Participatory methods for collecting germplasm: Experiences with farmes in Rajasthan, India

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Introduction

Strategies for collecting genetic resources

Germplasm has been collected and exchanged for many centuries. Initially, explorations aimed at finding appropriate species and local "varieties" for cultivation as such, whereas later on, when plant breeding emerged as a scientific discipline, indigenous genetic resources (landraces) commenced to be regarded as a "raw material" for crop improvement, containing useful traits which had to be combined or improved by plant breeders. This change has been documented at least since the period between 1910 and 1920 (Flitner 1995). Usually, germplasm explorations were undertaken by scientists, with the intention of collecting the widest possible range of genetic diversity of a crop or wild species, based on geographical distribution, observation of morphological traits, agroclimatic data, soil conditions and population genetic considerations (Marshall and Brown 1975; Witcombe and Gilani 1979).

For practical reasons and lack of information on the population genetic structure of a target species, the number of samples to be collected was usually kept as high as possible, even if they were found in relatively close proximity. The ideal of genetic conservationists was to preserve the whole range of variability in a species (Marshall 1990). As time is usually a constraint during collecting trips, a minimum of information about each sample was collected, limited mostly to agronomic and environmental factors which can be observed in the field that is sampled. This information includes soil conditions, associated crops or weeds, and the presence of certain pests and diseases. As a result, very large collections were formed with relatively little information about individual samples (Weltzien and Bhatti 1991; Appa Rao 1978).

Newly collected material is then systematically characterized on research stations based on criteria considered to be important by taxonomists and plant breeders, so that information about the new collections can be made available to potential users.

Worldwide, more than 6 million accessions are presently stored in genebanks (Hammer 1998), and regeneration, multiplication and evaluation of these huge collections have become a considerable cost factor (Hawtin *et al.* 1997). The documented information associated with the collected samples is often insufficient to identify duplicates, and to decide how many and which samples would really be needed to represent most of the genetic diversity of a given crop species. In recent years, genebanks have started developing core collections, a concept which aims at representing and maintaining the diversity of a species within a manageable number of accessions, using hierarchical approaches based on criteria such as geographical origin, or morphological and agronomic traits to stratify the parental collection (Brown 1989).

Genebanks are also facing new challenges, such as repatriation of landraces when seed was lost involuntarily due to drought, migration, wars or other factors. Another issue is to link *in situ* and *ex situ* conservation in a more efficient way, so that both the formal breeding sector and farmer breeders can use the diversity of the collections for their crop-improvement efforts. The attitude toward landraces has been changing in recent years, as improved cultivars have not always proved to be superior, for example in marginal environments or under specific socioeconomic conditions (Weltzien and Fischbeck 1990; Ceccarelli *et al.* 1992). Landraces are sometimes also preferred by farmers for quality aspects (Dhamotharan *et al.* 1997). Thus, a new interest has arisen to use traditional landraces as such, or in breeding programmes.

In the approach outlined in this article we propose that farmers' knowledge could help to identify samples that are most representative of a landrace, and also to classify and use landrace collections more efficiently. Involving farmers in the collecting of germplasm could avoid unnecessary cost of evaluation, because some of the information required might already be known among the present users.

Given these considerations, we decided to test and adapt communication methods based on PRA approaches for their use during collecting trips. Our objective was not only to document the farmers' knowledge together with each sample, but also to actively involve the farmers in the identification of landraces and representative samples to be collected. We used pearl millet [*Pennisetum glaucum* (L.)R.Br.] in the Indian state of Rajasthan as an example. The samples were required for a diversity study in the framework of a collaborative project: "Enhancing quality, diversity, and productivity of farmers' pearl millet genetic Resources in Rajasthan, India", which is implemented jointly by the

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the University of Hohenheim, Germany, and funded by BMZ, the German Ministry for Economic Cooperation and Development.

Pearl millet in Rajasthan

Rajasthan is a semi-arid region in the northwest of India (Fig. 1), with mean annual rainfall between less than 350 mm in the western part of the state, and more than 750 mm in the southeast (Fig. 2). Soils are mainly sandy in the western part, whereas higher silt and clay contents are found more frequently in the central and eastern parts. Topographic structures like hills, riverbanks and man-made water-catchment areas have created diverse soil conditions and microenvironments.

Pearl millet is cultivated on $4\text{-}6 \times 10^6$ ha in Rajasthan, and is the main food and fodder crop of the state. It is grown as a monsoon crop (June/July to October), sometimes with additional irrigation. A variety of legumes, i.e. mung (*Vigna radiata*), moth (*Vigna aconitifolia*), guar (*Cyamopsis tetragonoloba*), and other crops like sesame (*Sesamum indicum*) and cucurbits (*Citrullus* spp.) are often grown in mixtures with pearl millet. During the winter season, crops like wheat (*Triticum aestivum*), mustard (*Brassica* spp.) and cumin (*Cuminum cyminum*) can be grown under irrigation or in water-catchment areas. Animal husbandry (cows, buffalos, goats, sheep and camels) is an important part of the farming systems in Rajasthan, involving use of crop residues, natural rangelands and agroforestry (legume trees).

In the higher-rainfall areas, i.e. the central and eastern parts of the state, single-cross hybrids and open-pollinated improved varieties have been widely grown by farmers for the last 10-20 years. Seed markets are well developed, and in some areas local landrace varieties have largely been replaced. In the western part of Rajasthan, where growing conditions are harsher, farmers prefer to use landraces or grow mixtures of traditional and modern varieties of pearl millet.

Methods

Identification of sites, key informants and collecting

Prior to collecting, nine districts of Rajasthan were defined as target areas, covering the east-west dimension of the state and a wide range of socioeconomic as well as natural conditions. These districts were Barmer, Jodhpur and Bikaner in the drier western part, Ajmer, Sikar and Churu in the centre, and Jaipur, Alwar and Sawai Madhopur in the east. However, parts of Pali, Nagaur and Tonk districts were also explored during the trips (Fig. 2).

The collecting was carried out in three stages:

First step: The purpose of the first stage was to identify areas or villages in a district where landrace cultivars are still regularly grown. We gathered initial information from local NGOs and pearl millet scientists working in the state. We talked directly with farmers about where traditional landraces were still being grown and used, and why. In such places, we identified 2 or 3 families having the most representative material and being experts in knowledge about pearl millet seed in the opinion of the villagers. These farmers were informed about the purpose of our study and that we would like to visit them again at the harvesting time to collect the samples. The farmers were also asked to give a general description of their landrace, and whether it was different from other local cultivars grown in surrounding villages or other nearby places. Occasionally, we found that only a single family in a village maintained a landrace. In these cases, most often it had been brought from other places, and samples were then collected from the place of origin.

Pearl millet being a cross-pollinating crop, it is not always easy to identify landraces without introgression of exotic material in areas where both landraces and modern varieties are grown. Therefore, it was part of our methodology to ask questions of elder villagers about the history of a landrace in the village and with a farmer family, about seed management during drought periods, and about differences between present-day landraces and the landraces they had known during their youth. This information was needed to separate more or less "pure" or original landraces from material where a lot of introgression had taken place in recent years.

Second step: From each identified variety and farmer, we collected a sample of 20-40 whole panicles randomly from their fields or threshing floor at the time of harvesting. This sampling strategy was selected because of the specific requirements of a diversity study, for which the samples were needed, and may not be adequate for other purposes, such as conservation of landraces. The information on seed-management practices, description of the landrace, environment and agricultural practices, as well as specific adaptation, uses and reasons for the family to grow this variety were recorded. Names of the donor(s) as well as people who participated in the interviews were documented for each sample.

Third step: In a third step we revisited villages and farmers of specific interest during the post-harvest

time. At this time we could collect detailed information about grain and stover quality aspects and specific seed-management procedures followed by the villagers. These are areas of expertise of women in Rajasthan, and do require specific attention.
Step one was completed in September 1997, in 10 days of traveling in eastern and central Rajasthan, 2-5 weeks before harvest. Step two and the collecting of samples took place in October 1997 in these districts, in 20 days of traveling. However, harvesting started soon in some areas of western Rajasthan, and thus steps one and two had to be merged together in some cases. In total, more than 800 farmers were interviewed at roadsides, village tea-shops, in their fields and at their homes. The third-step visits were restricted to only seven villages/regions of specific interest, and 2-4 days were spent in each of them.

Composition of collecting team
In a gender-sensitive social environment such as Rajasthan, the composition of a germplasm collecting team is also an important part of the methodology. Our team consisted of a female agronomist/agricultural social scientist, a male socioeconomist and translator of the local language, and a male driver/assistant. Some of the places were visited in the post-harvest period (third step) with a female-only team to encourage women farmers to express their knowledge, which is more difficult in the presence of men.

Communication tools
Participatory communication tools had already been developed and used with farmers in Rajasthan (Dhamotharan *et al.* 1997). Based on this experience, we decided to use semi-structured interviews in discussions with groups and individual farmers. This interview technique leaves the conversation open, but some pre-defined questions will always be asked sooner or latter during the interview. Nevertheless, unexpected topics raised by the farmers themselves can also be discussed, and the questions can purposely be asked in a way to encourage new and unexpected points (Sch,nhuth and Kievelitz 1994, p. 77-79).
An important element of PRA methods is visual sharing of the matters discussed. Therefore, farmers were encouraged to show the crop in the field or describe traits using grain samples or whole panicles, whenever possible. Additionally, tools like pairwise ranking or mapping were sometimes used to describe differences between varieties, soil conditions, agronomic or seed-management practices in greater detail (Sch,nhuth and Kievelitz 1994, p. 82 ff.).

Documentation
The interviews were documented by one team member taking notes during the interview. Soon after each interview, we filled in details and clarified the notes. In some cases, the documentation was done with tape recorders, and the interviews transcribed and translated later. The collecting team added information such as latitude and longitude of the collecting site, topography, agronomic score, frequency and their own observations. The data were transferred into a specifically designed form after collecting, so that the conversation with the farmers was not dominated by the form-filling procedure (an example of the form used is given at the end of this article).
The 42 samples were stored at the genebank of ICRISAT for further analysis, and a second set of samples sent to the National Bureau for Plant Genetic Resources, New Delhi, along with the collecting report (Christinck *et al.* 1998).

Results and discussion
Experiences with PRA techniques during collecting trips
It soon became evident that semi-structured interviews and PRA tools can be successfully applied for communication with farmers, even when the collecting team visited the village for the first time. The research team going to traditional meeting places, farmers' houses, and fields, and initiating the conversation with open questions allowed the villagers to express their knowledge. Farmers themselves very often suggested visual sharing like looking at samples or fields, so that PRA elements such as pairwise ranking could easily be integrated into the conversation. This, however, depends on the season and availability of whole plants or panicles during the interview time.
There was a tendency toward large gatherings of the villagers during the first stage of the collecting process, with the result that lower-status persons could not speak freely. This could be avoided by also talking to people in their fields or houses. In this context, it was clearly an advantage to visit the same villages and families twice. The working atmosphere was more relaxed during the subsequent visits, and thus the quality of the information was considerably better. This was particularly apparent in those cases when the follow-up visits were conducted during the post-harvest season. During this

time, farmers as well as researchers are not pressed by pending harvest operations. Having more time in a village also opens up the possibility to meet people from more different castes and groups in the village, and more women, which is particularly important if gender-specific knowledge has to be documented. In Rajasthan, women are key persons involved in activities such as seed selection and storage, preparation of food and medicines, and feeding animals, but do usually not participate in a conversation in the presence of (male) villagers. The follow-up visits allowed researchers to explain in more depth the possible implications for participants, answer farmers' questions, and develop a relationship of personal trust.

Organization of a participatory germplasm collecting

The organization and time frame of germplasm collecting is particularly important, as participatory research takes time. It may be that sometimes the whole group has to go to a field and bring appropriate material for demonstration, or grain samples from a store, etc. The villagers also have their own daily routines, and researchers have to adapt to this rhythm to get good-quality information. Based on our experience, and as proposed in step one, the optimum would be to visit the villages once before the actual collecting and focus on group discussions, identify farmers who have appropriate material, and are willing to participate. At the harvesting time, the samples could be collected by the villagers themselves, or by members of the collecting team and other helpers like NGO field workers, with active participation of the farmers (step two). Interviews with farmers would be less useful at harvesting time, because they may not have enough time for long discussions. The team should then return after the harvesting period for more detailed interviews and village meetings. We were able to work like this in the major part of the study area. This has very clear advantages over only one-time visits in which one has to rush from one place to another during the harvesting period without enough time to explain to the farmers what the study is about.

As the study area was quite large, and harvesting had to be done at the same time in distant places, time constraints were quite pressing during a peak period of about 2 weeks. This problem could be partly solved by forming separate teams, working independently and avoiding too much long-distance traveling.

Identifying landraces with farmers: Villages where landraces are grown and families who preserve landraces

Generally, farmers we met were strongly interested in the pearl millet landraces, and willing to share their knowledge for documentation. In the central and eastern districts most farmers had at least heard about the regions where landraces were still grown. The places suggested by them were nearly always good sources of samples for collecting. In this way, seven villages were identified in the eastern and central districts that are or had been famous for the quality of their landrace seed. In three of these villages the landrace varieties were clearly threatened, because the number of farmers growing them and maintaining seed stocks had decreased over the years and was very low. In the other four villages, seed production of the landrace variety is still a common enterprise for many farmers. Seed is being sold not only in the direct vicinity of the place of origin, but also to other villagers who come from places as far as 50-150 km.

The landraces of four of these villages had been identified by a previous comprehensive collecting mission in Rajasthan in 1977 as particularly interesting and worth preserving (Appa Rao 1978), whereas three of these villages, and their landraces, had not been previously identified, but clearly have much in common with the others in terms of need for support for preservation of their germplasm.

In the western districts of Rajasthan the farmers did not seem to differentiate local germplasm into distinct varieties. In this region, landrace pearl millet is widely grown, and is not immediately threatened, except in the vicinity of larger market centres, like Jodhpur, where improved seeds are sold. In this region, interviews in the first step of discussions focused on identifying villages or farmers with no or less contact with the formal seed market.

Landrace descriptions

Farmers gave descriptions of those traits of their pearl millet landraces which they considered to be important (Table 1). This included mostly botanical traits, possible uses, quality aspects, specific adaptation, and other information such as local names of soil type, etc. Another important aspect of farmers' descriptions of varieties was that they explained advantages and disadvantages under specific growing conditions, and their personal reasons for growing this particular landrace. The most common reasons given were food quality and adaptation to poor growing conditions. If farmers knew several landraces or improved varieties, they often added trait-wise comparisons to their description.

Additionally, the interviews often revealed information about a landrace's potential risk of being lost, or the importance for local seed markets.

Efficiency considerations

Conducting a landrace collecting in a participatory way facilitates the identification of landraces that farmers perceive as being unique, of a specific quality and worthy of conservation efforts. Thus, only comparatively few samples are being actually collected for medium- or long-term conservation. For each sample, information about the farmers' contribution to the development of this specific seed sample will be available. This includes management of the seed crop, seed selection, processing, storage, exchange and measures to control outcrossing. At the same time, information about morphological characteristics, production behaviour and relative adaptation to specific growing conditions found in the collecting region can also be documented. Many of the traits that farmers used for describing their varieties, like adaptation to specific stress factors, are complex in nature and difficult and costly to assess in the context of a normal germplasm evaluation trial, which can rarely be achieved for a large collection.

The information obtained from farmers is not comparative for all samples obtained, but only for those varieties which a specific farmer knows. This knowledge is based on long-term observations under the range of growing conditions encountered on his farm and village. This knowledge could guide other potential users who work under comparable growing conditions, as well as researchers who are searching for a specific type of adaptation in a larger collection. This would, for instance, allow researchers to test only a subset of the collection with an increased chance to find specific traits, and with a smaller number of entries in the trials.

Population geneticists recommend that the aim of exploration for conservation of genetic resources should be to maximize the possibility of collecting alleles which are locally common and thus may represent important adaptation to the local environmental conditions. This strategy would require information about the population genetic structure of the target species, which is most often, and especially in the case of quantitative genetic traits, not available to the researcher. Therefore, the following was suggested: The collectors should visit as many diverse collecting sites as possible within a range of environments, and consequently spend a minimum of time at each site (Marshall 1990).

This recommendation has had serious consequences for the long-term management of genebanks. For example, the ICRISAT genebank presently stores more than 100 000 accessions under medium term storage conditions. Approximately 23 000 accessions are samples of pearl millet, a cross-pollinated crop, requiring elaborate efforts during rejuvenation and seed multiplication, in order to maintain its genetic identity and avoid inbreeding depression. With the participation of farmers, only key samples that farmers themselves value highly as being representative of a particular landrace and thus may represent a high specific adaptation, were collected. This strategy would save both time and resources, and could keep the numbers of new samples arriving at a genebank down to a justifiable minimum. In some cases, it could also be considered how the farmer from where the original sample was collected could be involved in rejuvenation and multiplication of the sample, or further evaluation, if required.

Sampling landrace germplasm appropriately within a region without involving the farmers appears difficult after the experiences we had during this undertaking. While natural selection certainly has a big influence in shaping the composition of landrace populations, the contribution of farmers' seed-management practices seems to be underestimated. For example, interviews revealed that farmers in eastern Rajasthan tend to maintain specific landraces with well known characteristics, and different villages pursue different strategies. In western Rajasthan, however, farmers aim at increasing variability within their seed stocks, and keenly integrate new acquisitions of germplasm into their individual seed stocks (Dhamotharan *et al.* 1997; Weltzien *et al.* 1998). Farmers' seed-management activities such as selection, processing and exchange do contribute significantly to the composition and the distribution of genetic variability between and within populations. Future research on the collection itself will investigate the distribution of DNA-marker variability, to substantiate these observations at the molecular level.

The knowledge of a community's and individual farmers' seed-management strategies could help to adjust the sampling strategy to the actual conditions found in the region. For example, in most villages some farmers maintain the landrace even over drought periods and regularly supply seed to others. Seed from these farmers could be considered as priority samples, and farmers' involvement in the process of collecting can contribute immensely to identifying such samples.

Documentation and use of local knowledge

Farmers' participation in collecting germplasm poses new challenges for documentation and use of the information. Farmers in different regions of the world where a crop like pearl millet is grown might have different priorities, ways to use the crop, food habits, etc. Therefore, it is difficult to save this information in standardized databases, as is presently done in most genebanks. The important questions for interviews, and for finding out the differences between cultivars as perceived by farmers, have to be developed together with the local people. Most probably, these questions will not be applicable in other regions where pearl millet is grown and used.
Therefore, the important question is whether and how farmers' knowledge could or should be documented so that it is "available" along with the samples stored in genebanks. Technically, it would perhaps not be too difficult to build up general databases with geographical or basic agronomic information, and connect subgroups of the accessions with other specialized databases where the detailed knowledge of the donors (farmers) is documented. But using farmers' knowledge in this manner would of course only be a one-way route, as more detailed information would be made available to those people who are formally in a position to retrieve the database. The gain for local communities would be very limited.

Linking farming communities, genebanks and plant breeders
We would, therefore, not see the primary purpose of applying PRA methods in the context of crop germplasm collectings in the "*ex situ* conservation" of farmers' knowledge for plant breeders and other users of genebanks. The real chance of the methods described in this article is the establishment of links between farmer communities and other people concerned with conservation of crop diversity and breeding, intellectual property rights, and in the process enhancing the efficiency of management and use of germplasm collections.
For example, farmers who have the most representative material of a given landrace would also be excellent contact persons, who are likely to be both interested in and knowledgeable about future *in situ* conservation activities. In case the landrace is still frequently grown, these farmers could be visited regularly, e.g. every other year, to find out whether any change of the situation has occurred. If the landrace has become rare, farmers and people from national and private institutions can try to find out together about how farmers who are interested in its conservation could be supported. It could be by storing a considerable amount of seed after each season which farmers consider to be good for seed quality, and making this seed available in periods of shortage, or by other mutually accepted measures.
In regions where landraces are lost or are in the process of being lost, the reasons for this could be identified and farmers and biodiversity activists could start to think together about alternatives, such as improving the landrace through participatory breeding, introducing landraces from other places or other varieties which might be adapted to the conditions and needs of farmers (Witcombe *et al.* 1996). In the course of our interviews, many farmers expressed their wish to have access to other sources of information and landrace seed from other places, or other varieties, for their own crop improvement activities. Another important aspect is that the discussions in villages about the value of traditional crop germplasm, and possible problems to maintain these varieties, can help to increase awareness about this issue among the farmers. Documenting names of persons and communities who creatively contributed to the development of a specific variety and seed sample would facilitate benefit-sharing in the context of farmers' rights and intellectual property rights issues.
We therefore think that the benefit of participatory germplasm collecting could be to find new strategies for crop diversity management, linking farmers' knowledge, needs and concerns with local, national or international institutions working in this field. It would, of course, imply that these institutions need to develop other programmes, besides biotechnical- or database-oriented ones, for new village-oriented activities.

Acknowledgements
We thank the German Ministry for Economic Cooperation and Development (BMZ) for the financial support of this project through the German Society for Technical Cooperation (GTZ). The commitments and contributions of the farmers we visited went far beyond our expectations and made this work possible. We also thank Ms Saroj Kumari Nein and Mr Atul Bansel for translation during the trips and Mr H.R.N. Choudhary for translation of recorded interviews. The NGOs SWRC (Tilonia) and GVVS (Jodhpur) provided much appreciated logistical support and facilitated contacts with "local experts". We further thank Dr D.C. Bhandari of the NBPGR Regional Station, Jodhpur, for valuable instructions and Dr Thomas Presterl (University of Hohenheim) for joining the collecting trip and discussing the manuscript of this article.

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Collection of Pearl Millet Landraces in Rajasthan 1997
GTZ/ICRISAT/University of Hohenheim Special Project

Date*: 11.10.97* ***Collector****: AC* ***Accession No.****: 14/1*

Species name: *Pennisetum glaucum* ***Common name****: Pearl Millet (Bajra)*

Cultivar name: *Desi* ***Regions explored:*** *Ajmer and Jaipur district between Kishangarh and Bagru*

Village: *XXXX* ***Tahsil:*** *XXXXX* ***District:*** *Jaipur-State: Rajasthan*

Latitude: *XXXXX* ***Longitude:*** *XXXXX*

Farmer's name: *XXXXX*

Source: *Farmer's Field* *Field Store* *Threshing Floor* *Farm Store*

Status: *Landrace*

Frequency: *Abundant* *Frequent* *Occasional* *Rare*

Material: *Inflorescence (Panicle)*

Sample type: *Population*

Sample method: *Random*

Habitat: *Cultivated*

Observed diseases: *Ergot disease was there, this year also*

Disease symptoms: *Frequent* *Occasional* *Rare* *Not observed*

Striga: *Frequent* *Occasional* *Rare* *Not observed*

Insect pests:

Cultural practices: *Irrigation (1)* *Rainfed*

Season: *Kharif*

Approx. sowing date: Beginning of July *Approx. harvesting date: End of September*

Associated crops: *Sole* *Mixed with:*

Soil: *Black* *Brown* *Red* *Yellow* *White*

Sand *Silty sand* *Loamy sand*

Local name:

Stonyness: *Stony* *Pulverized*

Topography: *River Bank* *Level* *Undulating*

Agronomic score: *Very poor* *Poor* *Average* *Good*

ADDITIONAL NOTES:

Date*: 11.10.97* ***Collector:*** *AC* ***Accession No.:*** *14/1*

Species name:*Pennisetum glaucum* *Common name: Pearl Millet (Bajra)*

Cultivar name: *Desi* ***Regions explored:*** *Ajmer and Jaipur district between Kishangarh and Bagru*

***Village:** XXXXX* ***Tahsil:** XXXXX* ***District:** Jaipur* ***State:** Rajasthan*

***Latitude:** XXXXX* ***Longitude:** XXXXX*

***Farmer's name:** XXXXXX*

Which types of Pearl Millet are grown in the village in which proportions?
Desi** 50 %* ***Sankar** 50 %* ***Others

What are the typical characters of this landrace?
Plant height about 10 ft.; length of heads 1 ½ ft.; grain longish; tasty; good fodder quality and high fodder yield; less tillers than sankar millet; leaves of this desi have bristles, sankar not; a lot of narrow, fine leaves; draught tolerant; duration 3-4 months according to rainfall conditions.

What are the main reasons for farmers to grow it?
Good taste and high nutritious value; grain is even good for medicinal use, they prepare it for mother animals after calving; high fodder yield and quality; the variety is adapted to limited rainfall (if there is one more rain after germination, it will not fail).

Are there any constraints/problems/disadvantages (i.e. pests, diseases, parasitic weeds)?
In some fields they have observed striga, it is considered to be poisonous, plants become yellow and will not grow; they try to weed it; it is not in irrigated fields; ergot disease occurs when there are continous rains.

Origin of seed:
Home production; this millet has been here since their childhood; it is from their fathers forefathers; it has never been bought as far as they remember.

Seed management (selection, processing, storage):
They do not select heads, but grade before sowing (take bigger grain for seed purpose).

Further information given by farmers:
Whenever some diseases occur that might infest the seed, they apply chemicals; there are no differences between different families' desi millet; they have not observed any changes since introduction of sankar millet, they say that flowering of sankar is earlier, so it doesn't mix; because of the difference in earliness, people grow sankar and desi millet separately.

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

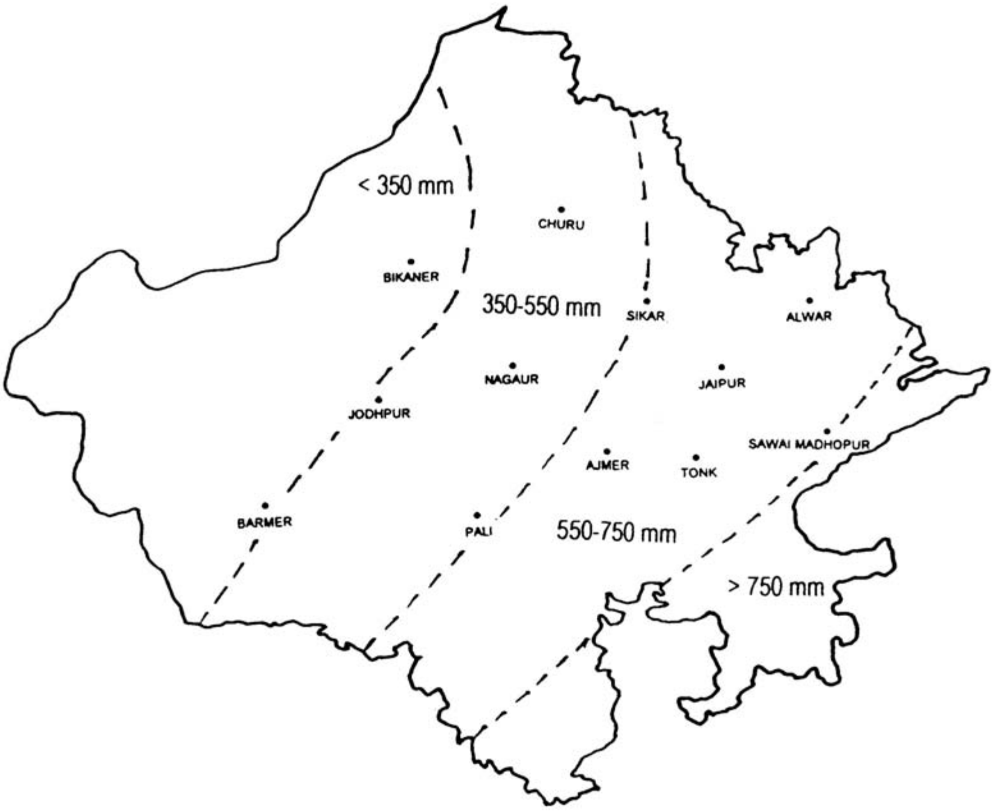

Fig. 2. Mean annual rainfall in the study area.

Table 1. Type of information given by farmers to describe pearl millet landraces

Information about	**Parameters used**	**Examples**
Botanical traits and yield components	panicle characteristics grain characteristics grain yield other plant characteristics	length, shape, diameter, compactness size, colour, shape number of tillers, time for maturity, simultaneous maturity of tillers
Possible uses and quality aspects	grain stover	food preparations, medicinal use, storability fodder quality, usefulness as thatching material, storability
Specific adaptation	to environmental conditions to soil condition to pests, weeds or diseases to cultural practices	drought, thunderstorms, heat, sandstorms, unseasonal rainfall soil type, availability of manure or chemical fertilizer, poor fertility resistances or susceptibility, i.e. toward locusts, insect pests, striga, ergot, smut mixed cropping, irrigation, deep sowing
Other issues	local names crop rotation importance for local seed markets importance for food grain or fodder markets	of the landrace, soil type, pests, diseases, weeds description of the market and quantities sold market value of grain and stover, quantities

	risk of loss of variety	sold reasons why number of users has decreased