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ON-STATION FARMER PARTICIPATORY VARIETAL EVALUATION: A STRATEGY FOR CLIENT-ORIENTED BREEDING

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SUMMARY

On-station participatory evaluation of varieties was used to identify the characteristics of pearl millet (*Pennisetum glaucum* L. Br.) preferred by farmers in western Niger. Large numbers of productive tillers, large grain size, plant height of about 250 cm and a crop cycle of 100 d or less were the main traits that motivated farmers' preference for ICMV IS 92222. High grain yield was of less concern to farmers than these factors. Small grain size, short or thin panicles, short or thin stalks and a crop cycle of 110 d or more are traits likely to be rejected by farmers. Evidence of gender-based trait preferences was significant only for short or thin panicles and thin stalks. There was no evidence of location-driven trait preferences. Farmer participation in the on-station varietal evaluation provided a means of identifying a wide range of traits that were valued by farmers and could provide guidance on farmer demand for use in varietal evaluations.

INTRODUCTION

During the green-revolution era, high-yielding cultivars were successfully transferred to farmers, with their limited involvement in the research that produced them (Tripp 1982; Maurya *et al.*, 1988). Internationally available on-shelf technologies were easily transferred and adapted to well-endowed areas. However, the process of adaptation is more difficult in marginal areas or where the objectives and constraints of client farmers vary widely (Farrington 1988). The valuable insights of breeders and physiologists in adapting cultivars to environments could be complemented with the indigenous expertise of farmers. This is critical when determining which plant and grain traits are valued or preferred. An important positive aspect of farmer participation in the research is the provision of the 'demand-pull' necessary to ensure focus (Rhoades and Booth, 1982).

Varietal selections are usually based on well-developed sets of breeder criteria of which grain yield and short crop cycle in short-season environments are prominent. Adding information on farmers' perspectives of plant and grain trait preferences to these criteria will prove helpful to the varietal selection process. The need to account for farmers' needs and preferences motivated intuitive on-station and on-farm research strategies (Maurya *et al.*, 1988; Sperling *et al.*, 1993). Maurya *et al.* (1988) matched traits of advanced lines with farmers' varieties grown under the same on-station conditions. Few selected varieties were given to farmers to grow and evaluate. Implicit in the approaches are assumptions that (1) scientists and farmers use the same selection criteria, and (2) the local varieties embody all the good traits and exclude any undesirable traits. If either assumption is not valid, then one preliminary approach is to involve farmers in the evaluation of advanced stage varieties grown on-station before a selected few are evaluated later under farmer management. This is consistent with the approach adopted by Sperling *et al.* (1993).

This paper reports farmer evaluation of advanced stage varieties and a local cultivar (Sadoré Local) of pearl millet (*Pennisetum glaucum* L. Br.) grown under the same on-station conditions. The objective of the research was to identify advanced stage varieties of millet that have the plant and grain traits required by farmers in western Niger. The preferred varieties could then be recommended for on-farm trials.

MATERIALS AND METHODS

Over several years, the millet breeding programme of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Sahelian Center at Sadoré in western Niger monitored the agronomic performance of a number of millet varieties. Based on monitored performance, 25 of the varieties were regrouped in a yield evaluation trial in 1993. From these, 14 promising varieties (including Sadoré Local as a control) were selected for an advanced stage of evaluation in 1994 (Table 1). The net plot size per replicate was 126 m^2 and there were four replicates per variety.

The plant and grain traits of the 14 varieties were evaluated by farmers nominated by their peers on the basis of their extensive knowledge of millet varietal traits. Since mean annual rainfall increases from 400 mm in the most northern villages to about 550 mm in the most southern villages, it was hypothesized that farmers' preferences for different varietal traits might differ between locations. Therefore, a total of 30 farmers were selected in equal numbers from six villages across a north–south transect of western Niger, namely Sadièze Koira and Samari (70–75 km north of Niamey [13°30′N, 2°7′E]), Berkiawel and Liboré (about 30 km north-east and south-east of Niamey), and Dogol Kaina and Karé (about 65–75 km south of Niamey). Although the female population in Niger is slightly greater than the male, decisions about millet production are made mainly by men. However, women influence varietal choice decisions and therefore to account for gender-based varietal trait preferences, the sample of farmers from each village consisted of men and women in the ratio of 3:2.

The farmer evaluations were conducted in two phases. The first evaluation was conducted at about 82 d after sowing (DAS), when the plants were at the reproductive phase. This allowed the farmers to get a good idea of the essential characteristics of each variety compared with their local varieties planted at about the same date as the on-station lines. Structured questionnaires were prepared based on preliminary informal surveys of the traits that could influence varietal choices. These were used to solicit individual feelings about the varieties, and to

Table 1. *Summary data on promising pearl millet varieties grown at Sadoré in western Niger, 1994*†

Variety	Grain yield (t ha^{-1})	Time to 50% bloom (d after sowing)	Plant height (cm)	% plants infected with downy mildew‡ ni	ai	Seed mass (g $(1000\ grains)^{-1}$)
ICMV IS 89305	1.54	75	254	1	12	11.0
ICMV IS 86330	1.47	64	232	4	4	11.8
Sadoré Local	1.46	81	280	3	12	11.0
SOSAT-C 88	1.23	64	203	0	0	11.8
ICMV IS 90309	1.21	70	235	0	0	10.8
ICMV IS 88217	1.10	69	226	0	4	11.5
ICMV IS 92222	1.06	67	251	0	4	11.5
ICMV IS 88212	1.00	69	245	0	4	11.3
CIVT	0.94	67	234	1	16	11.3
ICMV IS 94206	0.90	71	267	0	4	11.0
ICMV IS 90311	0.86	70	230	0	0	10.0
ITMV 8001	0.79	72	251	1	1	11.3
GB 8735	0.62	54	160	4	4	12.2
ICMV IS 85333	0.56	71	233	1	8	11.5
L.s.d.	0.31					
Maximum	1.54	81	280	4	16	12.2
Minimum	0.56	54	160	0	0	10.0

†Fertilizers applied were 45 kg N + 36 kg P_2O_5 ha^{-1}
‡% plants infected with downy mildew: ai = artificial inoculation (in a separate downy mildew nursery trial); ni = natural infestation that occurred in the yield evaluation trial.
Source: Millet Breeding, Genetic Enhancement Division, ICRISAT Sahelian Center, Sadoré, Niger, 1994.

identify the specific traits of millet plants and grain that influence decisions about the adoption or rejection of new varieties. During the second phase of the evaluation, the post-harvest processing and food-quality traits of the grain of the on-station lines were assessed by farmers in their homes. Each was supplied with two kg grain from each of the 14 varieties examined on-station. The grains were conditioned and processed into traditional food preparations by the female sample farmers and the wives of the male sample farmers. Evaluations of grain and food quality by individual farmers were conducted using a second structured questionnaire.

Chi-squared tests were conducted in order to verify hypotheses about gender and location influences on varietal trait preferences. However, since chi-squared analysis is approximate if sample size is small, iterative binomial logistic analysis was conducted using GENSTAT (Lawes Agricultural Trust, 1993) to check the validity of the Chi-squared tests, and to extend the analysis for gender and location terms. Changes in deviance ratios attributable to gender and location were examined in order to determine the probability that they influenced decisions to reject varieties. In cases where Chi-squared values were high, Fisher's exact test was used to check the significance of the term because the sample size was small.

RESULTS

The largest grain yields were produced by ICMV IS 89305, followed by ICMV IS 86330 and Sadoré Local (Table 1). ICMV IS 85333 produced the lowest grain yield. The time of 50% bloom ranged from 54 days after sowing for GB 8735 to 81 days after sowing for Sadoré Local. This provided the farmers with an adequate range of choice of crop cycles. With the exception of GB 8735, plant height ranged from 203 cm for SOSAT-C 88 to 280 cm for Sadoré Local. This was a good range on which to base choices determined by plant height considerations. Seed sizes ranged mostly between 10.8 and 11.8 g (1000 grains)$^{-1}$. The largest 1000-grain weight was 12.2 g for GB 8735, the smallest was 10 g for ICMV IS 90311. Levels of natural infestation with downy mildew were low for all the varieties, but under artificial inoculation CIVT, ICMV IS 89305 and Sadoré Local had higher levels of infestation than the other varieties.

Of the varieties examined, most farmers preferred ICMV IS 92222 because of its productive tillering capacity, large grain size, average plant and panicle lengths, and short crop cycle (Table 2).

At the 5% level of significance, Chi-squared values showed an important difference between male and female farmers' decisions to reject short panicles (Table 3). This was confirmed by Fisher's exact test and a deviance ratio of 5.68 (same order of magnitude as the Chi-squared value). In addition, Chi-squared values, confirmed by Fisher's exact tests at the 10% level for one-tailed significance, showed differences between male and female farmers' decisions to reject

Table 2. *Reasons for choices of pearl millet varieties by farmers† during an on-station varietal evaluation in western Niger*

	Number of farmers choosing variety and citing listed traits				
Reason for choice	Sadoré Local	ICMV IS 85333	ICMV IS 92222	ICMV IS 94206	Total number of farmers influenced by trait
Crop cycle:					
Early	0	0	12	6	18
Medium	0	1	0	1	2
High grain yield	0	1	7	1	10
Large grain size	1	0	14	7	22
Stalk:					
Thick	0	0	2	1	3
Long	1	0	0	1	2
Average plant height	0	1	14	3	19
Panicle:					
Big	1	0	3	1	5
Medium	0	1	9	1	11
Big and long	0	0	1	5	6
Good tillering	1	0	17	7	26

†The sample of farmers consisted of 30 men and women in the ratio 3:2.

Table 3. *Numbers of farmers in western Niger motivated to adopt or reject new varieties of pearl millet on the basis of different plant traits*†

	No. of farmers motivated to adopt variety			No. of farmers motivated to reject variety			No. of indifferent farmers	
Plant trait	Male	Female	Total	Male	Female	Total	Total	X^2
Crop cycle (d)								
90	18	12	30	0	0	0	0	–
100	15	8	23	3	4	7	0	1.12
110	7	4	11	10	8	18	1	0.18
Panicle								
Thin	4	7	11	12	5	17	2	3.19**
Big	15	12	27	2	0	2	1	1.52
Long	18	11	29	0	1	1	0	1.55
Short	2	6	8	16	6	22	0	5.57*
Stalk								
Thin	2	5	7	14	7	21	2	3.11**
Thick	17	11	28	0	1	1	1	1.47
Long	14	8	22	4	4	8	0	0.45
Short	3	6	9	15	6	21	0	3.81**
Ease of threshing	15	12	27	1	0	1	2	0.78

†Listed traits suggested by farmers in informal surveys were used to construct a structured questionnaire.
*The one-tailed significance level for Fisher's exact test is at 5%; **the one-tailed significance level for Fisher's exact test is at 10%; X^2 has 1 degree of freedom.

thin panicles and short and thin stalks (Table 3). Low Chi-squared values for the other factors showed that there was no evidence that the distribution of responses is dependent on gender. No important changes in deviance ratio for the effect of location were observed.

DISCUSSION

The absence of traits preferred by farmers and the presence of unacceptable traits are technology-dependent qualities that constrain the adoption of new varieties by farmers. Studies in Burkina Faso showed that farmers rejected new varieties because of technology-specific factors (Stoop *et al.*, 1982). If grain yield had been the main selection criterion, as is often the case in crop improvement programmes (Etasse, 1977), ICMV IS 89305 should have been selected by the farmers. However, many of them rejected it because of the size of its grain. Since ICMV IS 92222 ranked seventh in terms of grain yield, high grain yield was not the most important selection criterion. It seemed that farmers were searching for other traits even if some grain yield had to be sacrificed. Moreover, good management resulted in larger yield gains. Preference for the productive tillering capability of ICMV IS 92222 suggested a desire for yield stability provided by compensation for damage caused by biotic and abiotic factors. In the harsh production environment that characterizes millet-producing areas of the Sahel, a search for yield stability is a rational strategy.

Differences in trait preferences between locations were not evident over the 150 km north–south climatic gradient studied. The implication is that over distances where climatic conditions are not significantly different there is no need to select widely dispersed villages to study the trait preferences of different farmers.

Most farmers showed a clear preference for millet varieties with shorter crop cycles than their traditional varieties (Table 3). However, preference for short crop cycle did not override other considerations. For example, millet varieties with short or thin panicles cannot be tied into bundles satisfactorily and so men, required to tie harvested panicles into bundles, rejected GB 8735 overwhelmingly despite its short crop cycle. Most women do not have to tie millet panicles into bundles. This explains the gender-based differences in the rejection of short or thin panicles. Most farmers preferred millet varieties with thick stalks because these are used for livestock feed, and for the construction of sheds, granaries and fences. Gender-based differences in the rejection of thin stalks were likely because men usually gathered and utilized stalks for livestock feed and for construction. The preferred length of stalk was about 250 cm. The quality of food preparations from millet grains and large grain size were important adoption criteria for farmers (Table 4). Conversely, small grain size caused new varieties to be rejected.

Table 4. *Numbers of farmers in western Niger motivated to adopt or reject new varieties of pearl millet on the basis of different grain characteristics*

	No. of farmers motivated to adopt variety			No. of farmers motivated to reject variety			No. of indifferent farmers
Grain characteristics	Male	Female	Total	Male	Female	Total	Total
Grain							
Small	4	5	9	14	7	21	0
Large	17	12	29	1	0	1	0
Yellow colour	14	11	25	2	1	3	2
White colour	15	11	26	2	1	3	1
Grey colour	9	8	17	7	4	11	2
Round	13	10	23	3	2	5	2
Oval	9	7	16	7	5	12	2
Taste of food preparations made from grain							
Porridge	18	11	29	0	1	1	0
'To'†	18	11	29	0	1	1	0

†Local name for a thick paste food preparation made from maize, sorghum or millet dough and eaten with a sauce.
Values for X^2 not reported because insignificant.

Farmers chose a large variety of desirable trait combinations. Only two of the 30 farmers chose the same combination of preferred traits. With a large variety of trait preferences, the appropriate 'outcome' of a new technology cannot be encapsulated in a single technical criterion such as yield (Farrington, 1988). Nonetheless, an important implication of the variety of farmers' preferred trait combinations is the need to involve farmers in the evaluation of crop varieties to identify minimum sets of basic traits and provide adoption and rejection criteria for farmers. This will lead to a strategy that provides alternative varieties with different combinations of preferred traits, but with a minimum set of desirable traits. An assessment of the varietal traits that motivate the adoption of new pearl millet varieties targeted for western Niger (Tables 3 and 4) has shown that plant characteristics should include a crop cycle of ≤ 100 d; thick, long panicles and stalks; ease of threshing; large grain size; and ability to produce tasty food preparations from the grain. The results have wider implications because western Niger is an important millet producing area in a leading millet producing country.

Significant differences in the performance of cultivars are observed in farmer-managed tests (Matlon, 1987). However, differences between on-station and on-farm performances of varieties are likely to be observed in only the grain and stover yields. Also, since the logistics of transporting farmers to research stations and isolated sites limit the sample size, it may be questioned whether on-station evaluation by farmers from a target domain is needed before varieties are selected for on-farm testing. Since the farmers were nominated by their peers as the most knowledgeable about millet varietal traits, the preferences indicated should be meaningful despite the small sample size. Furthermore, the involvement of farmers from areas targeted for new recommended varieties in on-station evaluation of advanced stage varieties offers opportunities for them to see a wider range of traits than could be possible in experiments on farmers' fields. This strategy will reduce the development of varieties with traits that farmers will eventually reject during on-farm trials because farmers would have had an early opportunity to exchange views about the varieties with agronomists, social scientists and breeders. The involvement of farmers as well as breeders, agronomists and social scientists in the planning and decisions in on-station trials, stage of development of new varieties and the number of days after sowing at which to conduct evaluations would be an ideal client-oriented strategy.

Breeders and agronomists have made tremendous progress in their search for cultivars which are adapted to targeted environments. However, varietal choices made by farmers suggest that there are desirable trait tradeoff factors that need to be incorporated in client-oriented varietal evaluation criteria. Farmer participation in the choice of preferred plant and grain traits during the evaluation of advanced stage varieties provides the necessary information.

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