11

Participatory Approaches in Pearl Millet Breeding

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Introduction

There are many good reasons to encourage farmers' participation in the process of agricultural research and technology development. When scientists and farmers work together to improve agriculture by learning from each other, they begin to understand the differences between their worldviews and knowledge systems. Working together, bridging the gap between these differences, creates opportunities to develop solutions that respond to the requirements and felt needs of particular farmers which may be generalised for the requirements of many farmers. Solutions oriented towards felt needs of farmers have a greater potential for adoption and for achieving desirable changes in the farming system. However, it requires effort, on the part of both scientists and farmers, to bridge this gap. It requires new approaches to research that enable scientists and farmers together to explore problems and evaluate solutions.

One of the goals of the Consultative Group on International Agricultural Research (CGIAR) is to develop strategies and research methods to cope with increasing demand for food production under resource depletion. This commitment to integrate growth and poverty alleviation with environmental protection was reinforced by Agenda 21 (CGIAR, 1993). A large proportion of the world's poor live in the harsh environments of the semi-arid tropics. It is one of the goals of the International Agricultural Research Institute for the Semi-Arid Tropics (ICRISAT) to develop innovative techniques to improve the impact of its research on the nutritional and economic well being of low-income people in these environments. Developing methods to bring farmers and scientists closer together has been one of the approaches used to achieve research results with more relevance to specific farming communities. Understanding farmers' priorities helps to target research efforts. Giving farmers opportunities to choose, improvise, and adapt from a range of choices will create more useful technologies (Farrington and Martin, 1988; Okali et al., 1994).

New varieties, breeding populations, and improved genetic materials are among the major outputs of ICRISAT's commodity research efforts. Farmers involvement in this process of genetic enhancement has traditionally been limited to donating germplasm and receiving a final product. Opportunities for farmer participation in the various stages of varietal improvement will be explored in this paper, based on research results obtained with pearl millet (*Pennisetum glaucum* [L.] R. Br.) in the state of Rajasthan in north-western India.

Pearl millet is the primary cereal crop and staple food in the driest, hottest regions of India. In the state of Rajasthan, it is grown on 4-6 m ha annually, which represents approx. 45% of the area planted to this crop in India and approximately 20% of the world acreage. The total area planted as well as the growing conditions for pearl millet are highly variable and unpredictable (Gupta *et al.,* 1994; Sharma and Pareek, 1993). In Rajasthan, productivity of pearl millet has increased only marginally over the past decades, and adoption levels of modern cultivars are very low. In contrast, modern cultivars of pearl millet are widely grown in better endowed environments in India, and have contributed to significant increases in productivity (Jansen, 1989). This situation suggests that specifically targeted crop improvement efforts are required for the harsh environments in Rajasthan. The research presented here is part of a collaborative effort with local and national institutions to identify and develop technologies to improve the productivity of this farming system.

Farming systems research (FSR) and on-farm research (OFR) methods have developed in response to the failure of much single commodity-focused research to meet the needs of complex farming systems, particularly in situations where farmers' needs are not well understood by researchers and where there are strong interactions between different sub-systems or components of the whole farm enterprise. FSR methods allow scientists from a range of disciplines to gain insight into the major processes and constraints contributing to productivity of individual components of a farming system. In FSR and OFR, commodity-focused researchers of different disciplines evaluate technology with the participation of farmers in the context of the whole farming system, i.e. taking into account the interactions between sub-systems (Shaner *et al.,* 1982; Norman and Collinson, 1986; Byerlee and Tripp, 1988; Norman, 1992). Methodology for diagnostic research and farmer-researcher interactions has recently seen a large diversification with the adaptation of participatory approaches for rural development as a tool for agricultural research (Chambers *et al*., 1989; Haverkort *et al*., 1991; Tripp, 1994; Scoones and Thompson, 1994; Stiles, 1995).

For the research reported here on pearl millet improvement, the choice and adaptation of diagnostic methods was driven by the need to understand the environmental conditions for pearl millet growth, to identify farmers' preferences for new varieties, individual traits and trait complexes, and to understand interactions between livestock and crops, as these may affect farmers' requirements for pearl millet. These methods include:

- analysis of secondary data on production environments to define target domains;
- on-farm farmer-managed trials;
- surveys of farmers' seed production practices;
- on-station evaluations of breeding material by farmers, and
- surveys and informal discussions to understand the interactions between environment, crops, and livestock.

An interdisciplinary team including breeders, socio-economists, and agronomists, contact persons from Government Organisations (GOs) and Non-governmental Organisations (NGOs), and farmers participated in the diagnostic studies.

It is the objective of this paper to explore opportunities for involving farmers in the process of breeding varieties of an open-pollinated crop. We describe and discuss here the methods we used to interact with farmers and report results relevant to pearl millet breeding for Rajasthan. The description and analysis of methods and specific results of farmers participation in this breeding programme is divided into four sections corresponding to the four major stages of the cycle of any breeding programme (Schnell, 1982): evaluating varieties; selection among experimental varieties; generating new variability and segregating populations; and defining goals for the breeding programme. This will facilitate the comparison and application of these results to other situations.

Variety Evaluation With Farmers

It is common to have some level of farmer involvement in the final stages of variety testing, generally after varieties have been identified for release. These trials are normally researcher-managed on-farm trials, on-farm demonstrations, or large-scale minikit type trials. Once a variety is released, similar trials are commonly organised by extension services to expose large numbers of farmers to newly available varieties and other technologies. Usually these trials are managed with the full range of recommended external inputs, which can be atypical of the predominant management practices in the target region. Farmers have little or no input into the management of these trials, nor into the choice of varieties being tested. These trials are usually evaluated solely on the basis of grain yield performance. Farmers' evaluations of the tested genotypes are usually not sought, and farmers' evaluation criteria are not regularly used, or if they do, they do not enter final reports and play little or no role in the decision making process for varietal releases and recommendations (Farrington and Martin, 1988).

We initiated a series of variety evaluations with farmers (Table 11.1) in Rajasthan with the objectives:

- to understand farmers' criteria and approaches for evaluating new varieties of pearl millet, and
- to obtain farmers' assessments of new varieties and their specific characteristics (Weltzien *et al.*, 1996a,b).

Here we describe in detail the methodology used for these on-farm trials. The results presented focus on one of the test varieties (RCB-IC 911).

Table 11.1 Location and number of on-farm trials conducted each year with the support of local organisations

Year	District	Village	No. of Trials	Supporting Organisation
1991	Ajmer	Kotri	12	Social Work and Research
		Singla	12	Centre (SWRC)
		Brijpura	12	
		Nallu	12	
1992/1993	Ajmer	Nunwa	15	IGDP†
		Udaipur Khurd	15	SWRC
	Jodhpur	Aagolaie	30	DSSWSP‡ and CAZRI§
	Bikaner	Kichiyasar	30	URMUL Trust
1994	Jodhpur	Aagolaie	20	DSSWSD, CAZRI
		Malunga	20	GVVS¶
	Bikaner	Kichiyasar	20	URMUL Trust
	Churu	Krejada	20	URMUL Trust
	Barmer	Bhadka	20	SURE#
		Mangla	20	SURE
1995	Jodhpur	Aagolaie	20	DSSWD, CAZRI
	Bikaner	Kichiyasar	20	URMUL Trust
	Barmer	Rewali	20	SURE
		Rohili	20	SURE

† IGDP Indo-Swiss Integrated Goat Development Project
‡ DSSWSD Department of Soil Conservation and Watershed Development of the Government of Rajasthan
§ CAZRI Central Arid Zone Research Institute
¶ GVVS Grameen Vikas Vigyan Samiti
# SURE Society for Uplift of Rural Economy

Methods

Selection of participating farmers. The intended beneficiaries, and therefore participants in this activity, were farmers for whom pearl millet is an important crop. They live in areas where local varieties and farm-saved seed still predominate and yields are low. The target region is western and central Rajasthan (Fig. 11.1), where pearl millet is the predominant crop and staple cereal. Within this target region, three districts were chosen to span the major range in agro-environments for pearl millet cultivation in Rajasthan, i.e., differences in rainfall patterns, soil types and crop-livestock systems: Ajmer, Jodhpur, and Bikaner. This transect from Ajmer to Jodhpur and Bikaner is characterised by:

- Rainfall reliability and levels that decrease from 432 mm seasonal rainfall in Ajmer to 304 mm at Jodhpur, and 228 mm at Bikaner (van Oosterom *et al.*, 1996).
- Soils that increase in sand content and decrease in clay content.
- Long-term average pearl millet yields that fall from approximately 450 kg ha^{-1} at Ajmer to a 150 kg ha^{-1} at Bikaner.
- Decreasing experience or familiarity with modern varieties (MVs) of pearl millet (Kelley *et al.*, 1996).
- The importance of milk animals decreases, while that of sheep and goats increases.

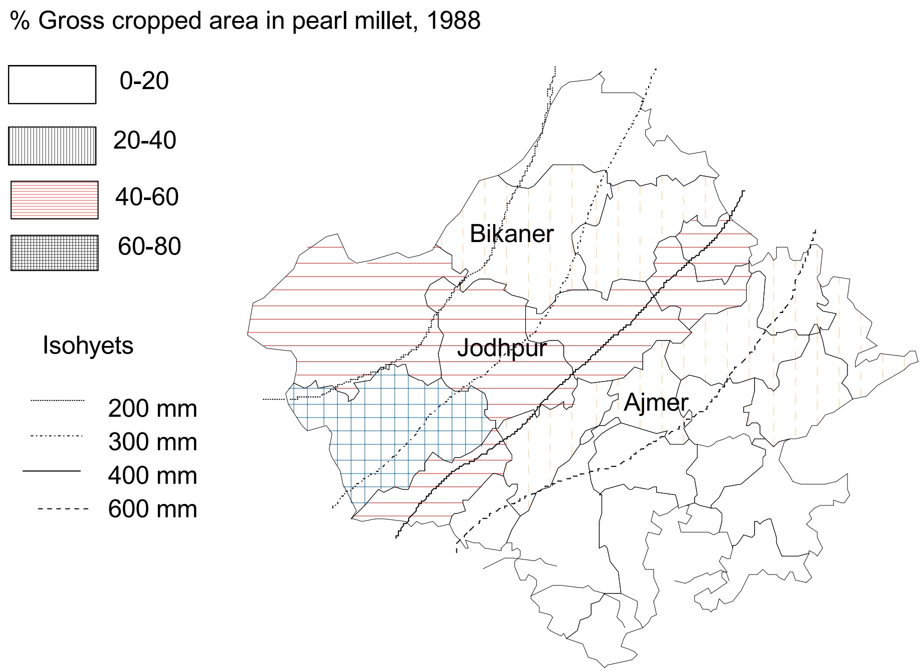

Fig. 11.1 **Distribution of pearl millet (% gross cropped area, on a district basis), rainfall isohyets in Rajasthan and on-farm trial locations.**

Local governmental (GOs) or non-governmental (NGOs) organisations in the chosen districts were identified to act as local links between ICRISAT researchers and farmers. The three criteria for choosing local organisations were:

1. interest of the organisation in the research;
2. experience/interest in agricultural development of their target clients; and
3. quality of their rapport with potential villages.

NGOs were identified in Ajmer and Bikaner districts; two GOs were identified in Jodhpur district (Table 11.1). Each local organisation nominated individuals to serve as contact persons for the collaboration.

Selection of village sites was done jointly by ICRISAT researchers and the contact persons. The four criteria for choosing village sites were:

1. village ties to the local organisation which would enable our work to build on existing trust of local farmers;
2. villages where pearl millet was important in the local farming systems and for farm household income;
3. villages which are representative of the district in terms of agro-environmental conditions and socio-economic conditions, e.g. they do not have unusual soils or occupations, and
4. villages where there are no social/political hindrances to effective researcher-farmer interaction.

These are not easy criteria to evaluate through secondary data. Visits to potential villages with members of the collaborating organisation and informal discussions with village farmers were used to evaluate appropriateness of the villages.

Once a village was chosen, ICRISAT researchers and the contact persons jointly identified one or two villagers as potential local investigators. The role of the village investigators was to monitor the on-farm trials and collect information from participating farmers during and after the crop season. The four criteria for choosing investigators were:

1. one male and one female investigator in each village;
2. adequate functional literacy for project needs;
3. good relationships with village farmers and ability to interact positively with farmers of any caste, and
4. interest in the intended work.

ICRISAT economists, with experience in a variety of survey techniques, with the assistance of the contact persons conducted a three-day training workshop for village investigators to explain project goals and methods, and to train them in basic survey techniques. Adequate performance in the training programme was also a criterion for recruitment.

To choose participating farmers for the on-farm trials, ICRISAT economists and the local contact persons visited each village before the beginning of the rainy season. A meeting of farmers was held to explain the objectives of the research and the way trials could be conducted.

The initial selection of farmers was done through a village census, in which farm households and their resources were identified (land, livestock, farm resources). Participating farmers were chosen using three criteria:

1. to span the range of household resources, i.e. size of landholdings;
2. to include both men and women farmers; and
3. because of their interest in the research, i.e. the project had a preference for experimenters and farmers interested in seed-related issues.

Landholding size (as an indicator of a household's resource availability) was used as a criterion for stratification because many of the varietal traits we wanted to evaluate and discuss with farmers are related to food/feed needs and security. For poor households, these issues may be more important than for better endowed households. Our rationale for actively involving women and men in the study was that both are actively involved in pearl millet production. Also, women in many societies have special responsibilities for providing food, which may be linked to responsibilities for grain and seed storage, and hence have special skills and knowledge in seed-related issues.

In selecting villages and farmers, we relied heavily on the knowledge of the local collaborating organisations. We are now developing techniques for initial village characterisation that will provide reliable and rapid information to support village selection and village household stratification in economic or social terms (Dhamotharan *et al.,* 1996).

On-farm variety trials

Three contrasting varieties were chosen by ICRISAT researchers for the on-farm trials in 1992 and 1993. For the 1994 trials four varieties were chosen to meet the following four criteria:

1. to cover a wide range in time to maturity;
2. to cover a wide range for tillering potential and panicle types;
3. to have been widely tested for yield, and preferably be released or near release, and
4. preferably to be an open-pollinated variety and not a single-cross hybrid, so that farmers could produce their own seed (Table 11.2).

The choice of varieties was made based on on-station trial results focusing on Rajasthan, results from a formal survey on reasons for non-adoption of released varieties (Kelley *et al.,* 1996), and discussions with farmers growing modern varieties in the target district. We adapted the choice of the varieties from year to year in response to farmers' evaluations and interests.

Table 11.2 Main characteristics of experimental varieties chosen by researchers for 1992 on-farm trials

Character	HHB 67	RCB-IC 911	ICMV 155
Growth duration	extra early	early	medium
Plant height	short	medium	tall
Basal tillering	medium	low	low
Panicle size	small	thick	long
Grain size	large	very large	medium
Variety type	hybrid	open-pollinated variety	open-pollinated variety

Thirty farmers participated in each district during 1992 and 1993. The number of participants in each village was reduced to 20 in 1994 and 1995 to allow us to include more villages (Table 11.1). Each participant was given one of the experimental varieties. Thus in 1992 and 1993 each variety was evaluated by ten farmers in each district, whereas in 1994 and 1995 each variety was evaluated by five farmers. Varieties were allotted by lottery. Farmers were asked to sow the experimental variety adjacent to their own variety and to manage the two varieties as similarly as possible in order to facilitate valid comparisons of varietal performance. The farmers otherwise designed their individual experiment by choosing the field, plot size, planting density and the crop mixture in which these varieties were sown. The farmers usually sowed an area of approx. 0.2 ha to the experimental variety.

The village investigators monitored the trials throughout the growing season and collected information from participating farm households, through the use of structured questionnaires to get data on farm household resources, cropping history, crop and livestock management, crop management in relation to environmental stresses, changes in crop management over time, and the management of the season's experiment.

Evaluation of on-farm trials

We used three methods for understanding farmers' evaluations of specific varieties:

1. individual comparisons of experimental varieties with each farmer's own variety;
2. group interviews to compare a range of experimental varieties; and
3. semi-structured interviews to record farmers' grain and stover yield measurements and their experiences with the food quality of the grain and the feed quality of the stover.

Researchers and farmers visited each field before flowering and discussed field management and early growth of the experimental variety relative to the farmers' own variety. The researchers returned prior to harvest to visit the fields and discuss in detail the farmers' observations of differences between the experimental variety and the farmers' own variety. Individual farmer's observations made while viewing the standing crop indicated which traits farmers use to distinguish the varieties. For each distinguishing trait farmers were asked to rank the two varieties, as well as rank the varieties for their overall preference. Researchers sought reasons for the preferences indicated.

Farmers were asked to harvest both varieties separately, and measure grain and fodder yields using their local measurement units (usually standard baskets) and to estimate of the area sown to the experimental and their own variety. The farmers were given two cloth bags each to keep some of the grains harvested from both varieties separately, so that they could evaluate grain quality of the experimental varieties in comparison with their own when they used the bagged grain for cooking. Farmers were also asked to observe the stover quality. The researchers used semi-structured interviews with individual farmers to record the yield estimates and to understand the components of quality assessment for fodder and grain.

Group interviews were conducted with groups of 3-6 farmers, representing farmers' participating or not participating in the experiments, as well as men and women farmers, to compare all experimental varieties with each other and with the local variety at the end of the growing season. Groups toured several fields to see all experimental varieties under similar growing conditions. Farmers collected 3-4 representative plants from each variety to have specimens available during the discussions.

Discussions were structured so that farmers were first encouraged to talk about differences between the local variety and the experimental varieties. For each trait they mentioned, a picture was drawn on a card. The cards were then used to identify rows in a matrix ranking table. For each variety one column was made. Farmers ranked the three experimental varieties for each of the characteristics they had mentioned, by putting more or less stones or large seeds in a particular cell. Usually these discussions led to other topics, such as crop management, crop utilisation and seed related issues. In conducting these group discussions, care was taken to keep the groups small (2-5) to be able to listen to the opinions of individuals. We found that in larger groups there was a tendency for strong or respected personalities to dominate the discussions. For the same reason, group discussions with women were conducted separately from discussions with men.

Results

The discussions with individual farmers during 1992 indicated that farmers from Ajmer district expressed a very strong overall preference for the open-pollinated variety RCB-IC 911 over their own varieties, as well as over the other experimental varieties tested during that year (Table 11.3). The results of these comparisons showed that the main reasons for this preference in Ajmer district were the relative earliness of this variety combined with its superior grain yield (Table 11.4). During the group discussions farmers further indicated that RCB-IC 911 had superior stover quality, tillering, grain size and that it required less water than the local varieties to achieve these superior results (Table 11.5). The group discussions thus further supported the overall preference for RCB-IC 911 by farmers from Ajmer district.

Table 11.3 **Farmers from the three districts that preferred the experimental varieties over their own variety, during the discussions with individual farmers growing on-farm trials in 1992.**

	Ajmer		Jodhpur		Bikaner	
Variety	**Preference (%)**	**Farmers (No.)**	**Preference (%)**	**Farmers (No.)**	**Preference (%)**	**Farmers (No.)**
RCB-IC 911	78	9	44	8	44	7
HHB 67	56	9	13	8	56	9
ICMV 155	25	9	11	8	11	9

Table 11.4 **Percent of farmers from three districts in Rajasthan, preferring the variety RCB-IC 911 more than their own variety for individual traits, during discussions with individual farmers' growing on-farm trials with this variety in 1992 and 1993.**

	Ajmer		Jodhpur		Bikaner	
Trait	**1992**	**1993**	**1992**	**1993**	**1992**	**1993**
Grain yield	100	67	100	100	100	100
Stover yield	42	0	33	--	0	--
Earliness	100	50	25	--	67	100

Farmers' post-harvest yield measurements confirmed these results (Table 11.6). The clear superiority of RCB-IC 911 over the local variety under the low rainfall conditions of 1993 resulted in farmers' keen interest in obtaining larger quantities of seed of this variety. In a series of group meetings, farmers indicated a willingness to pay 10 Rupees kg^{-1} for seed of this variety, slightly more than the price for local varieties in this area. Farmers expressed strong interest in obtaining sufficient quantities of seed to provide the community with its requirements. As this variety is not a hybrid but open-pollinated, farmers can multiply and maintain relatively pure seed stocks in the village. Pamphlets and posters were provided illustrating how fields might be isolated and pure seed stocks maintained. The release of this variety would allow the formal sector to produce seed of this variety for wider distribution in Ajmer district and other regions of Rajasthan.

Table 11.5 Comparison of RCB-IC 911 with other test varieties and with the local variety in group discussions with farmers from 2 villages in Ajmer district in 1992 and 1993.

	RCB-IC 911 compared† with:		
Characteristic	**Local**	**HHB 67‡**	**ICMV 155‡**
Early maturity	+	-	+
High grain yield	+	+/-	+
High stover yield	+	+	+
Tall plant height	-	+	-
Stover quality, not chopped	-	-	-
Stover quality, chopped	+	-	+
High tillering	+	-	-
Large grain size	+	+	+
Low water needs	+	-	+

† + RCB-IC 911 superior
+/- RCB-IC 911 similar
- RCB-IC 911 inferior
‡1992 data only, from 5 group discussions with 4-6 farmers per group in two villages

Table 11.6 Summary of performance of RCB-IC 911 in farmer-managed† on-farm trials.

	Grain yield (kg ha^{-1})		**Percent of**	**Stover yield (kg ha^{-1})**		**Percent of**
Location	**RCB-IC 911**	**Local**	**local**	**RCB-IC 911**	**Local**	**local**
Ajmer District						
Nunwa 1992	1341	1101	122	3519	3386	104
Udaipur-Khurd 1992	919	931	99	3300	3525	94
Nunwa 1993	925	756	122	4688	3656	128
Udaipur-Khurd 1993	416	291	143	3625	4089	89
Bikaner District						
Khichiyasar 1992	595	495	120	990	995	100
Overall mean	839	715	121	3224	3130	103

† In each village 5 farmers had plots of RCB-IC 911 adjacent to the local cultivar. After threshing each farmer reported his grain and fodder yields.

Discussion

In the on-farm trials each farmer was given only one experimental variety to grow. The farmers decided themselves about the trial location and field management. This allows the farmer to exercise some control over the level of risk that is appropriate for him/her. With only one new variety, the farmer observes keenly its behaviour and characters relative to his/her own variety. This approach has provided researchers and farmers with rich information on the comparative growth and behaviour of the varieties in farmers' fields.

We found that group discussions had the advantage that they frequently lead to discussions between farmers on a wide range of issues. This allowed the researcher to assume more of an observing role, and thus an opportunity to gain a better understanding of the reasons for differences in trait and variety preferences, with his/her own preconceptions influencing the discussion less.

One difficulty with organising group discussions in the western part of Rajasthan is that farmers do not normally live in closed villages, but rather in hamlets near their fields. It can thus be very time-consuming to arrange group meetings, and to conduct the field tour to look at each experimental variety under similar growing conditions. To overcome this limitation, and to encourage visits to each other's fields, we had formed clusters of farmers, whose fields were close to each other. Within each cluster all the three/four varieties were distributed randomly. However, with the high chance for crop failure, the frequent need for replanting and the wide range of soil fertility conditions in any small area, only a few clusters could actually serve this purpose. We encouraged farmers to visit each others' fields so that they would see the range of diversity in plant traits represented by the three/four experimental varieties, but this seldom happened even when the fields were close. Reasons for this appear to include time constraints, and social factors. During the end of the grain filling period of pearl millet, when it is best to evaluate varieties in the field, other crops, like moth bean (*Vigna aconitifolia*) or mung bean (*Vigna radiata*) are usually being harvested, so that farmers do not have much time to spare.

It is our experience that the type of on-farm trials described here, combined with an attitude towards learning and understanding from farmers by researchers, provides new information for assessing the overall usefulness of a new genotype. Similar approaches have been used by others working with a variety of crops and in different agricultural settings (IDRC, 1996; IPGRI, 1996) to identify locally well adapted varieties from the often wide range of already released varieties or from breeder's initial varietal trials. Such participatory evaluation and selection of existing, or released varieties has great potential for identifying locally acceptable varieties quickly. This may be useful at an early stage in the variety dissemination process or may contribute valuable information during the variety release process. Furthermore the potential for adoption of varieties preferred by participating farmers may be increased as farmers are already familiar with the variety's characteristics and its suitability for cultivation once the seed is made available. An urgent challenge faced in India now is to integrate such a participatory approach to variety evaluation into the formal structures of national and state release procedures for new varieties.

Farmers' Participation in the Varietal Selection Process

Selection is the key activity in any breeding programme and it occurs at all stages of the breeding process: choosing the composition of base material, selecting parents for crossing, selecting among progenies, selecting among experimental varieties, and maintaining breeder seed stocks. Selection is often conducted for several traits simultaneously, and thus requires consideration of their relative economic importance (what trade-offs are to be made) and their heritabilities (how much opportunity for progress). Each of these selection stages is normally conducted at experiment stations where uniform conditions and facilities for handling large numbers of test materials exist.

Farmers' visits to experiment stations are usually limited to viewing demonstration plots of a few highly selected advanced varieties. Feedback from farmers on these displayed options is usually not sought, and opportunities for their input into the selection process are thus extremely limited. However, possibilities for farmers' participation in selection are as diverse as the nature of selection itself, e.g., selection among single plants, progeny rows, experimental varieties, selection on-station, or selection on-farm.

We have experimented with farmers' participation in the selection among experimental varieties grown at research stations in order to supplement our conventional on-station variety evaluations with farmers' opinions and observations. This activity was also intended to improve our understanding of farmers' preferences for different varietal traits. It presented a wider range of genotypes to farmers than could be handled in on-farm evaluations.

Methods

Groups of farmers from different villages, men and women, participants- and non-participants in on-farm varietal trials were invited to the CAZRI (Central Arid Zone Research Institute) research station at Jodhpur during 1992, 1993 and 1994. Farmers observed one replication of the Rajasthan Varieties and Populations Trial (RVPT) which evaluates the most advanced breeding materials produced by the collaborative breeding programmes of ICRISAT with CAZRI at Jodhpur, and the Rajasthan Agricultural University at Fatehpur-Shekhawati and at Jaipur (Durgapura). The trial consisted of between 40 and 60 entries each year, and included unimproved local varieties and a range of released varieties (hybrids and open-pollinated varieties) as controls. The composition of the trial changed each year.

Participation by farmers with a keen interest in seed issues is crucial to the success of this type of exercise, but requires considerable time at the farmers' busiest period. The exercise requires commitment and skill to observe, extrapolate, and communicate observations successfully to researchers. We invited farmers who had already made considerable effort in on-farm varietal trials. Additionally, the local investigators were encouraged to invite other farmers who had not participated in these trials, but who had an interest in seed issues. Care was taken to bring women's groups separately to the research station, because it is a custom in Rajasthan that women do not express their opinions in the presence of men.

We began the visit with a discussion on the crop management practices at the experiment station and the season's rainfall pattern in order to provide some context with which farmers could judge the material in the trial. Small groups of 4-6 farmers were allowed to enter the trial at any one time to insure unobstructed observation of the test material. They were asked to look first at the whole experiment before making any selections so that they could select from the full range of varietal types represented. Farmers were given 10 labels each, numbered with a code referring to each individual farmer. They were asked to attach one label to each of the ten best rows in the trial, considering the needs of farmers in their local area. Each plot had four rows, and was accessible from both ends. Farmers thus had the opportunity to select the same genotype more than once.

Following the selection exercise, we discussed with each group separately the range of variability that they saw, the traits they considered to be useful or problematic, and the basis on which they had made their selections. Care was taken to insure that all participants could express their opinion. The farmers' visits were concluded by inviting every participant to chose the one variety he/she liked the most from a demonstration of approx. 20 advanced and released varieties. Seed of these varieties was provided to the participants at the beginning of the following season.

We assessed the farmers' varietal selections in three ways:

1. by identifying the most commonly selected varieties;
2. by determining the range of varietal types selected by individual farmers; and
3. by determining the frequency that varieties with specific critical traits such as earliness, tillering ability and large panicle size were selected.

Table 11.7 Contrasting plant type groups used for classifying experimental varieties in the Rajasthan Varieties and Population Trial

Plant type group	Maturity	Tillering	Panicle size	Representative variety
A	medium	Low	large	ICMV 155
B	early	Low	large	RCB-IC 911
C	medium	High basal	medium	HiTiP 89
D	extra early	High basal	small	HHB 67
E	early	High basal and nodal	small	ERajPop 91
F	early-medium	medium basal and nodal	medium	Barmer landraces
G	early	Medium	medium	interpool populations

The second and third approaches to examining farmers' selections relied on the classification of the experimental varieties into groups of contrasting plant types according to their maturity, tillering habit and panicle size ("plant type groups") (Table 11.7). We then compared the frequency of selection of the different plant trait groups by sets of farmers grouped by gender and location to help us understand gender and location specific patterns of varietal and trait preferences. As the composition of the trial varied each year, not all varietal groups were represented each year, and the genotypes within each group were not always the same.

Results

Rainfall patterns during the three seasons at Jodhpur were quite different, as is typical of this production environment. The 1992 season was rather wet with unevenly distributed rainfall, with short drought spells in the vegetative stage and towards harvest. The 1993 trial experienced severe early season drought, but then received moderate rainfall for the remainder of the season. The conditions for millet growth were excellent throughout the 1994 season. The differentiation between early and later maturing genotypes was very clear at the time of the farmers' visit in 1992. The later visits in 1993 and 1994, just before harvest, made the differences for maturity less obvious.

The farmers' selections in this on-station trial were widely distributed across a large number and different types of varieties. The most preferred variety in each year received only about 12% of the total labels (Table 11.8). However, these varieties were selected by most of the participating farmers, indicating wide-spread interest in these materials. Over all three years, the varieties RCB-IC 911, CZ-IC 923 and RCB-IC 926 were generally most preferred by the farmers from very different villages having different growing conditions for pearl millet (Table 11.8). The six most preferred varieties represented contrasting plant types. Each year varieties from four different plant type groups (Table 11.8) were identified as most preferred, but these groups differed each year.

Individual farmers selected varieties from 2.8 to 4.1 different plant type groups, averaged within each of the three years (Table 11.9). Individual farmers had identified varieties with very differing maturity, tillering ability and panicle and grain characteristics as being most suitable for their region. This selection of a wide range of plant types occurred with farmers from different villages (production environments) and gender groups, although women tended to select a slightly narrower range than men.

However, the frequency of selecting particular plant type groups did differ between villages and gender groups. Farmers from Jodhpur district more frequently selected earlier and higher tillering varieties than did farmers from wetter Ajmer district in 1992 (Fig. 11.2). In 1993, farmers from further west, in Bikaner district, had more frequently selected early, high tillering and taller varieties, most of which were landraces from Barmer, another low rainfall district (Fig. 11.2). This contrasts markedly with the wide range of maturity, tillering and panicle types of varieties selected by farmers from Jodhpur in the same year.

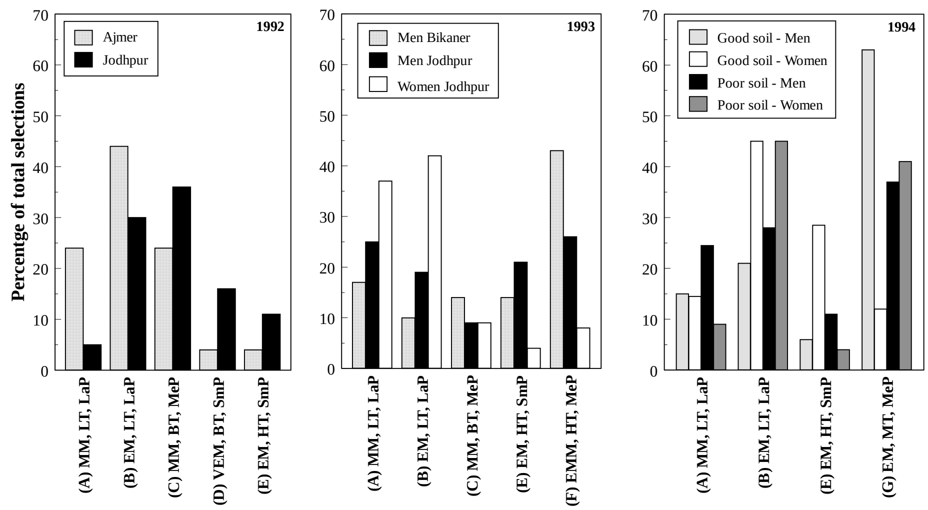

Fig. 11.2 Selection made by farmer groups from three districts in Rajasthan among groups of pearl millet varieties differing in plant type, as percentage of total selections made in 1992, 1993 and 1994.

A: medium maturity (MM), low tillering (LT), large panicle (LaP);
B: early maturity (EM), low tillering (LT), large panicle (LaP);
C: medium maturity (MM), basal tillering (BT), medium panicle (MeP);
D: very early maturity (VEM), basal tillering (BT), small panicle (SmP);
E: early maturity (EM), high tillering (HT), small panicle (SmP);
F: early-medium maturity (EMM), high tillering (HT), medium panicle (MeP);
G: early maturity (EM), medium tillering (MT), medium panicle (MeP).

Table 11.8 Most frequently selected varieties during the on-station visits to Jodhpur in 1992, 1993, 1994.

Rank	1992 Variety/ (plant type†)	1992 Percent of labels	1992 Percent of farmers	1993 Variety/ (plant type)	1993 Percent of labels	1993 Percent of farmers	1994 Variety/ (plant type)	1994 Percent of labels	1994 Percent of farmers
		N = 138	N = 14		N = 266	N = 27		N = 289	N = 38
1	CZ-IC 922 (A)‡	12.3	93	RCB-IC 924 (B)‡#	7.5	59	HHB 67 (D) ‡	12.5	61
2	ICMH 89951 (B)§	10.9	93	RCB-IC 911 (B) ‡	7.5	33	RCB-IC 911 (B) ‡	8.7	34
3	CAZRI 1002 (C)	10.1	64	RCB-IC 912 (A) ¶	7.1	37	CZ-IC 923 (A) ‡	6.6	32
4	HHB 67 (D)‡	10.1	50	CZ-IC 912 (A) ‡	6.8	44	RCB-IC 926 (B) ‡	6.2	24
5	CZ-IC 923 (A)‡	9.4	50	WRajPop (E) ‡	5.3	44	AAG 3 (G)	5.5	29
6	RCB-IC 926 (B)‡	8.0	71	Barmer LR (F)	5.3	44	ICMH 90852 (E)	5.2	37

† classification of plant type groups:

A: medium maturity,	low tillering,	large panicle
B: early maturity,	low tillering,	large panicle
C: medium maturity,	basal tillering,	medium panicle
D: extra early maturity,	basal tillering,	small panicle
E: early maturity,	high tillering,	small panicle
F: early-medium maturity,	high tillering,	medium panicle
G: early maturity,	medium tillering,	medium panicle

‡ tested in 92, 93, 94

very similar plant type to RCB-IC 926

§ tested in 92, 93, very similar to CZ-IC 923

¶ very similar plant type to RCB-IC 911

Table 11.9 Average number of variety groups selected by individual farmers during on-station visits in 1992, 1993 and 1994.

	Total No. Of groups	Overall mean	Ajmer men		Jodhpur poor soil condition				Bikaner		Jodhpur good soil condition			
					Men		Women				Men		Women	
Year			x†	n‡	x	n	x	n	x	n	x	n	x	n
1992	5	4.1	3.5	6	4.6	8	-		-		-		-	
1993	5	3.6	-		4.0	13	3.0	7	3.4	7	-		-	
1994	4	2.8	-		3.3	11	2.9	7	-		2.9	1	2.3	9

†x = mean
‡n = no. of farmers

The 1993 Jodhpur district women farmers selected large panicled and less tillering varieties much more frequently than the men from the same village, whose selections were more equally split between large panicle, high grain yield potential varieties and varieties with more tillering and better stover yield and quality (Fig. 11.2). Women in 1994 from both the same village and a new study village with more productive soils had also selected large panicled, lower tillering varieties much more frequently than men from the same villages. Follow-up discussions indicated that women from these villages especially valued grain yield, earlier availability of grain for food security and the ease of harvesting by hand resulting from lower panicle number and lower plant height. A novel class of varieties which combines the high tillering of local varieties with large panicles of introduced varieties (group "G") was frequently selected in the very favourable 1994 season (Fig. 11.2). This group of varieties was selected with equal frequency by men and women from the village with previous experience of growing some of these varieties. Men from the new study village with more productive soils had selected this group of varieties even more frequently, whereas the women had almost completely ignored it. These women placed a strong preference on high grain yield and ease of harvesting. With the better soil conditions in this village, and more experience with modern varieties, these women have a higher chance of utilising this plant type successfully than the women from the other village in Jodhpur district.

Discussion

Farmers' selection of experimental varieties in on-station trials offers breeders an additional source of information for evaluating new varieties and deciding which varieties to promote for advanced testing. The direct input of farmers at this stage of testing would be especially important for crops such as pearl millet in Rajasthan, where there is such a wide range of farmers' considerations relating to varietal preferences. Also, this information is gained at little extra cost as observations are made on routine trials.

To summarise the information gained by seeking to understand farmers' observations and preferences at the stage of initial testing of pearl millet varieties:

- A wide range of varietal types are important to farmers in the region.
- Gender differences in varietal preference do exist and are related to the importance of grain and stover characteristics and characteristics related to ease of harvesting.
- Varietal preferences vary by production environment within this region. Earlier maturing, higher tillering varieties are needed for drier production environments, whereas the role for introduced varietal types with larger panicles and medium growth duration is potentially larger in the better endowed environments.
- There are good opportunities for adoption of a novel varietal type combining characteristics from both local and introduced pearl millets.

We observed the following potential weaknesses of evaluating farmers' selections in on-station trials:

- the trials are grown under different conditions than the farmers' own;
- farmers see the varieties at only one time in the season, and
- evaluations of individual varieties is difficult.

Specific varietal differences may not be clearly visible at the time of the farmers' visit, e.g., early maturity or synchrony of tillering would not be apparent if the visit occurs late in the season, or the grain and stover yield of all of the entries if the flowering range in the trial is large and the visit occurs earlier in the season.

The advantages of having farmers select varieties in on-station trials are that farmers can be exposed to a much larger range of variability under uniform growing conditions than in on-farm trials, and there is no risk to the participating farmer of crop failure of unadapted types. Farmers who decide to participate in the visit to the research station are usually keen experimenters, and are prepared to spend time to interact with the researchers. Thus discussions are fruitful and informative, providing valuable input for targeting an applied breeding programme. Additional gains in efficiency of the research process could also result from farmers choosing their own varieties for on-farm evaluation, facilitating an earlier involvement of farmers in the process of varietal evaluation.

Generating Variability - A Role for Farmers?

Choosing breeding material, developing the germplasm base, choosing parents, making crosses, and random mating populations are major and crucial activities of every plant breeding programme. It is generally assumed that breeders have a major comparative advantage over farmers in choosing germplasm and in the breeding activities that produce genetic recombination leading to new combinations of traits and gene complexes for quantitative traits (Sperling and Scheidegger, 1996, Ceccarelli *et al.*, 1996). However, for cross-pollinated crops where crossing occurs naturally, we envisage a role for farmers in this process, based on observations made during the on-farm variety evaluations, and during interviews regarding seed management issues.

Farmers use exotic germplasm

After two years of on-farm variety trials in western Rajasthan, with new varieties that differed from the local varieties in many significant ways, we observed that participants in on-farm pearl millet variety trials in western Rajasthan are involved in generating new variability. Although none of the experimental varieties fully satisfied the participants' needs, the farmers nevertheless saved seed of these varieties for their own efforts in seed selection because they valued specific traits of the new varieties. This saved seed was most often planted in a mixture with their own local variety. Farmers typically do this to reduce the risk of crop failure from a new seed source. These mixed sowings resulted in further inter-mating of the two groups of material. During the excellent growing season of 1994, farmers in Aagolaie observed frequently an increase in variability in their seed stocks. We observed intense discussions among farmers about selection in these more variable seed stocks.

Based on this experience, we propose that it may be worthwhile for breeders to consider using population crosses and random matings made by farmers as base material. Potential benefits in the extent of recombination and effectiveness of selection could be obtained under farmers' field conditions with the very large population sizes and thus high selection intensities for the farmers' most preferred traits and trait combinations. Natural selection would help to eliminate genotypes unadapted to the most severe stress factors. Breeders, in contrast, must often operate under nonrepresentative or off-season conditions and thus may have to cope with large genotype x environment interactions (Ceccarelli *et al.*, 1996). Furthermore, breeders commonly face severe limitations on the number of plants that can be handled per population cross. A further advantage of using farmer generated population crosses could be that the breeders' efforts could be concentrated on targeted improvement of specific traits that farmers cannot easily select for on a single-plant basis (e.g., grain yield, stover yield or disease resistance) by reducing efforts dedicated to selecting for yield components and adaptive or quality traits.

The primary role of the breeder in the process of generating new variability with farmers would be to make useful new variability available to farmers so that the chances are high for generating new population-crosses with a high productivity level and the genetic variability required to achieve genetic gains for the target traits. To make appropriate choices it would be beneficial for the breeder:

- to have farmers' involvement in evaluating the range of available variability and identifying the sources of highest priority, and
- to have estimates of the combining ability of farmers' local varieties with the different sources of germplasm that the farmers would like to use.

To date, we have limited experimental evidence that such farmer-generated population crosses fulfil the expectations of high productivity and useful variability. A few seed stocks of farmer generated population-crosses were collected in 1993 from farmers participating in the on-farm trials in Jodhpur and Bikaner districts in Rajasthan. These samples were included for evaluation in the Rajasthan Varieties and Populations Trial in 1994. One entry (AAG 3) was among the five varieties most preferred by farmers who visited the Jodhpur research station in 1994 (Table 11.8). Its grain and stover yield was as high as that of the improved varieties evaluated by farmers in the on-farm trials described earlier (data not reported).

Quantifying farmers' breeding efforts

As a result of this observation we designed a separate study to evaluate the performance of farmer-generated seed stocks in comparison with their own food-grain stocks and the varieties evaluated in the on-farm trials. These studies are on-going, and will help to determine the benefits that can be obtained from involving farmers in the process of generating population crosses between locally adapted landraces and modern varieties or other germplasm with desirable characteristics.

As part of this study, we conducted semi-structured interviews in the villages in Ajmer, Jodhpur and Bikaner districts where on-farm trials were conducted to seek information about indigenous methods of seed production and selection. These interviews were conducted as we collected farmer-generated seed stocks and mostly involved farmers who are considered locally to be experts in seed selection and production. This included both participants and non-participants in the on-farm trials. Topics addressed during the interviews included the traits used for selection under different conditions, factors affecting the decision to select in the standing crop rather than on the threshing floor, methods for storage of seed and food grain, and the movement of seed in and out of individual farms.

These discussions, held after both the 1994 and the 1995 cropping season with 28 farmers from the four villages in Ajmer, Jodhpur and Bikaner districts, revealed that farmers in the two drier districts, Jodhpur and Bikaner, were very particular about maintaining their own seed stocks, because they perceived that purchased seed may be unadapted to the harsh conditions in these areas. They tend to store seed grain separately from food grain and regularly keep seed stocks from good years for 2-3 years, as a safeguard against crop failures. Farmers in Bikaner district with larger land-holdings were proud to report that their families had maintained their own seed stocks even through major drought periods throughout the last 100 years. In Ajmer district, farmers try to maintain preferred varieties on their farm, but frequently purchase certified or locally produced seed from the market.

Farmers who keep their own seed practice selection in at least one stage: just before sowing, they sieve and winnow the seeds carefully so that only undamaged, large, well filled grains are sown, thus improving the chances for successful emergence. In years with good crop growth and good conditions for grain filling and ripening, many farmers will select better panicles to save as seed. The selection of panicles is either done in the standing crop before general harvest or on the threshing floor. This is frequently and predominantly done by women. Farmers indicated that the most important selection criteria are well filled and mature grains, to assure good emergence. Poor farmers tend to spend less effort on seed management and often rely on other farmers in the village for their seed supplies.

Based on our finding that farmers often practice selection among panicles for saving seed and our good experiences with a selection simulation exercise conducted in the standing crop of a variety mixture in 1992 in Ajmer district, we developed a panicle selection simulation exercise (Dhamotharan *et al.*, 1996). During this exercise, farmers were presented with a set of one hundred numbered pearl millet panicles, representing a somewhat wider range of panicle types then those commonly grown in this region. Farmers were asked to select out of this bulk ten panicles that would be most suitable for use as seed on their farm. They were then asked to describe the most important features of the selected panicles, and the main reasons for choosing the ten panicles. We tried this exercise in one village with highly variable soil conditions in Jodhpur district. We had not done any previous work in the village. Working with a wide range of farmers, representing men and women who own good land, or poor sand dune land, and those owning wells we found the following:

- Panicle size is an important selection criterion for which farmers have markedly differing preferences. Farmers with better land prefer larger panicles, whereas farmers with very poor, sand dune land prefer smaller panicles. Farmers associate specific growth characteristics with specific panicle types.
- Grain quality traits that are considered in the selection process are grain colour and grain shape. Lighter grain colours are normally preferred because the *chapati* (local flat bread) colour is more acceptable. Farmers associate a somewhat bitter taste with very dark seeds. Because pearl millet grains darken with age, a dark grain colour leads consumers to assume that the grain is old, which is less preferable. Round grains, rather than oblong, or grains pressed into angular shapes on a very compact panicle are preferred because of the perceived higher flour percentage obtained from these grain shapes.
- Bristles, especially long bristles, are always preferred, as they tend to deter birds. Bird damage can be severe in pearl millet, particularly in poor years, and thus farmers are keen to incorporate any type of bird protection into their varieties.
- Many farmers selected a wide range of panicles types to represent several different plant types of pearl millet. Farmers owning better quality land or more land tended to select panicles representing the most diverse range of panicle types. These farmers wanted seed stocks that would be useful for a broad range of planting conditions, i.e. high or low soil fertility, and early or later sowing for seasons with more or less rainfall. Some farmers also expected that the selection of the most extreme plant types would also produce intermediate plant types in the following generation of seed multiplication.
- Farmers with very poor sand dune land were the only ones in this village who selected only one type of panicle during the panicle selection simulation. They all selected very short, thin panicles with short bristles, with round grains largely covered by glumes. They associated these characters with the high tillering (basal and nodal) type of the local landraces. Panicles selected by these very poor farmers were the ones that the farmers with more and better lands had discarded as unsuitable for seed. It thus appeared that the seed requirements of farmers owning

different quality lands in the same village differ so much that there is not even an overlap in preferences as expressed in the panicle-selection simulation.

There are many advantages of using the panicle-selection simulation for interacting with farmers on these issues. The interviews can be conducted at a time when there are fewer demands on farmers' time, and thus favouring fruitful interactions. Farmers' participation in such a simulation exercise requires less time compared to growing an experiment or visiting a distant experiment station. This is particularly important for involving women and poor farmers. This exercise also tended to offer opportunities for more in depth discussion of specific topics, as well as offering opportunities for involving other farmers and family members in the discussions.

The results of the panicle selection simulation exercises appeared to be realistic, useful and reliable, corroborating or extending previous findings. The results themselves need to be verified by conducting the simulation exercise in a wider range of villages and with a larger number of farmers.

Discussion

Farmer involvement in generating variable breeding material appears to offer exciting possibilities for cross-pollinated species such as pearl millet. The farmers' advantages include large population sizes, opportunities for recombination, and both the farmers' own selection and natural selection in the target environment.

Conducting the matings to produce new population crosses in the target environment could have favourable consequences on gene frequencies and actual recombinations achieved. Where crossing involves elite but exotic populations developed under quite different conditions, large differences for adaptation, or specifically lack of adaptation, to the target environment may be expected. Reproductive fitness may be well related to adaptation, and crossing in the target environment could result in more favourable genetic composition of the crossed population. The beneficial effect of natural selection in broad based populations, especially when exposed to abiotic stress, have been documented in a number of species (Allard, 1996).

Improved understanding of farmers' concepts and strategies for maintaining their seed stocks, their selection and composition would strengthen any efforts to organise farmer-breeder collaboration in developing new sources of genetic variability as described in this section. This information would further benefit researchers who are utilising local germplasm in their breeding programme, as is being done for pearl millet improvement for western Rajasthan (Weltzien and Witcombe, 1989; Bidinger *et al.,* 1994).

Defining Goals for the Breeding Programme

The goals of a breeding programme influence the choice of breeding method, the type of the germplasm used, and the selection sites and screening facilities required. The formulation of goals is thus crucial to any breeding programme. It is therefore surprising that little research has been reported on methodology for identifying appropriate goals for breeding programmes. Historically plant breeding as an enterprise and a research discipline has evolved out of crop improvement in general (Gäde, 1993). Thus the intricate understanding of farmers' production goals and the familiarity with future trends in production conditions formed the basis for genetic crop improvement. With the rapid developments in genetics and their application to crop improvement, the linkage between genetic, agronomic and farming system improvements has weakened. Plant breeders may be unfamiliar with the specific production conditions and thus appropriate goals are not obviously set (Haugerud and Collinson, 1990). This is particularly critical in marginal environments where farming is frequently subsistence rather than market oriented, and farmers strategies for coping with large seasonal variations are not well understood (Matlon, 1987).

In the process of establishing a pearl millet breeding programme for the drier regions of Rajasthan, we needed to understand three main issues in order to focus the breeding work appropriately and effectively:

1. What is the relative importance of earliness, grain yield and stover yield, and how do these relate to regional and seasonal variations in growing conditions?
2. Which specific plant traits or combinations of traits are preferred by farmers, and why?
3. Are grain and stover quality traits important for choosing new varieties, and if so, what are determinants of desirable quality?

We used a wide range of methods and approaches to improve our understanding of these issues. These consisted of the previously described on-farm variety evaluations, farmers' selection in on-station trials, and discussions with farmers to understand their strategies for seed management.

Methods

We used formal, structured, pre-tested questionnaires in an initial study to understand the causes for non-adoption of modern pearl millet varieties in western Rajasthan. Most of the discussions with farmers centred on farmers' perceptions of the relative importance of grain versus stover yield (Kelley *et al.,* 1996). The informativeness of this survey was limited by the farmers' lack of experience with the full range of newly released and pre-release pearl millet varieties. These varieties differ for many agronomic traits, particularly for earliness. We found that it was difficult for farmers to conceptualise the full range of available varieties while expressing their preferences and concerns.

Farmer managed on-farm trials were therefore initiated with a range of newly-released or pre-release varieties as a way of facilitating this dialogue with farmers. Individual interviews were conducted with each participant to compare a single test variety with the adjacently sown local variety. The farmers were asked to indicate which traits differed between the two varieties, and which traits were desirable and important.

The results of these discussions were influenced by the particular genotype under evaluation and by the growing conditions in the experimental field. We tried to overcome the first limitation by discussing with each farmer the characteristics he or she would consider essential for an ideal variety. This discussion gave farmers the opportunity to mention traits that were not exhibited by the experimental or farmers' own variety, and to mention preferred trait combinations. Furthermore, interested farmers were invited to participate in group discussions comparing all varieties being tested in the village, and to visit the research station to examine a broader range of experimental varieties.

Results

Grain yield, stover yield and earliness

Earliness was one of the most frequently mentioned traits in the on-farm varietal comparisons and when discussing the nature of an ideal variety in all three districts (Tables 11.10 and 11.11). The frequency with which earliness was mentioned in Ajmer district was surprisingly high as it has the highest seasonal rainfall and the longest growing season (van Oosterom *et al.*, 1996). Although earliness would seem to be of most benefit in the drier areas of western Rajasthan, the differences among varieties for earliness were most pronounced in Ajmer district. Two of the experimental varieties, HHB 67 and RCB-IC 911, flowered and matured distinctly earlier than the commonly grown varieties in Ajmer district. Farmers in this area had no previous experience with this degree of earliness. It was perceived to be advantageous in 1992 as it gave many farmers the opportunity to plant a post rainy season crop with the late rains that year. Earliness was again seen to be desirable in 1993, but this year was a dry year and earliness was thought to be the key to higher grain yields. The local varieties from the two drier districts, Jodhpur and Bikaner, mature early, thus the differences between local and early maturing experimental varieties were smaller. The effect of low soil fertility and other stresses on delaying flowering may be greater for the experimental varieties (Weltzien, unpublished data), thus further reducing the maturity differences between these breeding materials and the local varieties. The desired degree of earliness was related to the length of the growing season in the three districts and the growth duration of the prevalent varieties in a district.

Farmers mentioned grain yield more often than stover yield in the two drier districts while comparing varieties in on-farm trials and describing an ideal variety (Tables 11.10 and 11.11). Responses from on-farm varietal comparisons in Ajmer district, however, indicated greater attention to stover yield than to grain yield. This could reflect:

- the locally grown varieties yield more fodder than two of the experimental varieties, especially HHB 67, and
- the greater need for stover in eastern Rajasthan to feed the larger cattle and buffalo populations.

Table 11.10 **Percentage of farmers using productivity related traits to distinguish the experimental variety from their own variety, 1992 to 1995 results combined, across all experimental varieties.**

Trait	Ajmer 1992-93	Jodhpur 1992-95	Bikaner 1992-95
No. of farmers surveyed	39	59	62
Grain yield	43	53	65
Stover yield	65	31	47
Earliness	50	41	50
Large panicles	59	41	51
Large grain size	43	46	39
High tillering	22	23	56

Table 11.11 **Percentage of farmers using a trait to describe an ideal pearl millet variety, based on surveys conducted in 1992 and 1994 in Ajmer, Jodhpur and Bikaner districts.**

Trait	Ajmer 1992	Jodhpur 1992/94	Bikaner 1992/94
No. of farmers	22	32	33
High grain yield	32	56	67
High stover yield	23	28	42
Earliness	55	50	61
Large panicle size	77	75	45
Large grain size	45	34	30
High tillering	27	72	70
Low water needs	0	6	42
Good grain filling	32	9	42

Group and individual discussions with participants in on-farm evaluations about the reasons for their varietal preferences indicated that farmers in all districts want varieties that will yield at least some grain, i.e. more than the local variety, in very poor years. They would rather sacrifice some grain yield in a good year than harvest only stover in a poor year. Farmers associated earliness and plant architectural traits such as higher tillering and smaller panicle size with the ability to yield grain under adverse growing conditions. The variety RCB-IC 911 was considered to provide the desired grain yield and earlier maturity for a wide range of farmers in Ajmer district. This variety was distinctly later flowering than the local varieties in Jodhpur and Bikaner districts, whereas the earlier maturing hybrid HHB 67 interested farmers, especially under relatively favourable growing conditions (Whitaker *et al.*, 1996). However, under early season drought stress and poor fertility conditions, the earliness of this variety did not provide any grain yield advantage over the local varieties, and its stover yield was frequently unacceptable.

Preferred plant type

The on-farm variety comparisons and descriptions of an ideal variety indicated that farmers' preferences between the higher rainfall district Ajmer and the drier western part of Rajasthan differed most strongly in the attention paid to tillering (Table 11.10). Tillering was important to farmers of western Rajasthan as it is a component of both grain and fodder yield as well as stover quality. Farmers associate tillering ability with better adaptation to water scarcity and poor fertility conditions (Table 11.12). They also consider it to be a component of stover quality. Nodal tillers frequently do not mature before harvest and thus increase the feed quality of the stover. Higher tillering varieties commonly have thinner stems, which result in higher intake by the animals, without the need to chop the stover. The type of varieties selected by farmers in the on-station trials (Fig. 11.2) as well as the type of heads chosen in panicle-selection simulations further supported this preference for high basal and nodal tillering in Jodhpur and Bikaner districts.

Table 11.12 Adaptive traits which farmers in Jodhpur and Bikaner district observed during three years of on-farm variety comparisons (items in bold were mentioned very frequently).

Trait	Reason
Plant type:	
• **Early maturity**	• associated with low water requirements
• **High tillering**, nodal tillering, many leaves	• associated with high productivity under stress conditions
• **Tall plant height**	• associated with high fodder yield under stress conditions
• Large panicle, large grain	
Overall adaptation:	
• Good germination, **fast germination**	• stand establishment is essential
• Low seedling death	
• Low water requirements, good growth in early drought, dark leaves, less drying, less leaf firing	
• Low soil fertility requirements	
• **Good seed set**	• flowering, pollination and early grain development are very sensitive to stress
• **Reduced bird damage by bristles**, glumes	• bird damage in poor years causes severe losses; bristles and glumes contribute to birds' non-preference for panicles
• Uniformity	
• Disease resistance	

Long and/or large (girth and length) panicles were frequently mentioned during individual variety comparisons and as a trait of an ideal variety. Panicle size was always a criterion used by farmers when simulating panicle selection for obtaining seed for sowing. Group discussions revealed that farmers realise that there is a trade-off between panicle size and tillering ability. Farmers from Ajmer district always preferred larger panicles over high tillering (Fig. 11.2); farmers from Jodhpur district consider these traits to be of equal importance; those from Bikaner district, where soils are mostly poor and rainfall is lower, preferred high tillering over large panicle size. However, further discussion with farmers from the same village revealed that differences in preference for these two traits exist (Fig. 11.2) due in part to highly variable soil conditions.

Although our discussions with farmers dealt extensively with these major agronomic traits, farmers also regularly observed a range of traits considered to be important for adaptation and productivity (Table 11.12).

Grain and stover quality

An initial structured survey of farmers indicated that the quality of grain and stover of pearl millet varieties are important, and the lack of desirable quality traits was one of the reasons given for the low adoption of modern varieties in Jodhpur district (Kelley *et al.,* 1996). A post-harvest survey conducted as part of the 1992 on-farm trials indicated that farmers recognise many determinants of grain and stover quality (Table 11.13).

Table 11.13 Percentage of farmers preferring their own cultivar for traits contributing to grain and stover quality, as observed during 1992

Trait	Ajmer	Bikaner	Jodhpur
No. of farmers	19	21	19
Grain size	5	0	0
Grain colour	26	53	95
Cooking quality	11	5	0
Chapati taste†	21	74	57
Chapati keeping quality	21	58	67
Overall grain quality	16	74	71
Stover appearance	16	16	43
Chopped quality	32	63	43
Animal preference	11	42	28
Overall stover quality	21	74	33

† local flat bread

Farmers in western Rajasthan clearly preferred the grain qualities of their local varieties. The most important aspects of grain quality were grain colour, *chapati* taste and keeping quality (Table 11.13). Farmers believe that grain quality is mostly related to lighter, yellowish grain colour, and sometimes the sweet taste of raw grain. Preferences in eastern Rajasthan, in contrast, appear to have changed through the wider availability and adoption of modern varieties (Table 11.13).

Thin stemmed stover of local varieties was consistently preferred by farmers who do not own fodder choppers, mostly in western Rajasthan. Fodder quality for chopped fodder was related to thicker stems, whereas thinner stems were preferred for direct feeding.

Discussion

Our varied interactions have shown how farmers' priorities vary by region as well as within region, within a village, and within a household according to production conditions and the range of seasonal variations. These results suggest that a range of pearl millet varieties is needed, and that it would be appropriate to provide farmers the opportunity to observe and choose from an array, those types that best meet their needs. Based on our interactions with farmers, our collaborative breeding work has placed greater emphasis on breeding earlier, higher tillering populations and varieties with improved seed setting ability, as an approach to develop high and stable yielding varieties. Work on high tillering, medium maturing varieties, for dual purpose use was reduced considerably. Also, new opportunities were identified that we would not have considered without direct involvement of farmers, such as earlier maturing varieties in a long-season growing environment.

Commercial endeavours succeed only if the consumers' needs and desires are effectively served. So too for the development of new crop varieties, the identification of needs and priorities of farmers is essential for setting breeding objectives. Dialogue between researchers and the farmers they intend to serve will help to ensure that the research pursued matches the needs and opportunities to the greatest extent possible. We used a range of methods to obtain a better understanding of the varietal requirements for the complex production systems for pearl millet in Rajasthan. These methods proved useful in providing both quantitative information, as well as insights and understandings important for focusing our breeding work. No method was perfect, and use of different methods helped to confirm or extend our findings.

Overall Conclusions

We have outlined in this paper opportunities for, and results from, farmer involvement and participation in the main stages of a formal breeding programme. Our results and observations indicate that at all stages input from farmers can be very meaningful and helpful in achieving appropriate outcomes, and thus making such programmes more cost-effective.

Our results showed that farmers' active involvement in the evaluation and ranking of experimental varieties leads to reliable and rapid identification of those that are most acceptable. It is also our experience that farmers will clearly state if varieties are not useful and why. Such information assists the breeder in deciding which varieties to promote for advanced testing or which ones to propose for release in a particular region. Information gained from farmers' evaluation of new varieties under target growing conditions could also be useful during the release process, assisting decision makers to release those varieties for widespread cultivation that farmers are interested in growing. Farmer involvement in variety evaluation could considerably reduce the time between initiating variety testing and variety adoption, particularly if farmers have the option of multiplying their own seed.

Farmers' participation in selection was mainly discussed with respect to farmers' involvement in on-station evaluation of progeny trials, or variety trials. In the system of pearl millet cultivation as it is found in Rajasthan, it is difficult to envisage how a large number of progenies or varieties could be effectively tested by farmers in their own fields for selection. There is, however, no difficulty to foresee farmers' involvement in the selection among single plants in a population bulk sown in their own fields, especially if simple methods for pollination control can be implemented.

The use of farmer-generated population crosses, may help to increase potential gains from a formal breeding programme by relieving breeders from selecting for adaptive and quality traits, and thus allowing more focus and intensity for selection on disease resistance or productivity related traits. Attempts to implement farmer-generation of population crosses would benefit from more detailed analyses of the local seed management systems, and further characterisation of the available genetic diversity for traits of particular interest in the target production system. A study is underway to investigate the effects of farmers' selection and seed composition strategies.

It is our experience that several different types of interactions with farmers regarding varietal and seed management issues also improved our understanding of farmers' needs and preferences. There is no doubt that appropriate targeting will help to maximise the gains that can be expected from a breeding programme. Understanding farmers' needs and preferences is helpful in developing these targets. Our work on understanding farmers' preferences for specific varietal traits has resulted in major shifts in the ICRISAT breeding programmes conducted in collaboration with national agricultural research institutes in Rajasthan. Most importantly, an increase in the efforts to combine early maturity and high grain yield, with high tillering and good stover quality. Work on medium maturity dual purpose types was much reduced. Further changes are the use of stover yield and a visual score of stover quality as routine selection criteria. We are further attempting to incorporate bristles into preferred varieties, as well as into our breeding populations. We place less emphasis on the improvement of pure landrace based populations, but increased the range of population crosses between local varieties and early maturing improved population of exotic origin. The use of non-Rajasthan locations as selection sites was also reduced. We plan to increase the testing of breeding material under low fertility conditions. Many of these changes are gradual in nature, but overall constitute a major reorientation with a clearer focus.

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