67	49.67	41.67	35.96	42.06	40.45
Duration	25.83	34.50	0.67	1.00	20.56	25.84	20.56	15.00
Grain price	0.00	0.00	15.67	16.00	1.67	2.81	2.97	1.82
Resistance to abiotic stress	8.33	6.70	0.67	0.33	6.10	6.18	5.10	5.00
Biomass quality	3.33	2.50	5.33	4.67	5.00	2.25	5.52	8.64
Taste	1.67	0.50	10.33	12.33	2.78	2.81	2.12	3.18
Bold and pure grain	7.67	1.50	1.67	0.00	4.44	4.49	3.40	5.00
Adaptation to specific soil type	3.33	3.00	2.33	0.67	5.00	4.49	5.52	6.36
Postharvest quality	0.83	3.00	6.67	7.67	0.00	5.06	0.00	2.27
Resistance to biotic stress	4.17	2.50	1.00	1.33	3.89	1.69	4.25	3.18
Cooking characteristics	0.83	1.00	1.67	2.00	3.89	3.92	3.40	5.00
Response to fertilizer	2.50	1.00	2.67	1.33	5.00	2.25	4.25	1.82
Competitiveness with weeds	0.00	0.00	0.00	2.33	0.00	2.25	0.00	2.27
Resistance to lodging	1.67	0.00	2.65	0.67	0.00	0.00	0.85	0.00
Adaptation to several preparations	2.34	4.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Traits are listed in order of importance. Grain yield includes tillering, panicle length, and number of grains. Resistance to biotic stress includes resistance to pests and blast. Resistance to abiotic stress includes resistance to zinc deficiency and drought. Biomass quality includes height and quality and quantity of straw. Postharvest quality includes ease of hulling and milling recovery. Cooking characteristics include cooking time, elongation ability, aspect after cooking, and impression in the stomach.

Medium-duration fields are grown mostly in medium land. Varieties such as Sarju-52, Ashwani, NDR-359, Pant-4, -10, and -12, and Indrasan are grown on the fields that are located in between upper and lower levels of land type. Farmers of Mungeshpur prefer to grow these varieties on the these land types on the belief that they need optimum moisture during the growth period. Fields differ in agrohydrological characteristics in Basalatpur; therefore, some farmers prefer to grow medium varieties on upland fields also.

Farmers' perceptions of useful traits in varietal adoption

To determine whether there are gender differences in perceptions of useful traits in varietal adoption, we used graphic illustrations of traits. We first showed cards that illustrate useful traits in selecting rice varieties. We then asked each farmer what traits he or she consider in selecting rice varieties for specific land types—upland and lowland fields. To assess how farmers valued each trait, we asked the question, "If you had 100 *paisa*, how much would you pay for each trait? The value in *paisa* allocated to a particular trait corresponded to the importance given by the farmer. Because many traits are interrelated, we reclassified them in consultation with a plant breeder. For example, we grouped traits such as ease in hulling and milling recovery under postharvest quality. Table 2 shows the selection criteria of male and female farmers for different land types and villages.

Favorable rainfed lowlands (Basalatpur, Siddathnagar district)

In the lowland areas in Basalatpur, yield and duration are the most important traits male and female farmers consider in selection rice varieties.

In this village, the popular traditional varieties are *Bengalia, Oriswa,* and *Kuwari mashuri.* These are short-duration (90–110 days), medium-height varieties. The average yields are 2.5 tons per hectare. Farmers prefer short-duration rice varieties in the uplands because of the importance of growing early winter crops such as oilseed, linseed, pulses, peas, and potatoes. They prefer to parboil *Bengalia*; otherwise, its grains break easily. Women in Basalatpur use traditional rice varieties for making puffed rice and *churra*, beaten rice like cornflakes.. For women who continue to use the traditional method of hand-pounding rice, postharvest qualities such as ease of hulling and high milling recovery are additional useful traits. The men did not mention these. The finding that women are more concerned than men with postharvest traits and milling recovery are similar to the findings in a participatory breeding project in the high altitudes in Nepal. Sthapit, Joshi, and Witcombe (1996) also observed that women farmers are particularly skillful in assessing postharvest traits, such as milling recovery, and the cooking and eating quality of rice. They found that the evaluation scores between male and female farmers in Chhomrong village showed significant agreement. Women farmers reported that they would like to decide on variety selection after the postharvest evaluation. Consumers preferred white-grained rice to red-pericarped rice because it saves women time in milling.

In Basalatpur, both male and female farmers agreed upon the important traits for lowland rice varieties. Grain price is an important consideration for farmers here because they sell traditional varieties in the market. These, like *Kalamanak*, command a higher price because of their good taste and aroma. *Kalamanak* gives low yields of 1.5 to 2 tons per hectare. In contrast, grain price is not an important consideration in Mungeshpur because rice is mainly used for home consumption and is seldom sold in the market.

Shallow, submergence-prone uplands (Mungeshpur, Faizabad district)

In Mungeshpur, both male and female farmers agreed upon important traits in selecting varieties for the uplands. Women gave more importance to postharvest qualities and grain quality such as bold and pure grains. For the lowlands, both males and females cited better grain yield, medium duration (125-135 days), biomass, and resistance to abiotic stress as their selection criteria for lowland rice varieties. Women gave greater weight to better adaptation to specific soil types and to grain quality. Women mentioned additional useful traits for varieties in the uplands and lowlands that were not mentioned by men: competitiveness with weeds and postharvest quality. Weeds are the major problem in the uplands, particularly when rice is direct-seeded. In the lowlands, weeds are more prevalent during drought. These additional traits are related to the roles and responsibilities of female family members (e.g., hand weeding and feeding rice straw to livestock).

Farmers' evaluation of new rice genotypes grown in farmers' fields

During the 1999 monsoon season, two farmers from each of the villages of Mungeshpur and Sariyawan (rainfed neighboring village) of the Faizabad district and from Basalatpur were selected to check the performance of rice genotypes in their fields. The genotypes were (1) advanced lines from a shuttle breeding project from Uttar Pradesh, (2) released varieties, and (3) the most common local varieties. Of the 14 genotypes screened in Basalatpur, two are scented varieties (*Kamini,*

which flowers in 136 days, and *Sugandha*, which flowers in 124 days). Scientists distributed the seeds through the FPB project. In this approach, breeders select the most promising lines with farmers, and farmers are given a "basket of choices," growing several genotypes in their specific environments.

Ten farmers (five women and five men) visited the individual plots and ranked the rice genotypes grown on farmers' fields past the maturity stage. Farmers were asked to rank the rice lines from 1 (excellent) to 14 or 16 (worst) on the basis of visual assessment. The rankings of the new cultivars by the farmers generated an n x k matrix, where n equals the lines being evaluated and k equals the farmers evaluating the crop performance. Kendall's Coefficient of Concordance (W) was used to measure the agreement in rankings among male farmers and among female farmers, and the correlation between male and female farmers' rankings. High and significant correlation values indicate close agreement on the ranking of the rice genotypes by men and women in the sample.

Tables 5a to 5d show that in the two villages, male and female evaluators were in close agreement in the ranking of the lines. The *W*s were highly significant, revealing that farmers' and breeders' rankings are often acceptable. Table 6 shows the summary of the ranking of male farmers, female farmers, and plant breeders indicating their choices. Of the 14 and 16 varieties ranked in Basalatpur and Mungeshpur, PVS 1, PVS3, PVS7, PVS9, PVS10, and PVS15 came out as the farmers' and breeders' choices in 1999. The traits of these lines are shown on table 7. During the crop season in 2000, several of these lines were compared with local check through PVS. Twenty-three farmers in two villages in Faizabad grew three rice lines, while 50 farmers in six villages in Siddathnagar grew six rice lines obtained from PVS trials.

Table 5a. Summary Ranking of Rice Genotypes in Basalatpur, Siddathnagar District, 1999

Field 1		Males(5)		Females(5)		Breeders (3)	
No.	Lines	Ave. Score	Rank	Ave. score	Rank	Ave. score	Rank
PVS1	**NDR-40032**	**2.4**	**3**	**2.6**	**2**	**3.0**	**2**
PVS2	**Kamini**	**8.4**	**8**	**8.8**	**6**	**11.3**	**12**
PVS3	**NDR-9730004**	**5.8**	**5**	**7.0**	**5**	**4.0**	**3**
PVS4	Bindili	6.4	6	8.8	6	10.3	11
PVS5	NDR-9830103	10.6	10	13.2	11	9.3	10
PVS6	Sugandha	10.8	10	7.0	5	12.0	13
PVS7	**NDR-96005**	**6.8**	**7**	**7.6**	**7**	**6.3**	**5**
PVS8	4113	14.0	11	12.4	10	14.0	14
PVS9	**NDR-9730015**	**3.0**	**2**	**1.8**	**1**	**5.3**	**4**
PVS10	**NDR-9730020**	**2.0**	**1**	**4.0**	**3**	**2.0**	**1**
PVS11	**Malasia**	**9.6**	**9**	**5.2**	**4**	**8.7**	**9**
PVS12	RAU-1308-10-11-3-1-2-4-3	8.6	11	7.4	5	6.7	6
PVS13	CN-1035-61	4.8	4	10.0	9	8.0	8
PVS14	RAU-1411-10	10.4	10	9.2	8	7.0	7
		w=.73**		w=.63**		w=.70**	

**Significant at 0.5 and .10 per cent level.

Table 5b. Summary Ranking of Rice Genotypes in Basalatpur, Siddathnagar District, 1999

Field 2		Males (5)		Females (5)		Breeders (3)	
No.	Lines	Ave. score	Rank	Ave. score	Rank	Ave. score	Rank
PVS1	**NDR-40032**	**2.2**	**2**	**3.8**	**3**	**3.3**	**4**
PVS2	**Kamini**	**7.2**	**6**	**7.8**	**7**	**10.7**	**10**
PVS3	**NDR-9730004**	**8.2**	**7**	**5.4**	**5**	**2.7**	**2**
PVS4	Bindili	5.6	4	2.6	2	11.7	11
PVS5	NDR-9830103	8.0	7	9.2	8	9.7	9
PVS6	Sugandha	6.4	5	6.2	5	9.3	8
PVS7	**NDR-96005**	**4.6**	**3**	**6.4**	**5**	**5.3**	**5**
PVS8	4113	11.0	9	12.2	10	13.3	12
PVS9	NDR-9730015	1.8	1	1.8	1	1.3	1
PVS10	**NDR-9730020**	**2.4**	**2**	**5.0**	**4**	**3.0**	**3**
PVS11	**Malasia**	**12.6**	**10**	**7.2**	**6**	**9.3**	**8**
PVS12	RAU-1308-10-11-3-1-2-4-3	13.6	11	12.2	10	7.7	7
PVS13	CN-1035-61	8.6	8	12.2	10	6.0	6
PVS14	RAU-1411-10	12.8	10	11.0	9	11.7	11
		w=.90**		w=.72**		w=31**	

**Significant at 0.5 and .10 percent level.

Table 5c. Summary Ranking of Rice Genotypes in Mungeshpur, Faizabad District, 1999

Field 1		Males (5)		Females (5)		Breeders (3)	
No.	Lines	Ave scores	Rank	Ave scores	Rank	Ave scores	Rank
PVS1	NDR-40032	3.2	3	2.6	2	1.7	1
PVS2	Kamini	15.8	16	15.2	14	15.3	16
PVS3	**NDR-9730004**	**6.6**	**6**	**6.0**	**4**	**3.0**	**2**
PVS4	NDR-9730003	10.4	13	7.2	7	3.7	3
PVS5	RAU-1308-9-3-1-10-3-4-3	8.4	8	9.0	8	13.0	13
PVS6	PSRM-1-16-48-1	13.8	15	14.8	13	14.0	13
PVS7	**NDR-9830102**	**2.9**	**1**	**1.8**	**1**	**5.7**	**5**
PVS8	NDR-9730002	9.2	10	12.6	10	7.0	8
PVS9	**NDR-9730015**	**8.0**	**7**	**6.6**	**5**	**5.0**	**4**
PVS10	**NDR-9730020**	**5.4**	**4**	**7.0**	**6**	**6.0**	**6**
PVS11	**Mashuri**	**6.6**	**5**	**10.6**	**9**	**9.7**	**10**
PVS12	RAU-1308-10-11-3-1-4-3	10.2	11	13.0	11	12.0	12
PVS13	NDR-96012	9.0	9	8.8	8	8.0	9
PVS14	RAU-1411-10	10.4	12	6.0	4	10.0	11
PVS15	NDR-9830103	3.0	2	3.4	3	6.7	7
PVS16	RAU-1400-13-200-4-6	14.0	14	13.2	12	13.3	140
			w=71**		w=.81**		w=0.79**

**Significant at 0.5 and .10 per cent level.

Table 5d. Summary Ranking of Rice Genotypes in Mungeshpur, Faizabad District, 1999

Field 2		Males (5)		Females (5)		Breeders (4)	
No	Lines	Ave scores	Rank	Ave scores	Rank	Ave scores	Rank
PVS1	NDR-40032	4.2	3	3.4	3	2.3	1
PVS2	Kamini	11.4	12	14.4	14	14.7	11
PVS3	NDR-973004	8.0	7	6.2	4	4.7	2
PVS4	NDR-973003	8.6	9	8.0	8	8.0	6
PVS5	RAU-1308-9-3-1-10-3-4-3	14	12.0	12	14.3	10	10
PVS6	PSRM-1-16-48-1	12.8	13	11.8	11	12.3	8
PVS7	NDR-9830102	3.6	2	2.4	2	7.0	5
PVS8	NDR-9730002	8.0	7	10.0	9	8.7	7
PVS9	NDR-9730015	5.6	5	6.4	5	5.0	2
PVS10	NDR-9730020	5.2	4	7.0	6	6.0	4
PVS11	Mashuri	10.6	10	13.6	13	7.0	4
PVS12	RAU-1308-10-11-3-1-4-3	8	10.2	10	12.7	9	9
PVS13	NDR-96012	10.8	11	7.2	7	9.3	7
PVS14	RAU-1411-10	7.0	6	10.0	9	9.0	7
PVS15	**NDR-9830103**	**1.6**	**1**	**1.4**	**1**	**5.3**	**3**
PVS16	RAU-1400-13-20	15.0	15	10.0	9	9.7	6
			w=.65**		w=.65**		w=.60**

**Significant at 0.5 and .10 per cent level.

Table 6. Summary Ranking of Preferred Lines by Male and Female Farmers and Plant Breeders, 1999

	Male farmers		Female farmers		Plant breeders	
	Field 1	Field 2	Field 1	Field 2	Field 1	Field 2
Basalatpur						
PVS1	3	2	2	3	2	4
PVS3	5	7	5	5	3	3
PVS7	7	3	7	5	5	5
PVS9	2	1	1	1	4	1
PVS10	1	2	3	4	1	3
Mungeshpur						
PVS1	3	3	2	3	1	1
PVS3	6	7	4	4	2	2
PVS7	1	2	1	2	5	5
PVS9	8	5	5	5	4	2
PVS10	4	4	6	6	6	4
PVS15	3	1	3	1	7	6

Table 7. Farmers' Assessment of New Rice Lines during the 1999 *Kharif* Season

Lines (Location)	Name	Positive traits	Negative traits
PVS1		Good yield	
		Medium plant height	
		Good straw (quantity and quality)	
		Has regeneration capacity (faster recovery after submergence)	
		Short, bold, heavy grains	
		Best for puffed rice, has good	
PVS-3	NDR-973004	Medium plant height	
		Submergence-tolerant	
		Good tillering capacity	
		Long panicles	
		Good eating quality	
		Good milling recovery	
		Remains soft after cooking	
PVS-7	9830102	Short duration (110 d) which makes rice available during the lean period	
		Good yield (4 t/ha)	
		Medium plant height	
		Good straw (quantity and quality)	
		Better for early rabi crops	
		Good taste	
PVS9	NDR9730015	Medium plant height	More broken grains after milling
		Suitable to land type	Becomes hard after cooking
		Submergence-tolerant	
		Good tillering capacity	
		Long, bold grain size	
		Good straw	
		Good for puffed rice	
PVS10	NDR9730020	High yield—more grains per panicle than PVS1 (NDR-40032)	
		Suitable to land type	
		Medium plant height	
		Resistant to lodging (hardy stem)	
		Resistant to pests and diseases	
		Longer panicles	
		Grains are long and cylindrical and finer than PVS9 (NDR9730013)	
		Higher milling recovery	
		Good taste	
		Remains soft after cooking	
		Good for special social occasions	
		Easy to harvest and thresh	

Listening to the voices of male and female farmers

Aside from asking men and women to rank traits and varieties through visual assessment, we conducted informal interviews with men and women farmers, separately. This enabled plant breeders to listen not only to men but also to women. Some of their perceptions of the rice varieties and lines tested are below.

Mrs. Yadav is 53 years old, illiterate, and a full-time farmer. Her husband is a full-time worker in the flour and oil mills. This makes her the *de facto* head of household. She supervises the farm and makes decisions regarding what crops and varieties to grow. Three years ago, she grew mostly local varieties because of a lack of irrigation facilities. We gave her seeds of NDR 97, a new variety, which she planted on 0.10 ha of land. Later she increased the area planted to this variety to 0.5 ha. She told us the positive traits she likes in this variety, such as suitability to her land type, good taste, shorter duration, good milling recovery, ease of threshing, and medium height, and negative traits such as less rice straw:

> *I tried many varieties since the last four to five years such as Saket4 and NDR80, but because they were damaged by drought and disease, I stopped growing them. I shifted back to a local variety [ARJ] although it does not taste good, has poor milling recovery and coarse grains. But I like NDR97 because of its suitability to my land, good taste, and shorter duration. The only problem is that it produces less biomass [straw], which is not enough for my two bullocks and five buffaloes. We need more straw for the animals throughout the year. We also grow* curbi *[green fodder] and harvest them green during the* kharif *season. Due to the early duration of NDR97, we can cultivate our land for early* rabi *crops such as oilseed and vegetables before wheat. I also like the taste of NDR97 and I am satisfied with its milling recovery. It is also easy to thresh; it is neither very tall nor short.*

Mrs. Savitri Devi is 45 years old, illiterate, and a full-time farmer of the backward caste. She cultivates 1.1 ha of land in Mungeshpur. She has two types of land, upland and lowland. She grew NDR359, Sarju52, and *Jallahri* in 1998. We gave the new seeds of NDR359 to her in 1996. She prefers this variety because it has a good taste and short duration. She describes their use of NDR359:

> *I don't like the taste of Sarju52. It is coarse and does not remain soft after cooking. It also does not have many broken grains after milling. So we sold Sarju52 and used NDR359 for home consumption. One thing I noticed with the straw of NDR359 is that it is soft, so instead of storing it for a long time, we had to feed it immediately to our animals. If we keep the straw for two to three months, it will not be very easy to cut and the animals will refuse to eat it. Instead of leaving the rice stalks to dry in the field, which is our usual practice, we immediately thresh after harvesting. Its short duration also enables me to grow another crop during the* rabi *season.*

Mrs. T. B Singh, 50 years old, belongs to the upper caste. Due to labor shortages during the peak season and the lack of male labor (her husband is fully engaged in a nonfarm job), she has been forced to provide physical labor in most of the rice operations. She was able to finish five years in school. She is the decision maker in the household and is quite knowledgeable about farming. In 1997, she was one of the collaborators of the project. After testing 13 genotypes on her field, she obtained 5.2 tons per ha from PVS5 (NDRSB9730015), so she decided to continue to grow this variety and expand the area during the 1998 *kharif* season. She expected to get six tons per ha, but because of drought, there were many unfilled grains. She told us about the variety's positive traits aside from its high yield:

> *I prefer PVS5 because of its medium duration; medium bold, cylindrical grain; resistance to pests and diseases; and better milling recovery.*

In 1995, we gave her new seeds of BKP246.

I like this variety too because it is suitable for the lowland rainfed area, has good yields, and is not susceptible to diseases. I like the size and the shape of the grain—medium and bold. It also has the best milling recovery and commands a high price in the market. In 1998, I sold four quintals of paddy at Rs 400 per quintal, while the other varieties are Rs 50 less than BFK246. We use Sarju52 and Saket4 for home consumption. Saket4 has fine grains and matures early, a trait ideal for the uplands. Our agricultural workers prefer coarse grains, which last longer in the stomach than paddy with finer grains. I observed that the quantity of straw of BFP346 is less, but grain quality is more important to us.

Mr. Bansat Lal , 42 years old, an illiterate father from the backward caste, is a full-time farmer. His sons are fully engaged in nonfarm activities and his daughter-in-law supervises farm activities and takes part in decision making. In 1997, he was a collaborator in the plant varietal-selection program and obtained good yields. After threshing and milling, the female members of his household also agreed that the PVS5 (NDRSB9730015) and PVS6 (NDRSB9730020) should be grown the following year. Both Mr. Lal and his daughter-in-law have the same criteria for selection, such as better yield, good quality of straw, medium height, resistance to pests and diseases, longer and fine grains, no broken grains after milling, softness and expansion after cooking.

My daughter-in-law observed that PVS5 is easy to hull through hand pounding after parboiling. It is also good for puffed rice.

Mr. Lal shared the seeds of PVS5 with other farmers. In 1998, he cultivated PVS5 and PVS6 on his 3 *bigha* (0.3 ha) land area. He was able to obtain a yield of six quintals per *bigha* in one plot and four quintals in another plot. These yields were higher than those in nearby fields.

Conclusions

Socioeconomic surveys revealed that a major determinant of varietal choice is the conscious attempt of farmers to match varieties with the land type. Each field position in the topo-sequence corresponds to a risk of drought or submergence. In Mungeshpur (shallow and submergence-prone) farmers' criteria for selecting rice varieties are associated mainly with duration (short to medium), for growing *rabi* crops after rice in the upland fields, and with better yield. A second determining factor is the adaptation to different user needs: food, livestock fodder, thatching, and cash. A third determining factor is related to different postharvest operations like ease of threshing, good taste, high milling recovery (above 65%), good storage capacity, and premium market price. Gender-specific roles and responsibilities also determine varietal preferences. For example, women prefer medium or semi-tall varieties that are easier to thresh, as well as varieties that have a good quantity and quality of rice straw for livestock feed. Moreover, they prefer varieties for the specific rice products that they make. While it may be difficult to combine all their preferred traits into one unique variety because of genetic correlations, it is important that both men and women have a "basket of choices" of varieties suited to their needs and agroecosystems. Clearly, listening to farmers' perceptions and involving both men and women farmers in selecting rice varieties at the early stage of breeding can lead to faster adoption of varieties suited to their specific rice ecosystems and diverse needs.

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Opportunities and Constraints for Participatory Plant Breeding: Farmers' Seed-Management Strategies and Their Effect on Pearl Millet Populations in Rajasthan, India

Kirsten vom Brocke, Anja Christinck, and Eva Weltzien

Abstract

This paper presents information from a study on farmers' seed-management practices growing pearl millet in Rajasthan, India. It describes farmers' own crop-improvement activities in regard to yield, quality, and diversity of pearl millet, with emphasis on seed-management strategies, such as introgression of modern varieties, selection, storage, processing, exchange, and procurement. It also examines the farmers' definition of "variety" as compared to the definition used by professional plant breeders. For the study, farmers were divided into four groups, based on their seed-management practices. Data were collected on specific traits and correlated with grain yield under different climatic conditions. The potential and constraints of farmers' practices are discussed, with emphasis on areas where researchers could concentrate on specific weaknesses that farmers' own selection practices cannot effectively address.

Introduction

In many regions of the world farmers routinely produce seeds for their staple crops. This is particularly common in regions where agricultural production is affected by frequent and unpredictable droughts, as in most areas where pearl millet (*Pennisetum glaucum* [L.] R.Br.), a cross-pollinating crop, is grown. Under these harsh climatic conditions, farmers have developed landraces that tend to show good levels of tolerance to these environments. The farmers have also evolved strategies for maintaining seed during drought years in order to safeguard food production and animal fodder. Given the fact that formal plant-breeding programs have failed to develop superior varieties for marginal lands and low-input conditions, the main objective of the study presented here is to better understand farmers' own seed-management practices as a basis for planning and implementing participatory strategies that capitalize on farmers' local knowledge. This approach would allow researchers to then concentrate on specific weaknesses that farmers' own selection practices cannot effectively address.

To date, these local strategies, including the farmers' needs and preferences, along with details of their cropping systems, are not familiar to scientists involved in conventional breeding programs.

Kirsten vom Brocke is a PhD student at the Institute of Plant Breeding, Seed Science and Population Genetics, University of Hohenheim, Stuttgart, Germany; Anja Christinck is a PhD student at the Institute for Social Sciences of the Agricultural Sector, Department of Communication and Extension, University of Hohenheim; and Eva Weltzien is a principal scientist with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in Bamako, Mali (West Africa).

The work presented here is part of the project "Enhancing quality, diversity and productivity of farmers' pearl millet genetic resources in Rajasthan, India," which is a collaborative activity of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India; its national partner institutions in Rajasthan, including the Central Arid Zone Research Institute (CAZRI), Rajasthan Agriculture University (RAU Mandor), and the National Bureau for Plant Genetic Resources (NBPGR), and the University of Hohenheim in Germany. We thank all scientists and staff members involved for their personal support to this study, particularly Dr. Thomas Presterl and Prof. Dr. H.H. Geiger (University of Hohenheim, Institute of Plant breeding, Seed Science and Population Genetics), Prof. Dr. V. Hoffmann (Agricultural Social Sciences, Department of Communication and Extension), Dr. P. Bramel-Cox (ICRISAT), and Dr. O.P. Yadav (CAZRI). The enthusiastic and most competent participation of farmers from the villages of Aagolai, Udaipur Khurd, Kichiyasar, and Nunwa in the workshops is equally acknowledged. We further thank the German Ministry for Economic Cooperation and Development (BMZ) for funding through the German Society for Technical Co-operation (GTZ).

The objectives of this project are listed below:

1. To describe farmers' own crop-improvement activities in regard to yield, quality, and diversity of pearl millet, with special emphasis on seed-management strategies, such as introgression of modern varieties, selection, storage, processing, exchange, and procurement
2. To quantify the effects of farmer activities on the genetic structure and performance of pearl millet populations

Short description of the study area

Rajasthan is situated in the northwest of India (figure 1). It is a semi-arid region with a mean annual rainfall that ranges from < 250 mm in the western part (*Thar Desert*) to > 650 mm in the southeast (figure 2). In this study, we refer only to the western part of the state, where farmers must make do with less than 350 mm of annual rainfall, with high variability from year to year. Experienced farmers often talk of a 10-year cycle in which two seasons have good rains, two have severe drought with crop failures, and the rest usually have fair to good seasons. Soils are mainly sandy, and sand dunes are common. Villages are typically scattered across wide areas. Pearl millet is grown three to four months during the monsoon season, mostly in mixtures with other crops, such as legumes and cucurbits. Animal husbandry is another important part of the farming system. Social conditions in the villages are governed by the caste system. Even today, the caste system still largely determines people's social status, occupation, income, and access to education and information.

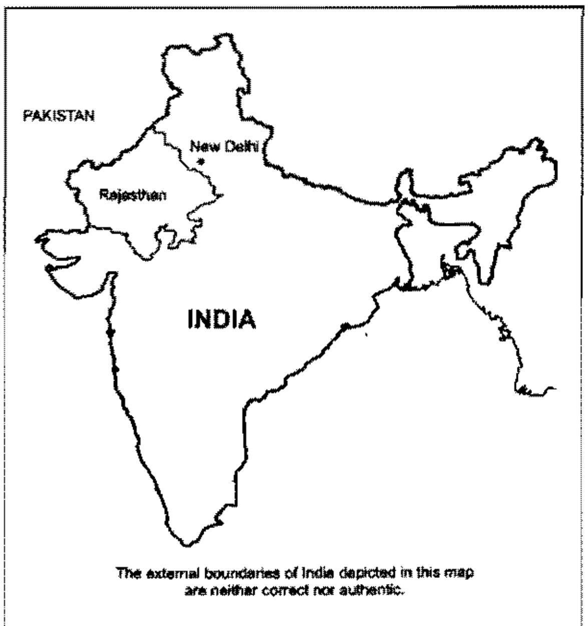

Figure 1. The state of Rajasthan in the northwest of India

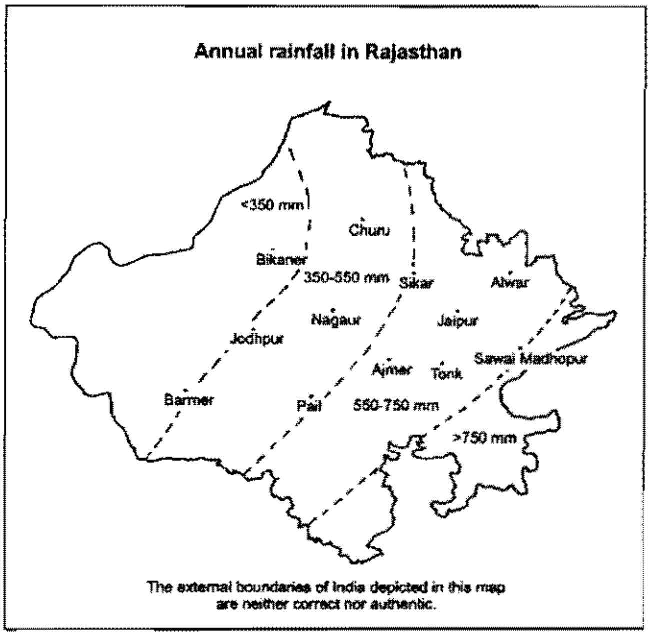

Figure 2. District capitals and zones of mean annual rainfall in the study area

Farmers' seed-management strategies

Farmer's concept of a "variety"

Farmers' seed management can only be evaluated if one fully understands the farmers' concept of a "variety." This term, as understood by plant breeders, does not seem to be fully appropriate for the farmers' pearl millet seed system in west Rajasthan. In order to learn how farmers perceive "varieties," informal interviews as well as classification and ranking exercises were carried out during workshops with farmers from the study villages. Care was taken to include both female and male farmers in the interviewing process. The results demonstrate that environmental adaptation was the main criterion for farmers' classification of pearl millet plants in western Rajasthan. Potential uses and quality aspects further contributed to the farmers' method of grouping different plant types (Christinck and vom Brocke 1998).

Traditional landraces that have adapted to the environment show a high basal and nodal tillering ability, indicating tolerance to drought and low requirements for soil fertility. If these characteristics are combined with thin stems, narrow leaves, and thin, compact panicles with small grains, farmers will conclude that such a plant will grow under low-input conditions (i.e., in their fields) and produce grain and straw of high nutritional quality. In contrast, the characteristics of modern varieties are low basal and nodal tillering ability, thick stems with broad leaves, and large panicles with relatively large grains that are mostly round in shape. From the farmers' experience, this plant type is not tolerant to drought stress, requires higher soil fertility, and has inferior food and fodder qualities. Farmers, however, are aware that pearl millet plants showing such characteristics can produce higher yields under favorable conditions (Christinck and vom Brocke 1998). Farmers are therefore concerned about the composition of their seed stocks, i.e., which plant types and, thus, which properties are present. Farmers expect plant types to change over time, in reaction to environmental conditions such as soil quality and rainfall, so that the seed stock generated in one year cannot be exactly reproduced the next season. They have a strong concept of continuous interactions between plant type and environment, as evidenced by their belief, or experience, that any pearl millet cultivar, including modern varieties, that is grown in their field for some years will eventually become like their local cultivars.

Contrary to the views of professional plant breeders, the farmers' concept of a "variety" is not that of a population with more or less uniform and stable plant characteristics based on its genetic background; the term "variety" is applied to a plant type that is evolving under or adapting to certain environmental conditions. This concept is reflected in the farmers' seed-management strategies.

What is seed management?

Seed management comprises all activities of a farming family that influence their seed stock, including introgression of modern cultivars (open-pollinated varieties or hybrids), seed selection, processing, storage, exchange, and procurement. In this paper, we refer mainly to seed selection and processing, and the ways in which farmers deal with modern varieties from the market.

Ways of selecting or processing seed

Farmers in Rajasthan generally employ two main selection methods. The first is winnowing or grading, which entails cleaning and separating seed grains. The rate of selection can vary greatly. It may be that only 10% of the threshed and stored grain will be rejected (mainly husks and broken

and insect-infested grains), or more than 50% if the grains, for example, are small and not fully developed. Generally, the smaller grains are be used for food.

The second method, which is also very common, is the selection of panicles that show preferred traits. Farmers usually select for panicles on the threshing ground after the panicles have been separated from the straw, although some farmers prefer to select for panicles in the field before harvesting, taking the entire plant into consideration, e.g., number of tillers, height. Even by inspecting the panicle, farmers can envisage what the plant's other characteristics looked like (or would look like when regrown). Many farmers do not perform panicle selection every year, but only in the better seasons, which usually occur every two to four years. In harsher years, they are most likely to use the winnowing/grading method. A third, less common, form of selection is to use the harvest of a preferred field—a field considered to be more fertile than others—for sowing the following year.

Using "improved varieties" or hybrids from the market

If a farming family does use pearl millet seed from the market, in most cases it will be mixed into the family's own seed stock. In western Rajasthan, farmers without access to irrigation facilities generally do not grow improved varieties or hybrids in pure stands. Market seed is mostly certified or "truthfully labeled" seed. Further advanced generations of such seed can be optioned from the market or from other farmers. This grain is not labeled and its origin is often unknown. There are two ways in which farmers use seed from the market:

1. Occasional introgression of new seed from the market into the previous year's seed stock: the resulting crop consists of many different plant types (traditional landrace, market variety, and several generations of progeny). Mixing ratio and frequency can vary widely, ranging from 1:10 up to 50:50.
2. Regular introgression of new seed from the market into the previous year's seed stock, selecting for desired plant types among outcrosses: One or more new plant types will become dominant, and the variability of plant types is less than in the first example. The amount and frequency of mixing new seed, as well as selection intensity, can differ greatly from farmer to farmer and from year to year.

It is important to understand that most farmers do not use improved varieties to replace their own seed, as is often assumed. Rather, they use new seed to increase the variability of plant types in their fields, thereby creating new options for their strategies of selecting for preferred plant characteristics, including grain and straw yield, food and fodder quality, storability, drought tolerance, early maturity, tolerance to adverse weather conditions (heat, sandstorms, thunderstorms), and resistance to bird or locust damage.

Social aspects of seed management

The availability of seed grain at the onset of rains is very important for farmers in western Rajasthan. The success of a crop depends very much on sowing immediately after the first rains of the monsoon. For centuries, farmers have had to deal with crop failures due to severe drought conditions. Therefore, "taking care of the seed" is considered to be of great importance. Farmers who can successfully maintain their own seed, or be in a position to provide other villagers with seed in times of scarcity, are considered to be good farmers and are respected by all. There is a special caste in most villages for whom maintaining seed and sharing it with others is considered to be a traditional obligation. Nevertheless, other farmers can also build up a reputation for owning good seed,

and "lending" or selling it to others. Seed management is, therefore, related to aspects of caste and status in village life. Furthermore, it is a gender-related activity. Selecting the seed, storing it, and processing it before sowing is traditionally done by women, whereas soil preparation and sowing is usually done by men. Men also often participate in harvesting, and depending on the family, they can be equally involved in selecting seed. Buying seed from the market and obtaining information about market varieties is done almost exclusively by men.

Diverse seed-management strategies co-exist in villages in western Rajasthan, reflecting the diversity of socioeconomic conditions: farmers who grow traditional landraces with or without selection; families who mix, sometimes or regularly, seed from the market into the landrace seed with or without selection; and families who sow the pure seed of market varieties. All these seed-management strategies can be found in one village. Even though pearl millet is a cross-pollinating crop, it seems to be possible for a village community to maintain a diversity of plant types. The reasons for a farming family using a certain strategy can only be partly explained by soil conditions and climatic factors. Other important factors seem to be the size of the landholding (market-oriented or subsistence-oriented), the number and species of animals and their fodder requirements, the access to cash income or loans to buy seed, the family tradition and knowledge, and access to information on new varieties, e.g., literacy and mobility. Most of these socioeconomic conditions are related to the caste system in Rajasthani villages.

Quantification of the effects of farmers' seed-management strategies

Material and methods

To quantify the effects of farmers' seed management, 69 grain stock samples were collected from 16 farmers located in four different villages in western and central Rajasthan during 1995–1997. Samples were characterized by the farmer, e.g., as separated seed grain and food grain, and were classified into four main seed-management strategies (table 1). These grain samples from farmers, along with 12 modern varieties known to be grown in these villages, were evaluated under varying drought-stress conditions at three research stations in western Rajasthan (Mandor, Jodhpur, Pali) between 1997 and 1998. Climatic conditions in 1997 were generally favorable, whereas in 1998 severe drought affected the plant growth, especially at Mandor. The field trials comprised 81 entries and were laid out in lattice designs with five replications. The different plant traits that are used by farmers and scientists to describe the performance of pearl millet were recorded in order to assess productivity and characteristics of entries. These plant traits included nodal tillering, leaf shape, stem diameter, panicle girth, number of productive tillers, grain weight, straw and grain yield, as well as diversity of plant types within one entry.

Table 1. Farmers' Seed-Management Strategies as Represented in Field Trials

LR	Maintains only local landrace seed without introgression of modern material Selection method mainly winnowing
IGR1	Occasionally introgresses modern varieties into landrace Selection method mainly winnowing
IGR2	Introgresses modern material more regularly than strategy IGR1 Selects regularly/frequently for panicles
MV	Modern varieties

Separate analysis of the five test environments revealed a significant phenotypic relationship between grain yield and plant characteristics (table 2). The number of panicles and basal tillers, plus nodal tillering and phenotypic diversity of plant types within one entry, were all positively associated with grain yield in the stress environments and negatively associated in the non-stress environments. Conversely, entries with large stems, large leaves and panicles, and bold grains showed negative correlation coefficients with grain yield under stress conditions and positive coefficients in the non-stress environments.

Table 2. Phenotypic Correlation of Observed Traits with Grain Yield

	Environments				
	Favorable		Mild terminal drought	Early drought	
Traits	MAN97	JOD97	PAL97	MAN98	JOD98
Grain weight	0.69**	0.75**	0.42**	0.08	–0.25*
Panicle girth	0.70**	0.83**	0.42**	–0.60**	–0.24*
Leaf width	0.38**	—	0.33**	–0.62**	–0.24*
Stem diameter	0.62**	0.69**	0.41**	–0.65**	–0.14
No. of panicles	–0.54**	–0.46**	–0.41	0.90**	0.48**
Tillers	–0.54**	–0.58**	0.01	0.67**	0.36**
Nodal tillering	–0.65**	—	–0.41**	0.56**	0.27*
Plant type diversity	–0.57**	—	–0.36**	0.32**	0.11

*$p < .05$.
**$p < .01$.

A genotype × environment (GE) analysis based on grain-yield data was carried out in order to gain an overall view of the effects of these strategies on the adaptation of farmers' seed stocks to different environments. For this purpose pattern analysis was used to classify environments and to assess relationships between the entries and between environments, as well as to analyze the interrelation between entries and environments. To generate the analysis, the statistical packet GEBEI was used (Watson et al. 1996). The details of this calculation will be published elsewhere.

Results and discussion

The phenotypic relationship described in table 2 shows the effectiveness of farmers' seed-management strategies. Entries with plant characteristics that farmers associated with adaptation to stress proved to be more productive under stress conditions than other entries. These findings were supported by the results of the pattern analysis. The analysis indicated that most of the entries classified as LR showed close interaction with the preflowering drought stress at Mandor and Jodhpur. Compared to the LR entries, entries classified as IGR1 tended to show a less specific interaction with the stress environments. In contrast to the management groups LR and IGR1, a change in the adaptation pattern seemed to be obvious in entries derived from IGR2. The positive interaction of the samples exclusively with the preflowering drought environments was mostly eliminated. Entries also tended to show relatively high productivity in more favorable environments. Samples grouped in IGR2 thus tended to perform fairly well in all the test environments. Entries labeled as modern varieties (MV), indicated almost no positive association with the preflowering drought