E C O N O M I C S

Working Paper 00-03

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Contents

Summary

Identifying the appropriate germplasm to be improved is a key component of any participatory breeding effort because of its implications for impacts on social welfare and genetic diversity. This paper describes a method developed to select a subset of 17 populations for a participatory breeding project from a set of 152 maize landraces. The larger set of landraces was collected in order to characterize, for conservation purposes, the maize diversity present in the Central Valleys of Oaxaca, Mexico. The method combines data representing the perspectives of both men and women members of farm households and those of genetic resources specialists, including professional plant breeders, gene bank managers, and social scientists. The different perspectives complement each other. The results show that when the choice of germplasm is based only on the perspective of genetic resources specialists, traits and materials that are important to farm households may be ignored. Such selections may be less valuable to farmers, limiting the impact of the participatory breeding effort on their livelihoods. However, the findings also indicate that relying solely on the perspectives of farm households may lead to lower diversity. Choosing populations based solely on either perspective involves a social cost—either in terms of diversity or in terms of farmer welfare. Although our approach has limitations, many of which are common to participatory research, it represents a systematic method for meeting one of the important challenges of participatory plant breeding.

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Introduction

Participatory plant breeding refers to a range of approaches that involve users more closely in crop development and seed supply (McGuire et al. 1999). These approaches may serve any one of several or more goals. For example, farmer selection for specific adaptation can improve the effectiveness of crop breeding in stressed environments (Ceccarelli et al. 1997). By making selection criteria more relevant to local needs, participatory breeding can reach poor farmers that have not yet benefited from modern varieties (Kornegay et al. 1996; Sperling et al. 1993; van Oosterom et al. 1996). Professional plant breeders generally have concentrated on developing a limited number of varieties that are stable over time and adapted to a wide range of environments. Participatory crop improvement, on the other hand, can encourage the maintenance of more diverse, locally adapted plant populations (Berg 1995; Ceccarelli et al. 1997; Joshi and Witcombe 1996), lending support to the in situ conservation of crop genetic resources (Qualset et al. 1997). In addition, participatory methods serve to empower farmers and / or actors who have been "left out" of the development process (McGuire et al. 1999).

A key component of any participatory breeding effort is the choice of which germplasm to improve. In some cases, farmers select materials from "finished" varieties. In others, they select segregating populations. Landraces from different communities may also be supplied to them "as they are," in order to expand the breadth of materials from which local farmers can choose. Practitioners of participatory breeding must in any case decide which germplasm should be included in their projects. They are faced, therefore, with two important questions:

- Which germplasm will have the greatest social welfare impact, including equitability and gender considerations?
- Which germplasm will contribute most to maintaining or enhancing the genetic diversity in the target agroecosystem?

As in any breeding endeavor, selecting the "right" germplasm is crucial. The choice of germplasm affects whether the research investment generates benefits, and whether those benefits are concentrated among a few or distributed among many. Some materials may also contribute more to the crop genetic diversity in the target ecosystem than others. When crop improvement takes place in a center of crop diversity, both the present and future needs of farmers and consumers inside and outside of the community may be affected. In choosing materials, the current and future interests of farmers, breeders, and other members of society must be considered.

This paper reports how the authors have addressed these questions in a pilot study with small-scale farmers in the Central Valleys of Oaxaca, State of Oaxaca, Mexico. The findings reported here are part of a project, jointly implemented by the International Maize and Wheat Improvement Center (CIMMYT) and Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP) of Mexico, whose goal is to determine whether it is possible to improve maize productivity while maintaining or enhancing genetic diversity. We define maize productivity broadly in terms of yield, stability, and other characteristics of interest to farmers. To attain this goal, it is necessary to identify the crop populations that contribute most to crop genetic diversity in the target area and best serve farmers' interests.

The region known as the Central Valleys of Oaxaca was chosen for this project for several reasons. First, the "Bolita complex" grown by the region's farmers has been identified as one of the most interesting and productive races of maize in Mexico, although it has not been widely studied or collected (Ortega 1995). This race contributed to the development of drought resistant cultivars such as Cafime and Celita (Ortega et al. 1991). Second, modern varieties have had an almost negligible impact in the region. Third, the region is ethnically diverse and agroecologically heterogeneous. Finally, despite the economic importance of labor migration to the local economy, Central Valley communities place a recognizable emphasis on culture, including culinary practices for maize.

The breeding activities of the project are confined to local landraces. The reasons for this approach are the strong on-farm conservation emphasis of the project and the fact that farmers in the region value multiple traits—particularly consumption—that are already well represented in these landraces and that would be fundamental to the acceptability of any breeding product.

The rest of this paper is divided into five sections. The first section of the paper presents the conceptual framework for research. Materials and methods are summarized in the second section. The analysis presented in the third section demonstrates how the choices of farmers and genetic resource specialists (professional plant breeders and gene bank managers) were used to identify maize populations for subsequent improvement and distribution. Finally, the discussion and conclusions are presented.

Conceptual Framework

The conceptual framework used here was originally proposed to support strategic decisions about which crop populations—in a well-defined reference area within a crop's center of diversity—are suitable candidates for ex situ and on-farm conservation (Smale and Bellon 1999). However, as explained below, we believe this framework is applicable to participatory breeding, at least in the context of a project such as ours.

The basis of the framework is summarized in Figure 1. The set of crop populations in any study region can be classified along two axes representing: (1) the probability that farmers will maintain the population, and (2) the contribution of the population to the overall genetic diversity in the area.

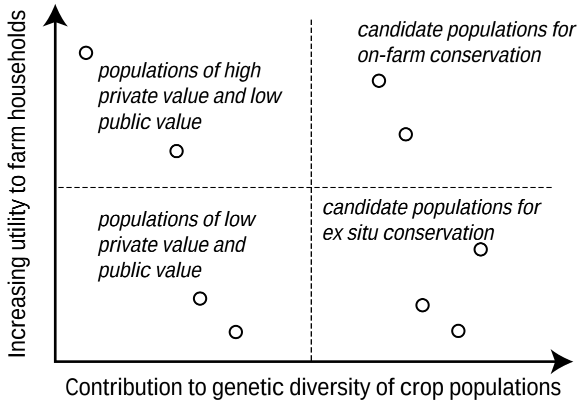

Figure 1. Framework for choosing crop populations to conserve on-farm and *ex situ*, in a given reference area.
Source: Smale and Bellon 1999.

The probability that farmers will maintain any variety or crop population is clearly a function of its value (commercial or noncommercial) to them. In our framework, the probability that a variety will be maintained reflects the number of production and consumption characteristics for which a variety ranks highly, and the relative importance of these characteristics to farmers in meeting their objectives. All varieties or populations can be ranked according to their capacity to supply the characteristics demanded by farmers.

Each of these populations also can be ranked according to its contribution to crop genetic diversity in the study region. The set of populations can be defined as a metapopulation that is interconnected through migration (David 1992; Olivieri and Gouyon 1990). Within a metapopulation, some populations are more similar than others in terms of their alleles, allele frequencies, and agromorphological characteristics. Clearly, two populations that are very similar contribute less to the overall genetic diversity of the metapopulation than two that are different. The contribution of any population is relative because it depends on the other constituent populations of the metapopulation in the study region.

The position of a crop population with respect to these two axes indicates its suitability for a participatory breeding effort in which maintaining genetic diversity is a goal. Participatory breeding could be used to move populations from the SW part of the graph to the NW by enhancing their value to farmers. Alternatively, participatory breeding could be used to further enhance the value to farmers of the populations located in the NW area of the graph. Because agricultural systems are dynamic, participatory breeding could play a role in assuring that populations that are of value today remain viable tomorrow.

Methods

The methodologies used here combine some of those employed by genetic resources specialists to collect, characterize, classify maize diversity and select core subsets of materials for ex situ conservation and for breeding, and some utilized by social scientists to elicit farmers' evaluation of the desirability of different maize populations and to identify their socioeconomic characteristics.

Genetic Resources Specialists

A collection of maize landraces was carried out in 17 villages of the Central Valleys of Oaxaca. These villages were identified to represent variation in maize races, maize uses by farm households, rainfall conditions, and elevation (1,310 to 1,830 masl). They were selected based on the knowledge of F. Aragón, regional maize breeder from INIFAP, who has collected maize samples in the region during the past several years. A total of 152 samples of maize landraces were collected. Each sample consisted of approximately 25 ears from a type and color recognized by the donating farmer.

The collection strategy tried to identify and collect all the diversity present in each community. This was done with the help of key informants who named all the different maize types grown in a community and helped to locate farmers willing to donate samples of them. During collection, farmers who donated the samples were asked about the traits and uses of each type of maize. Their responses were classified and used to compose a list of maize characteristics that are important to farmers.

During the rainy season of 1997, the 152 maize samples donated by farmers, 17 historical accessions from CIMMYT and INIFAP germplasm banks, and 1 improved population of the local landrace (a total of 170 materials) were planted in trials in 15 of the 17 villages. The trials were planted in farmers' fields in 85x2 incomplete block design non-replicated at each site. Morphological and agronomic data were recorded at each site. The trials suffered from drought during the months of July and August and 3 trials were totally lost. Complete data were collected only in 5 trials that received supplemental irrigation.

These data were used for a cluster and ordination analysis using the multivariate classification method of Normix after Wards (Franco et al. 1997). The analysis was based on the adjusted means of days to anthesis, days to silking, plant height (cm), ear height (cm), grain moisture (% at harvest), grain shelling (%), ear length (cm), ear diameter (cm), kernel row number, kernel length (cm), and kernel width (cm).

A core subset of this collection was determined with the use of a selection index based on yield (ton/ha), ear rot (%), erect plants (%), and moisture (%) calculated for each sample. The selection index was used to account for grain yield, grain quality, and standability. The upper 20% of the samples that represented the phenotypic diversity within clusters and had high selection index were chosen for the subset (Taba et al. 1998).

Social Scientists

Farmers were invited to evaluate the 170 maize populations at six field days—three conducted at physiological maturity and three held at harvest—at three sites. Farmers walked through the materials and recorded the numbers of all of the plots containing the populations they liked. Although most participants were literate, team members assisted those who were not to write down their votes. We view the participants' choices as votes and assume that the higher the percentage of farmers voting for a maize population, the more potentially valuable it is to participants. The purpose of this exercise was to get from the farmers a "quick and dirty" sorting of the maize samples into a gradient of interest.

Field days were open to all those who wished to participate. After the field days, researchers returned to the communities to obtain information on the socioeconomic characteristics of participants. To ascertain how well the field day participants represent the farmers in the study region, we employed the results of a stratified random sample survey of 240 maize-growing households in 6 of the 15 communities (data and methods reported in Smale et al. 1999).

Results

Genetic Resources Specialists choices

The genetic resources specialists collected 152 maize samples, which included five kernel colors (white, yellow, purple, pinto, and *belatove* [red]) belonging to the race Bolita with introgressions of five other races (Tuxpeño, Pepitilla, Cónico, Zapalote Chico, and Tabloncillo). The multivariate cluster analysis grouped the samples into five homogenous clusters with differences in kernel width and length, % shelling, kernel row number, and days to silking. Table 1 presents the means of key agro-morphological characteristics of each group. Group 1 includes high yielding plants of intermediate maturity, high % shelling, ears with a high number of rows and Pepitilla kernel type. Group 2 represents the typical "bolita" with shorter plants, flint grain, different grain colors such as white, yellow and purple, and with drought resistance. Group 3 compared to group 2 has late maturing plants with high yield, low % shelling, big grains, the ears with straight and long rows of the Tabloncillo type. Group 4 has late maturing plants with high yield due to the influence of Tuxpeño or Vandeño races. Group 5 has early plants with low yield of the Nal-tel type. The phenotypic variation within and between groups 2, 3,and 5 derives from the original race Bolita. Groups 1 and 4 have influences from the Pepitilla, Tuxpeño or Vandeño races due to their adaptation to wetter areas or irrigation. The upper 20% of the samples that represented the phenotypic diversity within clusters and had high selection indexes were chosen for the core subset. The five diversity groups identified by this analysis are later used in this paper as a proxy for genetic diversity.

Farmers' choices

Participants in the field days included male and female members of rural households, members of academic institutions, extension agents, and government official. Of the 306 participants, 213 belonged to households that planted maize, 57 that did not plant maize, and 36 could not be located or classified. Of the 213 individuals involved in maize farming, 54% were women. Only the votes of farmers were used in this analysis.

Figure 2 compares the votes of men and women participants. Each point is a landrace. The x-axis represents the percentage of men who voted for any particular landrace, while the y-axis represents the same information for women. If there were perfect agreement in the voting patterns of men and women, all points would fall on a 45^{o} line from the origin. Divergence from this line demonstrates that men and women vote differently.

Table 1. Means of selected characteristics of the five diversity groups

Diversity group	No. samples	Yield kg/ha	Silking days	Anthesis days	Plant height cm	Ear height cm	Ear length cm	Ear diameter cm	No. kernel rows	Kernel length cm	Kernel width cm	Grain moisture at harvest %	Grain shelling %
1	22	2385	77	72	220	121	14	5	13	1.2	0.9	27.6	80
2	84	2322	73	68	208	109	14	5	11	1.2	1.0	24.6	80
3	4	1714	65	61	181	83	14	4	12	1.2	0.9	18.9	81
4	48	2230	69	63	192	93	14	5	10	1.2	1.1	22.5	80
5	12	2740	73	67	215	108	15	5	10	1.3	1.2	25.1	74

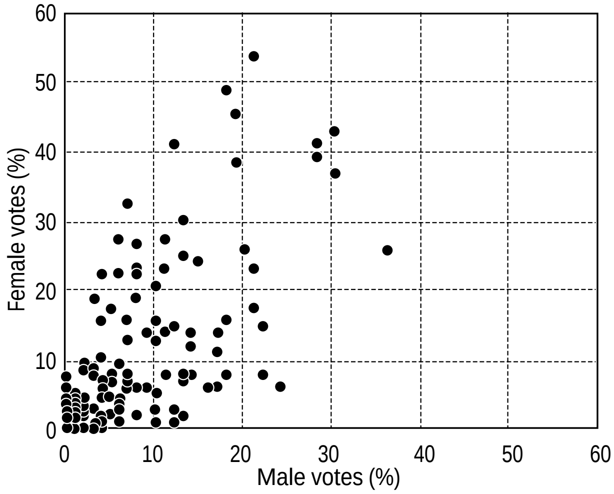

Figure 2. Comparison of the votes cast by men and women participating in field days.

The least desirable landraces were those chosen infrequently by both men and women, located in the SW portion of the graph. The landraces located more to the NE area of the graph are the most desirable. Differences in voting patterns between men and women were observed. On average, women chose more landraces than men (12 versus 9, respectively). Women also seemed to agree more with one another: the most popular landrace among women received 54% of their votes, while the top landrace among men received only 34%.

How do the participant choices compare in terms of the diversity groups identified by the genetic resources specialists? Table 2 presents the ten top choices by gender and indicates the diversity group to which they belong and the grain color of the landrace. Both men and women most frequently selected the materials belonging to diversity group 2. With females, all of their selections belonged to this group, compared to 5 selections among males. In fact, men's choices reflected more genetic diversity (four diversity groups) than women's (one diversity group). However, farmers generally chose "less diversity" than is represented in the population of samples, because diversity group 2 was overwhelmingly represented in their votes. It is important to recognize that farmers cannot observe the diversity groups identified by the statistical analysis. In terms of grain color—which is easily observed and on which the farmers base part of their own classification of maize varieties—both men and women chose a similar mix of white (6), yellow (3), and purple (1) maize types. Clearly, if we chose to work only with the most popular landraces selected by field day participants, we might end up with a more genetically homogenous group of landraces compared to the set of materials chosen by genetic resource specialists.

Table 2. Top ten voted landraces by gender

Men				Women			
entry	dg[a]	color	votes (%)	entry	dg[a]	color	votes (%)
152	1	white	36.4	25	2	white	53.9
49	2	yellow	30.3	27	2	white	45.3
123	2	white	30.3	49	2	yellow	42.7
42	2	purple	28.3	42	2	purple	41.0
30	2	yellow	28.3	23	2	white	41.0
95	5	white	24.2	30	2	yellow	39.3
121	5	white	22.2	123	2	white	36.8
118	4	white	22.2	129	2	white	32.5
37	2	yellow	21.2	140	2	yellow	29.9
35	5	white	21.2	72	2	white	27.4

[a] diversity group

Relating the Choices of Genetic Resource Specialists and Farmers

We have information on the choices of genetic resources specialists and of farmers. Is there any relationship between their choices? To investigate this relationship in greater depth we carried out a regression analysis. Since there were differences in voting patterns between male and female farmers, two regressions were carried out for each. The regressions relate the percent of male and female participants in field days voting for a material (dependant variable) to agronomic and morphological characteristics measured at the on-site trials where field days were located. Since the dependent variable contains zeros and ranges only from 0 to 100, the regression was estimated in LIMDEP (Greene 1998) using the two-limit 'Tobit' procedure now commonly used for censored models (Tobin 1958). Table 3 presents the regression results.

Table 3. Factors explaining the relative frequency of participants' votes for maize landraces

	Men[a]		Women[b]	
	estimated coefficient	standard error	estimated coefficient	standard error
(constant)	-18.570	21.576	25.939	35.610
yield	0.003	0.002**	0.006	0.003**
ear rot (%)	-0.231	0.077***	-0.457	0.125***
lodging (%)	-0.278	0.125**	-0.260	0.207
grain moisture (%)	0.640	0.303**	0.901	0.512*
ear length (cm)	1.945	0.663***	1.269	1.084
kernel width (cm)	15.645	6.161***	8.167	10.198
white kernel (yes/no)	-1.504	1.185**	-4.932	1.958***
kernel hardness (kg)	0.166	0.297	-0.160	0.489
tortilla yield (kg/kg)	2.251	4.556	-1.388	7.504
pasture yield (kg)	0.280	0.322	0.516	0.536
silking (days)	-0.517	0.270*	-0.806	0.449*
location	2.630	1.253**	4.827	2.076**

[a] value of log-likelihood ratio=- 80.631 Significance < 0.005
[b] value of log-likelihood ratio=- 56.6358 Significance < 0.005
*** (**) and * indicate significant at the 0.01, 0.05 and 0.1 levels of Z test, respectively

The independent variables in the regression include those used in the selection index, yield (kg / ha), ear rot (%), lodging (%), and grain moisture (%), as well as other explanatory variables that are of potential interest to farmers. Silking (days to silking) is an indicator of duration. Ear length (cm), kernel width (cm), kernel hardness (kg of compression force needed to penetrate a kernel at a speed of 2 mm / sec to a depth of 15 mm), and kernel color (dummy variable white or other) are ear and grain characteristics that farmers consider in seed selection and use to classify landraces. Fodder yield (kg of dry matter) was included as an indicator of the suitability for cattle feed. Tortilla yield (kg tortilla / kg flour), measured in the laboratory after harvest, is a trait of particular interest to women—although it is not clear whether participants can judge tortilla yield from other characteristics observed in the field. A dummy variable was also included to indicate whether the landrace was collected in the community in which the field day occurred or elsewhere (location). In general, local landraces are expected to perform better due to superior adaptation.

Results show that the variables used by the genetic resources specialists to construct their selection index were good predictors of voting patterns; the revealed preferences of farmers and the decision-making criteria used by genetic resources specialists are strongly associated. The sign of the coefficient on grain moisture is the opposite of that used by genetic resources specialists to define their selection index. Men and women chose landraces with higher moisture content, perhaps because they looked for heavier ears and ear weight is associated with moisture content. Other criteria hypothesized to be of interest to farmers also contributed to the relative frequency of votes for maize landraces, including grain color, ear length, kernel width, and days to silking. Likelihood ratio tests (Greene 1997) comparing regression of voting patterns on both the variables used in the selection index and those related to farmers' selection criteria suggests that each set of criteria is jointly significant ($l_{(obs)}$=41.59, with $l_{c(.05)}$ = 14.07 with degrees of freedom = 7, and $l_{(obs)}$=58.21, with $l_{c(.05)}$ = 7.81 with degrees of freedom = 4). Variables in the selection index are jointly most strongly associated with variation in votes, but leaving out either these criteria or the other set reduces the explanatory power of the regression.

Similar likelihood ratio tests confirm that the parameters that relate variety characteristics to votes are different for men and women, indicating regressions should be estimated separately for each ($l_{(obs)}$=40.96, with $l_{c(.05)}$ = 22.36 with degrees of freedom = 13). Among men, the significance of ear length and kernel width confirms their importance as selection criteria, but not for women. In both cases, participants tended to vote more for landraces with shorter duration, colored (nonwhite) maize landraces, and for those collected from the same location as the field day.

In summary, the results suggest that genetic resources specialists and farmers assess similar characteristics when they select maize populations. However, this does not mean that genetic resources specialists and farmers weigh the importance of those characteristics equally. Therefore, even if they may focus in very similar traits, their choices may be different. In addition, men and women farmers do not consider the same characteristics, and women's voting patterns are less well explained than men's.

Selecting the Final Set of Landraces

The voting exercise identified landraces that were not considered important by the genetic resources specialists. Although at this stage we do not know the specific reasons behind farmers' choices, they appear to differ between men and women. We were also able to show that relying exclusively on farmers' voting patterns, particularly those of women, would have led to the dominance of only one of the diversity groups of interest to genetic resource specialists.

These findings illustrate that choosing populations in a project whose purpose is to enhance diversity through participatory breeding may involve trade-offs between social welfare and conservation objectives. To select the final set of landraces, we used both types of information in an attempt to reduce the magnitude of the trade-off. First, materials were organized by diversity group and grain color. Diversity group is important to genetic resources specialists and grain color appears important to men and particularly to women. From each combination of diversity group and grain color, those landraces receiving the highest numbers of votes from men and women participants were chosen for inclusion in the second phase of the project. A population was excluded if its adaptation or performance was questioned by the genetic resource specialists.

Table 4 presents the 17 materials chosen for the second phase of the project. All are local landraces, except for an improved population based on the Bolita complex that was developed by the INIFAP breeder on the project. The set encompasses a range of diversity groups and grain colors, including introgressions of maize races other than Bolita, and represents collection sites from varying altitudes of the Central Valleys of Oaxaca. Seed from these populations will be made available to farmers for experimentation in the second phase of the project.

Table 4. Landraces selected for improvement and/or distribution

Entry	Diversity group	Kernel color	Altitude collection (masl)	selection index	Men's votes (%)	Women's votes (%)	Total votes (%)	Race
23	2	white	1700	94.2	12.1	41.0	27.8	bolita
25	2	white	1680	54.2	21.2	53.8	38.9	bolita/ zap[a]
29	4	purple	1710	30.5	8.1	18.8	13.9	bolita
30	2	yellow	1710	95.7	28.3	39.3	34.3	bolita
34	4	red	1520	72.4	18.2	15.4	16.7	bolita
39	5	white	1500	81.2	10.1	20.5	15.7	bolita
40	2	yellow	1500	98.6	17.2	13.7	15.3	bolita
42	2	purple	1530	88.2	28.3	41.0	35.2	bolita
95	5	white	1600	50.5	24.2	6.0	14.4	bolita
118	4	white	1447	46.6	22.2	14.5	18.1	bolita
123	5	white	1447	72.9	30.3	36.8	33.8	bolita/tab[b]
124	4	yellow	1447	78.0	17.2	6.0	11.1	bolita
134	4	white	1500	93.4	11.1	23.1	17.6	bolita/ tabp[c]
145	1	white	1310	71.8	16.2	6.0	10.6	bolita/pep[d]
151	1	purple	1310	48.0	6.1	27.4	17.6	bolita
152	1	white	1310	76.7	36.4	25.6	30.6	tuxpeño/bol[e]
170	2	white		79.9	7.1	7.7	7.4	bolita

[a] zapalote chico [b] tabloncillo [c] tabloncillo perla [d] pepitilla [e] bolita

Representativeness

A common problem of any participatory work is that it involves a self-selected group of people (those who choose to participate) who do not necessarily reflect the conditions and interests of all farmers in a region. How representative are the participants in field days of the farmers in the study region? Since these participants provide the information used to select the landraces to be improved or distributed the question arises: are we extending privileges or benefits to certain socioeconomic groups at the expense of others?

Table 5 compares some personal and household characteristics of participants in field days with a random sample of farmers in the study sites. The latter is a representative sample of the farmer population in the region. Men and women participants in field days are younger and better educated than the average for the region. They include a higher percentage of persons for whom Spanish is their mother tongue than respondents in the sample survey. In terms of nonfarm sources of income, there was no difference between field day participants and the sample survey, although the latter farm a larger maize area and a higher percentage of them own bullocks, cattle, horses, and mules. These data do not necessarily mean that field day participants were poorer. Because field day participants generally have more years of formal education, farming may contribute less to their livelihood than for farmers in the region as a whole. Field day participants seemed to be a biased sample of the overall farming population of the region. However, regardless of the reason for the bias of the sample, it is clear that maize farming is still important to participants, as was demonstrated by their attendance at the field days.

Unfortunately, with the data available to us, it is difficult to assess whether this bias translates into choices that favor certain groups at the expense of others. We tried to minimize the bias by inviting a large number of participants from many different

Table 5. Selected personal and household characteristics of participants in field days and sample survey

		Females		Males		Households	
Characteristic	Category/Units	field days	sample survey	field days	sample survey	field days	sample survey
Participants	number	116	240	97	240	213	240
age	years	38.3	48.1+++	50.1	54.2++		
education (%)	no formal education	8.6	31.3***	5.2	16.7***		
	elementary, but not completed	36.2	40.0ns	38.1	53.8 ns		
	completed elementary	38.8	22.5	33.0	22.9		
	junior high school	9.5	3.8	10.3	3.8		
	high school -technical school	5.2	1.7	3.1	2.1		
	college	1.7	0.8	10.3	0.8		
literacy (%)		92.2	67.9***	94.8	82.1***		
mother tongue (%)	Spanish	87.9	74.6***	87.6	68.3***		
non-farm sources	of income (%)						
	no off farm labor or remittances					25.4	26.3 ns
	only off farm labor					30.5	37.5
	only remittances					28.2	24.2
	off farm labor & remittances					16.0	12.1
maize area	hectares					1.8	3.0+++
ownership (%)	pair of bullocks					31.5	59.6***
	cattle					30.5	37.9*
	pigs					59.2	50.0*
	horses/mules					45.1	76.7***
	goats/sheep					38.0	40.4

++ (+++) t-test, significant at the .05 (.01) level
* (**) *** Chi-square test of homogeneity, significant at the .1 (.05) .01 level
ns not significant
Note-in the case of education and sources of income the test applies to all categories

communities to the field days. They included men and women, younger and older persons, and people with different mother tongues and levels of education. Farmers with large and small maize areas, and substantial or minor livestock holdings, participated. Currently we are in the process of assessing whether the benefits associated with the improvement and distribution of these landraces was concentrated in certain socioeconomic groups or more evenly distributed among the farming population in the study sites.

Discussion

The method described here is an initial attempt to answer two important questions faced by practitioners of participatory breeding regarding germplasm: Which germplasm will have the greatest social welfare impact, including equitability and gender considerations? And, Which germplasm will contribute most to maintaining or enhancing the genetic diversity in the target agroecosystem? The second question is important for participatory crop improvement initiatives that seek to maintain or enhance crop genetic diversity through participatory plant breeding.

We attempted to use the revealed preferences of farmers and the diversity analyses of genetic resource specialists to choose landraces for improvement, as depicted in the conceptual framework. The indicators we used have obvious limitations. The utility of field days as a research instrument depends on the extent to which farmers are able to deduce what they care about from a snapshot of varietal characteristics observed at that point in time. To evaluate many of the characteristics that matter to them, they need to experiment with materials on their own farms for at least several seasons. Although this shortcoming may be addressed through providing seed for experimentation, such experimentation always involves an economic risk, and the magnitude of the risk depends very much on the farmer. A second possible limitation is that diversity groups derived from agronomic and morphological characteristics measured in the field do not include the additional information that might be provided through molecular analyses. Nevertheless, the methods used here are modifications of the core subset method that is commonly used by genetic resources specialists (Brown 1995; Taba et al. 1998).

The second issue addressed in this method concerns the biases that may exist against certain groups of farmers when landraces are selected for improvement. Ideally, the socioeconomic characteristics of the farmer population would be better understood prior to conducting field days, and more effort could be made to ensure broader representation. In any case, it is important to assess the extent to which participants and the landraces they select represent the farmers and maize populations in the target area. Unfortunately, we were only able to partially address this issue in this instance. We know that the participants are a biased sample of the farming population in our study sites, although we cannot establish whether their choices are different from the rest of the population. To address this issue would have required inviting a representative sample of farmers to the field days in order to compare their choices to those at hand. However, participation is a voluntary endeavor, and farmers cannot be forced to participate purely to satisfy “representation.”

Large numbers of participants from different communities in field days may increase the chances of broadening representation. An alternative approach is to have a small number of “experts.” Aside from the problem of defining the term “expert,” this approach may lead to a greater bias in addressing the needs and interests of the farmer population. In any case, we cannot predict *a priori* how biased representation at this point may affect the distribution of social welfare benefits from the project. Currently, we are assessing how the initial benefits of our participatory breeding effort are distributed among the farming population in our study sites.

Conclusions

Identifying the “right” germplasm is an important problem faced by practitioners of participatory breeding. To address this problem, we have combined the perspectives of farming households, including male and female members, genetic resources specialists (professional plant breeders and gene bank managers), and social scientists. These different perspectives complement one another. When germplasm choices are based only on the perspective of genetic resources specialists, traits and materials that are important to farming households may be ignored—leading to choices that are less valuable to farmers or have a lesser impact on their livelihoods. At the same time, relying only on the perspectives of farming households may lead to less diversity, given the dominance of only one diversity group in the farmers' choices, particularly the choices of females. Although our approach has limitations, many of which are common to participatory research, it represents a method to deal systematically with one of the key problems of participatory plant breeding: how to select the appropriate germplasm. In the context of our project, this means the germplasm that may have the greatest social welfare impact while at the same time contributing to the maintainance or enhancement of genetic diversity.

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