

Analysis of the Demand for Crop Characteristics by Wealth and Gender: A Case Study from Oaxaca, Mexico

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Abstract

Small-scale farmers in developing countries are an important target for participatory breeding efforts. These farmers usually require multiple traits from a key crop. For successful participatory breeding, therefore, it is critical to identify and assess the multiple traits important to farmers and how these traits are supplied by the available germplasm. In addition, once “new” varieties are available it may be relevant to identify which are of most interest to farmers and hence have the highest potential for adoption. This paper describes a set of methods to: (1) identify crop traits important to farmers in a particular area; (2) assess their relative importance, particularly to different farmer groups; (3) assess the distribution of the traits among the varieties grown by farmers; and (4) identify “new” varieties that may be of interest to farmers. These methods are illustrated using data from a project on on-farm conservation of maize landraces in the Central Valleys of Oaxaca, Mexico. The methods were used during the diagnosis phase of the project. Although the examples presented refer to an on-farm conservation project, they are also valid in the context of participatory plant breeding.

Introduction

Many small-scale farmers in developing countries depend on one key crop, such as maize, rice, wheat, or potatoes, for their subsistence and for a source of income. Farmers require multiple traits from this key crop, since it plays various roles and fulfills different needs (Bellon 1996). These multiple traits have to be considered in breeding for successful new germplasm—farmers may not adopt a new variety if it only performs

very well for one trait and poorly for many other important traits. Identifying these multiple traits and assessing their relative importance to farmers is not always a simple task. Unlike their counterparts in the developed world, where markets are relatively efficient and the value of different crop traits is reflected in prices, small-scale farmers in the developing world mostly operate under conditions of imperfect markets, where prices do not reflect the value of traits. Furthermore, while these traits

may be obviously important to farmers, this information may not be articulated to outsiders, e.g., plant breeders, and therefore not easily recognized.

Participatory plant breeding (PPB) aims to reach farmers that have not been served by conventional breeding (Weltzien et al. 2000). It has been argued that a particular advantage of PPB derives from the strong links generated between scientists and end users. By making selection criteria more relevant to end user needs, participatory breeding can reach poor households that have not yet benefited from modern varieties (Kornegay et al. 1996; Sperling et al. 1993; van Oosterom et al. 1996). Therefore, two fundamental components of participatory breeding efforts are the identification and the assessment of traits that are important to small-scale farmers, particularly for farmer groups that may have been previously left out, have special needs, or face unique conditions. For PPB to be successful there should be methods of assessing so-called “subjective traits”. In food crops, these traits typically include taste, aroma, appearance, texture, and other characteristics that determine the suitability of a particular variety for culinary use. Because such traits are a function of human perception, they are difficult to measure quantitatively. This poses a major problem for plant breeders—before breeders can select for a trait, it must be well identified and subject to measurement.¹ Identification and evaluation of subjective traits requires close collaboration between plant breeders, social scientists, and

farmers. Social scientists traditionally have played a relatively minor role in plant breeding, but their contribution is fundamental when it comes to identifying subjective traits because of their knowledge of human perceptions and preferences.

The objective of this paper is to describe a set of methods to:

- identify crop traits that are important to farmers in a particular area;
- assess the relative importance of these traits to different groups of farmers;
- assess the distribution of the traits among the varieties grown by a group of farmers; and
- identify “new” varieties with traits that may be of interest to farmers.

These methods are illustrated with data from a project on on-farm conservation of maize landraces in the Central Valleys of Oaxaca, Mexico, and were used during the diagnosis phase of the project. The rest of the paper is divided into five parts. First, background information on the project is presented. Four sections follow this including a description, a presentation of some key results, and a short discussion of each method. Finally the conclusions are presented.

Background

The project “CG Maize Diversity Conservation: A Farmer-Scientist Collaborative Approach”² was a pilot study carried out between 1997 and 2002 with small-scale farmers in the

¹ Depending on the context, the plant breeder’s concern may be to improve these “subjective” traits or simply to maintain them while other traits are being improved. In either case, however, the breeder will need to be able to identify and evaluate the subjective traits.

² CG is an abbreviation of CGIAR: the Consultative Group on International Agricultural Research.

Central Valleys of Oaxaca. Its aim was to determine whether it is possible to improve maize productivity (in terms of yield, stability, or other characteristics of interest to farmers) while maintaining or enhancing genetic diversity. An important concept of the project is that while productivity is always important, it is fundamental to establish productivity within a specific context (for example, yields of grain or fodder under high or low input levels, or on steep slopes or flat lands). In other words, productivity is contextual, not absolute, and participatory methodologies can help to establish this context.

The Central Valleys of Oaxaca were chosen for the project because of the importance of the Bolita race (Wellhausen et al. 1952), which has been described as one of the most interesting and productive races of maize in Mexico, although it has not been widely studied or collected (Ortega 1995). Modern varieties have had an almost negligible impact in this region. This should not be construed as farmer conservatism, as discussions with farmers in the region revealed that available modern varieties do not meet their agroecological and cultural requirements. They believed that improved varieties have a long cycle that is not compatible with rainfall patterns in the area, or that these varieties are not well suited to the special preparations and culinary tastes that are very important in the region. The region is ethnically diverse and experiences a wide variation in precipitation (535-1,126 mm/yr). Despite the economic importance of labor migration to the local economy, communities in the Central Valleys place a recognizable emphasis on culture, including culinary practices for maize.

However, this diversity also faces threats, mainly from demographic and economic changes. While there are still strong incentives for farmers here to maintain their landraces, there is no guarantee that they will remain interested in maintaining maize diversity as their economic and social conditions change. Therefore, it is important to explore policy options or technical interventions that might support them.

The project was implemented in six communities of the Central Valleys. These communities were selected to represent contrasting agroecological and socioeconomic conditions present in the region. Because results differed across communities, this paper focuses on only one community, Santa Ana Zegache, for simplicity.

The project was divided into three components: (1) diagnosis, (2) interventions, and (3) impact assessment. The diagnosis was made during an earlier phase of the project. It included a collection of landrace samples representative of the regional maize diversity; an agronomic evaluation in scientist designed, farmer managed trials; a participatory exercise to identify a subset of landraces representative of the diversity present in the collection and those most likely to be valuable to farmers, i.e., a group of "elite" landraces; and a baseline survey. The baseline survey included a systematic evaluation of the characteristics farmers considered important in maize landraces and the distribution of these characteristics among the landraces grown.

The interventions component involved facilitating farmer access to a set of "elite" landraces through sales during demonstrations and field days. It also included farmer training in basic

principles of maize reproduction, seed selection in the field and in the house (including hands-on exercises in the field), and seed and grain storage principles and techniques.

The impact assessment component included a baseline survey and monitoring a sample of farmers who participated in each of the interventions. Monitoring consisted of yearly systematic interviews with sample farmers about their participation, their perceptions, and the collections of maize landraces they purchased and grew. To link project interventions to the conservation of genetic diversity, a study of the genetic structure and diversity of these landraces was conducted.

Identifying Crop Traits Important to Farmers

Crop traits important to farmers in the Central Valleys were identified during the collection of landraces representative of the regional maize diversity. The landraces were collected from certain villages in the area. The villages were selected by local scientists to include sites representing a range of agroecological and social conditions and wide variation in local maize materials. Selection criteria included physical features such as rainfall and elevation and social factors such as ethnicity and the diversity of maize use by farm households. Time and financial resources limited the number of villages visited to 15.

The different landraces grown in each village were identified with the help of key informants, mainly local authorities involved with farming and people in charge of maize milling outlets. Farmers

in each village willing to donate samples were also identified. During collection, these farmers were asked about the traits and uses of each maize type. Their responses were used to form the basis for identifying crop traits important to farmers including grain quality for cooking, fodder quality, and resistance to pests or abiotic stress.

Table 1 presents the responses of farmers who donated maize samples. An analysis of the frequency of farmers' statements shows that they considered many traits relevant. The most frequently cited positive characteristics were related to consumption, such as taste and suitability for special preparations (e.g., atole, a maize based drink), followed by high yield characteristics such as grain weight and short duration. The most frequently cited negative traits were low yield and poor resistance to storage pests. Farmers identified 11 different uses for their maize, including 9 special preparations (Table 2). The salience of consumption characteristics in farmers' statements and the high number of food uses discussed highlight the cultural importance of maize in the region.

Assessing the Relative Importance of Crop Traits to Different Farmer Groups

During the baseline survey, in which a random sample of 40 households in each of 6 villages were interviewed, male and female household members were asked to rate 25 traits in terms of importance (i.e., very important, somewhat important, or not important). This was undertaken to measure the extent to which farmers value these characteristics.

Table 1. Farmers' perceptions of the positive and negative characteristics associated with landraces collected in the Central Valleys of Oaxaca, Mexico.

Concern	Positive characteristics			Negative characteristics		
	Farmers' answers	Percentage responding	Cumulative response	Farmers' answers	Percentage responding	Cumulative response
Consumption	Good for atole	3.87				
	Good quality	1.66				
	Grain color	8.29				
	Good for pasture	2.76				
	Good taste	12.15				
	Good for tortillas	13.26				
	Good dough	1.66				
	Good for tostadas	0.55	44.20			
Yield	Thick grain	0.55		Low production	7.41	
	Produces cobs	0.55		Low yield	18.52	
	High weight	12.71		Small cobs	7.41	
	Good production	1.66		Few rows	3.70	37.04
	Good yield	0.55				
	Good yield by volume	18.23				
	A lot of grain	0.55	34.80			
Duration	Early	10.50	10.73			
Sale	Sells well	2.21	2.26			
Processing	Easy to shell	1.66	1.69			
Adaptation	Well adapted	1.66	1.69			
Abiotic stress	Withstands drought	1.10		Tall plants (lodging)	14.81	14.81
	Withstands cold	0.55	1.66			
Biotic stress	Withstands pests	0.55		Tall plants (lodging)	14.81	14.81
	Withstands weeds	0.55	1.10			
Storage	Stores well	2.21	2.21	Rot	22.22	
				Not resistant to weevils	7.41	
				Cob rots	11.11	
				Grain rots	3.70	44.44
Total		100.00			100.00	

Source: Bellon et al. (2002).

Table 2. Special culinary preparations and uses of maize identified by farmers during the collection of maize landraces, Central Valleys of Oaxaca, Mexico.

Preparation/use	Description
Tortillas	Flat bread made of maize
Atole	Maize based drink
Nicuatole	Type of gelatin made of maize
Buñuelos	Fried thin wafer
Nixtamal	Dough to make tortillas
Pinole	Powder made of maize
Pazole	Maize based drink
Tamales	Steamed maize mixture with a filling wrapped in a maize husk or banana leaf
Tejate	Sweet maize drink with cacao
Tlayudas	Special type of tortilla
Animal feed	Grain fed to poultry, leaves and stalk fed to cattle

Source: Bellon et al. (2002).

The list of characteristics included all those identified across the region. The reader should note that this list of 25 characteristics includes those that were not identified explicitly by farmers, but were included by researchers who perceived them to be important (which in fact they were). The list included yield stability (“produces something even in a bad season”), yield of tortillas by kilogram of dough, and suitability for all uses identified in the region (special dishes and preparations).

To examine the importance of these traits to different groups within the sample, all households were grouped into wealth classes through a wealth ranking exercise assisted by key informants in the project communities. The informants discussed local perceptions of wealth and, based on these views, identified three wealth classes (well-off, poor, and those in between) and characteristics of each. They were then asked to classify each participant into one of the three categories. The categories used to rank wealth were very similar among communities and are summarized in Table 3.

To test for gender differences in the demand for the aforementioned maize characteristics, the ratings given by male and female participants to each characteristic were compared using a Wilcoxon signed ranks test for two related samples. To test for differences in the demand for characteristics according to wealth, the ratings were grouped by wealth class. These ratings were compared for male and female groups according to the wealth class of the household they belonged to. The comparison was made using a Kruskal Wallis analysis of variance by ranks.

Table 4 compares the ratings of the important maize characteristics by men and women in farming households. The table shows the average rating, based on the following scale: 1 = very important, 2 = somewhat important, and 3 = not important. A Wilcoxon signed ranks test (a non-parametric statistical procedure) was used to test for statistically significant differences between male and female ratings for a characteristic.³

Table 3. Variables used to rank households by wealth, Central Valleys, Oaxaca, Mexico.

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- Source of monetary income: off-farm labor, non-farm labor, ownership of business, remittances from the USA or other parts of Mexico.
 - Access to land: quantity and quality of land, property rights over land, and access to irrigation.
 - Family demographics: availability of family labor, consumption demands of family members.
 - Ownership of animals, including access to animal manure.
 - Access to bullocks or tractor for land preparation.
 - Level of education.
 - Access to transportation, particularly ownership of a pickup.
 - Diversity of crops on the farm.
 - Access to finance and savings.
 - Importance of agriculture.
 - Interest in agriculture.
 - Ability to hire labor or purchase inputs.
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³ The table reports the mean or average rating, which makes it easier to identify differences and trends, but the test is based on the null hypothesis that the median (not the mean) of the population of differences is zero (Daniel 1978: 135-9). A non-parametric test, such as that used here, is more appropriate because the ratings are ordinal and their underlying distribution is unknown and is not likely to be normal. In this case this test is used because males and females were not selected independently of each other, but were members of the same household (they were related).

Table 4. Average ratings of importance of maize characteristics by males and females, Santa Ana Zegache, Oaxaca, Mexico.

Concern	Characteristic	Average rating			Top five characteristics	
		Males	Females	P value [†]	Males	Females
Consumption	Taste of tortillas	1.78	1.38	0.01		
	Good for atole	1.80	1.55	ns		
	Good for tlaxudas	2.23	1.63	0.00		
	Ease of shelling	2.08	2.68	0.00		
	Good for storage	1.08	1.50	0.00	2	
	Good pasture	1.90	1.70	ns		
	Good feed	1.20	1.53	0.02	5	
	Nixtamal quality	2.05	1.33	0.00		5
	Good for tamales	2.25	2.23	ns		
	Good for tejate	2.73	2.38	0.01		
	Good for pozole	2.95	2.80	0.03		
Good for nicoatole	2.90	2.70	0.02			
Yield	Yield by weight	1.25	1.05	0.03		2
	Yield by volume	1.28	2.03	0.00		
	Yield of tortillas	1.98	1.45	0.00		
	Yield stability	1.13	1.03	0.10	4	1
Duration	Duration	1.40	1.55	ns		
Sale	Ease of sale	1.85	1.53	0.03		
Abiotic stress	Withstands drought	1.03	1.08	ns	1	3
	Withstands wind	2.55	1.88	0.00		
	Withstands cold	2.75	2.30	0.00		
Biotic stress	Withstands weeds	2.45	2.35	ns		
	Withstands pests	2.40	1.60	0.00		
Management	Produced with little labor	1.40	1.85	0.01		
	Produced with little money	1.10	1.18	ns	3	4

† P value associated with a Wilcoxon signed ranks test for two related samples; ns = not significant. Source: Bellon (2001).

A comparison of men's and women's ratings shows highly significant differences for most characteristics. Of the 25 characteristics, only 7 had no statistically different ratings. Of the 5 most highly rated characteristics, however, men's and women's ratings coincided in 3: tolerance to drought,

yield stability, and low cash investment. Men also included storage properties and suitability for feed in the top 5 characteristics, while women included yield by weight and nixtamal⁴ quality. These results also show that men and women value many characteristics: the average ratings for 14 and 17

⁴ Nixtamal is the dough used to make tortillas. The milled maize is first soaked in water and lime.

characteristics for men and women, respectively, were between “very” and “somewhat important”.

These results show important gender differences in the demand for maize characteristics. Failure to recognize these differences would lead to biased interventions. In the Oaxaca project, if males alone had participated in the voting exercise to identify landraces for distribution, it is very likely that their choices would have been of more interest to them than for women. These results also have implications for breeding. Improvements in yield stability or drought tolerance would be beneficial for both men and women, but any improvements that come at the cost of nixtamal quality, for example, could negatively affect women more than men.

The large number of characteristics rated as “very important” or “somewhat important” also suggests that both men and women demand diversity, since it is unlikely that one maize type will be good at supplying all of their valued characteristics. Therefore there may not be a best or ideal maize type. Farmers in the study area require a range of maize types, and this motivates researchers to give farmers access to diversity in the Oaxaca project.

Similar analyses can be conducted using any farmer grouping or classification. Table 5 classifies men and women separately by wealth rank (i.e., well-off, intermediate, poor) and reports the average rating for each rank based on the following scale: 1 = very important,

2 = somewhat important, and 3 = not important. A Kruskal Wallis one-way analysis of variance by ranks (a non-parametric statistical procedure) was used to test for differences among the ratings, i.e., whether or not each rating for a characteristic was statistically equal among the three wealth groups.⁵

The analysis showed that the ratings of characteristics among wealth groups were not statistically different.⁶ Not surprisingly, of the top five characteristics, all wealth ranks among men and among women agreed on the importance of yield stability, tolerance to drought, and low cash investment. Men across all wealth categories agreed on the importance of storage properties. Women across wealth categories agreed on yield by weight. For poor women, the taste of tortillas and nixtamal quality were also particularly important.

These results suggest that improvements in any of the traits may benefit all farmers equally. If differences between wealth groups had emerged for certain characteristics, however, the improvement of those characteristics would have benefited some groups more than others. It is also important to note that losses in some characteristics may be more negative for some groups than for others. For example, if resistance to lodging is rated significantly higher by the rich farmers, the introduction of a more resistant variety may benefit them more than the other groups. On the other hand, if the poor farmers rate resistance to storage pests significantly higher, and a new variety has

⁵ The table reports the mean or average rating from which it is easier to identify differences and trends. However, the test is based on the null hypothesis that the three population distribution functions are identical against the alternative hypothesis that they do not all have the same median (Daniel 1978: 200-5).

⁶ The exception to this is the characteristic “good for tamales” among men, where the poor rated it higher than the other wealth classes.

Table 5. Average ratings of importance of maize characteristics by wealth rank for males and females, Santa Ana Zegache, Oaxaca, Mexico.

Concern	Characteristic	Males by wealth rank					Females by wealth rank				
		Well-off	Interme- diate	Poor	Total	P value†	Well-off	Interme- diate	Poor	Total	P value†
Consumption	Taste of tortillas	1.79	1.83	1.83	1.81	ns	1.38	1.54	1.00	1.38	ns
	Good for atole	1.64	1.92	1.67	1.75	ns	1.38	1.69	1.33	1.50	ns
	Good for tlayudas	2.21	2.42	2.17	2.28	ns	1.62	1.54	1.67	1.59	ns
	Ease of shelling	2.21	2.00	2.00	2.09	ns	2.54	2.77	2.67	2.66	ns
	Storage properties	1.14	1.08	1.00	1.09	ns	1.31	1.62	1.50	1.47	ns
	Good pasture	1.93	2.00	1.50	1.88	ns	1.46	1.92	2.00	1.75	ns
	Good feed	1.29	1.17	1.00	1.19	ns	1.46	1.54	1.67	1.53	ns
	Nixtamal quality	2.07	2.08	2.17	2.09	ns	1.46	1.31	1.00	1.31	ns
	Good for tamales	2.50	2.25	1.83	2.28	0.06	2.46	2.08	2.17	2.25	ns
	Good for tejate	2.86	2.75	2.67	2.78	ns	2.54	2.23	2.33	2.38	ns
	Good for pozole	3.00	2.92	2.83	2.94	ns	2.85	2.85	2.67	2.81	ns
Good for nicoatole	2.86	3.00	2.83	2.91	ns	2.69	2.69	2.50	2.66	ns	
Yield	Yield by weight	1.36	1.08	1.33	1.25	ns	1.15	1.00	1.00	1.06	ns
	Yield by volume	1.29	1.50	1.17	1.34	ns	2.15	1.85	2.00	2.00	ns
	Yield of tortillas	1.93	2.00	2.00	1.97	ns	1.62	1.54	1.17	1.50	ns
	Yield stability	1.14	1.00	1.00	1.06	ns	1.08	1.00	1.00	1.03	ns
Duration	Duration	1.29	1.58	1.50	1.44	ns	1.46	1.54	1.50	1.50	ns
Sale	Ease of sale	1.71	2.00	1.83	1.84	ns	1.31	1.85	1.83	1.63	ns
Abiotic stress	Withstands drought	1.00	1.00	1.00	1.00	ns	1.00	1.15	1.17	1.09	ns
	Withstands wind	2.43	2.58	3.00	2.59	ns	2.08	1.69	2.00	1.91	ns
	Withstands cold	2.71	2.50	3.00	2.69	ns	2.31	2.38	2.17	2.31	ns
Biotic stress	Withstands weeds	2.14	2.67	2.50	2.41	ns	2.15	2.31	2.67	2.31	ns
	Withstands pests	2.36	2.33	2.67	2.41	ns	1.31	1.85	1.50	1.56	ns
Management	Produced with little labor	1.36	1.42	1.50	1.41	ns	1.92	1.77	1.67	1.81	ns
	Produced with little money	1.07	1.08	1.00	1.06	ns	1.15	1.23	1.17	1.19	ns

† P value associated with a Kruskal Wallis one-way analysis of variance by ranks for males and females separately; ns = not significant. Source: Bellon (2001).

substantially lower resistance to these pests, the cost of adopting the new variety will be higher for the poor group than for the others.

By analyzing the ratings of these characteristics, as shown here, researchers have a method for predicting how the costs and benefits of introducing new germplasm are likely to be distributed among different groups of farmers and/or members of farming households.

Assessing the Distribution of Important Traits among Varieties Grown by Farmers

Varieties are not homogenous in supplying the characteristics that farmers want, otherwise one variety would be enough. Farmers are keenly aware of the differences in performance of their varieties and that these differences entail

trade-offs. For example, a variety may be very good for resistance to lodging but poor for husk coverage, while another may have the opposite combination. To assess the extent to which each of the maize types supply the 25 characteristics, farmers were asked to rate each of their maize types into three categories (very good, regular, or poor). These ratings were compared among landraces, according to grain color (the main taxonomic variable used by farmers), for male and female groups separately. The comparison was made with a Kruskal Wallis analysis of variance by ranks.

Table 6 compares farmers' ratings of the performance of Blanco (white), Amarillo (yellow), Negro (black), and Belatove (red) maize types by gender group. Each maize type was rated for each characteristic, based on the following scale: 1 = very good, 2 = intermediate, 3 = poor. For the characteristics related to labor and cash investments, the rating scale was: 1 = little, 2 = intermediate, 3 = a lot. The table reports the average rating per maize type,⁷ except for yield by weight, yield by volume, yield of tortillas, anthesis (days to male flowering), and days to harvest (an indicator of duration), for which the means of estimates provided by farmers in the appropriate units are used. A non-parametric Kruskal Wallis one-way analysis of variance by ranks for the ratings and a parametric one-way analysis of variance for the continuous variables were used to test for statistical differences across the different maize types for each characteristic.

Men's assessments of the four types showed statistically significant differences for most characteristics. The Blanco type is superior to the others for all characteristics, except for having the longest growing cycle or duration. On the other end of the spectrum, the Belatove type is inferior to all others, except for having the shortest duration. Amarillo and Negro are intermediate. The assessment shows a gradient of performance from Blanco to Amarillo to Negro to Belatove. These results suggest a trade-off between duration and good performance for other traits. All types, however, are considered particularly inferior for storage properties. These results are consistent with those obtained from the folk maize taxonomy exercise, in which farmers expressed that planting date—and therefore the uncertainty of the duration of the growing season—was very important. While Blanco had a high yield, multiple uses, and was easy to sell, it also had the longest growing cycle. Its longer duration was a disadvantage if rains were delayed and it had to be planted late because of increased risk of exposure to drought and frost. The other maize types had shorter growing cycles (Blanco>Amarillo>Negro>Belatove) and provided farmers with the flexibility to respond to the uncertain onset of rains, even though they were inferior for other characteristics.

Women's assessments of the four maize types showed statistically significant differences for a lower number of characteristics than did men's assessments. For example, unlike men,

⁷ The table reports the mean or average rating, which makes it easier to identify differences and trends. However, the test is based on the null hypothesis that the three population distribution functions are identical, against the alternative hypothesis that they do not all have the same median (Daniel 1978: 200-5).

Table 6. Male and female farmers' ratings of the performance of different maize types according to several characteristics of importance, Santa Ana Zegache, Oaxaca, Mexico.

Concern	Characteristic	Males Maize type						Females Maize type					
		Blanco	Amarillo	Negro	Belatove	Total	P value [†]	Blanco	Amarillo	Negro	Belatove	Total	P value [†]
Consumption	Taste of tortillas	1.00	1.11	1.00	1.33	1.04	0.01	1.03	1.07	1.00	1.00	1.03	ns
	Good for atole	1.00	1.47	2.46	2.33	1.42	0.00	1.00	1.33	2.40	3.00	1.32	0.00
	Good for tlayudas	1.00	1.17	1.00	1.00	1.04	0.09	1.00	1.00	1.00	1.00	1.00	ns
	Nixtamal quality	1.00	1.22	1.29	1.67	1.13	0.00	1.00	1.07	1.00	1.00	1.02	ns
	Good for tamales	1.00	1.06	1.93	2.33	1.24	0.00	1.00	1.07	1.10	1.00	1.03	ns
	Good for tejate	1.00	2.00	2.36	2.33	1.55	0.00	1.03	1.80	2.20	2.00	1.39	0.00
	Good for pozole	1.00	1.83	2.43	2.33	1.52	0.00	1.03	1.20	1.80	1.00	1.18	0.00
	Good for nicoatole	1.00	2.11	1.50	3.00	1.44	0.00	1.00	1.87	2.50	3.00	1.46	0.00
	Ease of shelling	1.05	1.11	1.36	1.00	1.12	ns	1.45	1.07	1.00	1.00	1.29	0.01
	Storage properties	1.75	2.06	2.71	3.00	2.05	0.00	1.85	2.20	2.90	3.00	2.11	0.00
	Good pasture	1.00	1.00	1.93	2.33	1.23	0.00	1.08	1.07	1.90	3.00	1.23	0.00
Good feed	1.00	1.00	1.07	1.00	1.01	ns	1.00	1.00	1.00	1.00	1.00	ns	
Yield	Yield by weight [‡]	653.80	544.90	520.40	461.30	595.10	0.01	395.80	296.00	230.00	156.70	346.90	0.01
	Yield by volume [§]	4.00	3.99	3.99	4.00	3.99	ns	3.97	3.97	3.98	4.00	3.97	ns
	Yield of tortillas ^{††}	38.37	38.78	39.14	39.00	38.64	ns	36.05	36.80	38.00	40.00	36.58	ns
	Yield stability	1.08	1.56	1.86	2.00	1.37	0.00	1.63	1.33	1.20	1.00	1.48	0.04
Duration	Anthesis ^{‡‡}	79.90	74.60	62.90	60.00	74.60	0.00	74.00	65.90	53.50	45.00	68.90	0.00
	Harvest ^{§§}	121.90	116.20	97.40	95.00	114.90	0.00	127.50	118.30	97.10	96.00	120.50	0.00
Sale	Ease of sale	1.00	1.28	2.00	2.00	1.29	0.00	1.00	1.20	1.80	2.00	1.18	0.00
Abiotic stress	Withstands drought	1.35	1.89	2.64	2.33	1.76	0.00	1.54	1.47	1.60	2.00	1.54	ns
	Withstands wind	1.25	1.33	1.21	1.33	1.27	ns	1.48	1.60	1.20	2.00	1.47	ns
	Withstands cold	1.13	1.11	1.14	1.00	1.12	ns	1.25	1.47	1.40	1.00	1.32	ns
Biotic stress	Withstands weeds	1.63	2.06	2.00	1.67	1.80	0.01	1.80	1.93	1.60	1.00	1.79	ns
	Withstands pests	1.45	1.56	1.71	1.33	1.52	ns	1.58	2.07	2.11	3.00	1.78	0.00
Management	Produced with little labor	2.50	2.33	2.50	2.00	2.44	ns	2.30	2.33	2.40	2.00	2.32	ns
	Produced with few purchased inputs	2.58	2.56	2.57	2.00	2.55	ns	2.33	2.40	2.40	2.00	2.35	ns

[†] P value associated with a Kruskal Wallis analysis of variance test for the ratings, except for yield by weight, yield by volume, yield of tortillas, anthesis, and harvest where it is associated with a parametric analysis of variance; ns = not significant.

[‡] Expected yield (kg/ha) calculated from the best, worst, and more frequent yields declared by farmers for each maize type using the triangular distribution method (Hardaker et al. 1997).

[§] kg/local unit of volume (almud).

^{††} Number of tortillas/almud.

^{‡‡} Number of days to anthesis (male flowering).

^{§§} Number of days to harvest.

Source: Bellon (2001).

the women did not consider differences for consumption qualities, such as taste of tortillas, nixtamal quality, tlayudas, and tamales, but they did for ease of shelling. All of these characteristics relate to aspects of maize preparation

that women are responsible for. Women provided much lower estimates for yield by weight and duration, but their ordering of these characteristics was similar to that given by the men. An important difference is that the women

considered Amarillo, Negro, and Belatove to have higher stability than Blanco. In general they rated colored maize types much more highly than men did. In particular, women perceived colored maize types to perform better compared to Blanco than men did, so the trade-off between good performance and duration is not as strong among women as men. It appears that colored maize types are considered more important by females than males, therefore, women may be playing an important role in the conservation of these maize types.

The study suggests that the performance of any new variety introduced into the Central Valleys of Oaxaca could be rated according to the aforementioned characteristics by a panel of farmers. The farmers could predict how the variety might fit into the production system, which varieties it might displace, and how it would complement other varieties. For example, a shorter duration white maize type, equal in other respects to the currently grown white type, could displace the colored maize types since it would decrease the trade-off between desirability and duration. On the other hand, improving the storage quality of colored maize types may encourage their conservation.

Identifying “New” Varieties that May Have Interesting Traits to Farmers

While it is important to know how currently planted varieties perform in terms of important traits, it may be desirable to identify “new” varieties that may be of interest to farmers. In the

Oaxaca project, these new varieties were simply landraces from the region that captured regional diversity (collected at the beginning of the project) but were mostly unknown in the project villages.

A set of 170 materials was evaluated by breeders and farmers in farmers’ fields during the rainy season of 1997. The set comprised 152 maize populations (landraces) collected from the area, 16 landraces from the gene bank, and 1 improved variety derived from the Bolita landrace. A crucial problem was the impossibility of working with such a large number of entries to promote on-farm conservation—the entries do not contribute similarly to diversity, nor are they of equal interest to farmers. There was a need to identify a subset that would be interesting to farmers and contribute to maize diversity in the region (see Bellon et al. 2002 for details).

To identify landraces of more interest to farmers among the landraces collected, farmers from the region were invited to evaluate the 170 populations at physiological maturity and harvest at 3 trial locations during the agronomic evaluation of 1997. At harvest, 213 farmers (54% females) participated. All ears from the inner rows of the experiment were harvested and laid out in front of the stand, so farmers could judge grain yield and examine the ears. Farmers walked through the trial, observed the landraces, and recorded the plot numbers of their preferred landraces. Each plot recording was interpreted as a vote for that landrace. The purpose of this exercise was to obtain a rapid sort or classification of landraces according to farmers’ expressions of interest. The exercise enabled us to systematically deal with

many materials (170) and many farmers (approximately 70 per field day) in a relatively brief period (2-3 hours). Field days were open to all those who wished to participate. We assumed that the number of participants' votes reflected the value of a landrace. Originally we intended to ask participants to rank the materials for a set of traits; however, this was precluded by the large number of materials exhibited and the large number of participants per demonstration.

Figure 1 compares the votes made by male and female participants. Each point is a collected landrace. The x-axis represents the percentage of men who voted for a particular landrace, while the y-axis represents the same information for women. While there was a high correlation between male and female votes (0.70, $p < 0.0001$), their voting patterns were not the same. For example, a higher number of females voted for particular landraces compared to males, suggesting that there was a higher level of agreement among females in their choices relative to males.

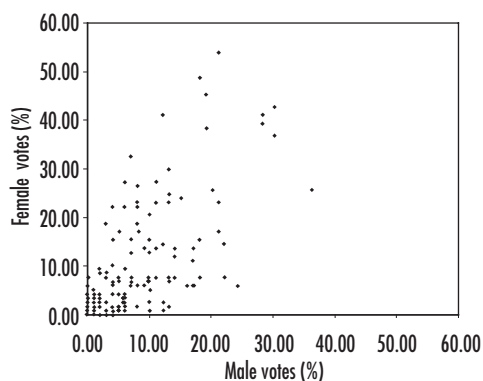


Figure 1. A comparison of the votes cast by men and women participating in field days in the Central Valleys, Oaxaca, Mexico.

Source: Bellon et al. (2002).

The most desirable landraces (those chosen frequently by both men and women) are located in the upper right section of the graph. The least desirable landraces are located in the lower left section. Results from the voting exercise show that there is great interest in diversity among participating farmers, as well as gender differences (Table 7). While male farmers voted for many landraces, women, on average, chose more landraces. Only about a third of the men and half of the women voted for the most popular landraces. Few landraces received no votes, suggesting that participants want a range of materials and that there is no "best" landrace. The fact that only a few participants voted for no landraces indicates a high degree of interest in all entries exhibited.

Breeders evaluated the landraces with the help of a selection index based on yield (Mg/ha), ear rot (%), erect plants (%), and moisture (%) calculated for each landrace in the set. The selection index was used to account for grain yield, grain quality, and standability. The selection index is a linear function of the

Table 7. Voting patterns of male and female participants in field days in the Central Valleys, Oaxaca, Mexico.

Landrace votes	Males	Females
Average number	10.800	13.700 [†]
Maximum number	40.000	38.000
Minimum number	0.000	0.000
Landraces with zero votes (%)	12.500	15.800
Maximum votes awarded to one landrace (%)	36.400	53.900
Participants who did not vote for any landrace (%)	5.100	3.400
Correlation between votes received and selection index for landraces	0.369 [‡]	0.362 [‡]

[†] t-test for equality of means significant at the 0.01 level (2-tailed).

[‡] Correlation significant at the 0.01 level (2-tailed).

Source: Bellon et al. (2002).

four variables mentioned above, adjusted to give a score of 100 to the best entry. The indices for the rest of the entries express the gap between their performance and that of the best entry. Farmers' votes were compared to this selection index (Table 7). There was a significant and positive correlation between the votes received by a landrace and its selection index. It is evident that farmers appear to consider agronomic performance, and that their voting patterns are far from random.

Conclusions

Although the examples presented in this paper refer to an on-farm conservation project, they are also valid in the context of PPB. In PPB there is a need to identify and assess the importance of crop traits, as well as to understand their distribution among current varieties. This should allow breeders and other scientists to identify gaps in the performance of these varieties, and to target and prioritize the traits that merit improvement. For new germplasm to be of interest to farmers, it has to provide a benefit that is lacking in the current germplasm or be superior for at least some traits. An important aspect of the complementarity between new and current germplasm is the extent to which the incorporation of a new variety into the set of varieties planted by a group of farmers reduces the trade-offs between varieties in the set. This may be analyzed by the methods presented here. For example, for a variety that yields well but has poor taste qualities, there is a trade-off between yield and taste. Introducing a variety with good yield and improved

taste lessens the trade-off between the traits. Furthermore, by analyzing the importance of various traits to different social groups, one can assess how the improvement of certain characteristics could benefit or harm some groups more than others.

Allowing farmers to see and evaluate new varieties, and systematically capturing their assessment, as illustrated by the "voting" method, should allow breeders and other scientists to identify traits and varieties that are interesting and potentially valuable to farmers. The selection index of farmers may differ to that of breeders, both in terms of traits included and the weighting given to each trait. Also, the farmers' selection index is not written down anywhere and therefore may not be easily elicited. However, by allowing farmers to see and assess new materials and have a systematic method of rating their assessments, their selection index can be revealed. A discussion of how to transform the voting exercise into a farmer selection index is beyond the scope of this paper, but remains an area for further study. The method described here may serve in the initial phases of a participatory breeding project to identify suitable donor or parent materials. Alternatively it could be used as part of a participatory varietal selection exercise. While there are other approaches of assessing new materials by farmers, the method described here is easy to implement. It can deal with many entries and many farmers in a relatively short time and requires minimal investment in training farmers to rate varieties.

Acknowledgements

This work was carried out with a grant from the International Development Research Centre, Ottawa, Canada. It is part of the project “CG Maize Diversity Conservation: A Farmer-Scientist Collaborative Approach”, implemented jointly by the International Maize and Wheat Improvement Center (CIMMYT) and Mexico’s National Institute of Forestry, Agriculture, and Livestock Research (INIFAP). The author gratefully acknowledges the work of the project team (Flavio Aragón, Julien Berthaud, José Alfonso Aguirre Gómez, Jorge Mendoza, Irma Manuel Rosas, Melinda Smale, and Suketoshi Taba) without who this paper could not have been written.

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Discussion Summary

The discussion following the presentation focused on how wealth, gender, and agroecological differences were dealt with in the case study. It was surprising to some workshop participants that there were no differences between wealth categories in terms of the importance of traits—in other settings there are usually clear differences, particularly between the rich and other socioeconomic groups. In terms of gender, differences between the results of this case study and those from other areas were also noted. For example, in Yemen, males and females selected the same varieties because the females visited the trial prior to the official evaluation, and felt that they had to agree with the men's selection. In Oaxaca, there were obvious differences between many of the men's and women's selections. The key point here is that results may be cultural and location specific.

A question was raised on whether the researcher intervention raised productivity, but the author pointed out that the main aim of the project was to give farmers access to diversity and, in some cases, to give back lost varieties. Furthermore, self selection was encouraged in the project, and participants seemed to be more interested in diversity than in the population at large. Discussion then focussed on possible biases related to the types of farmers participating in the study. Even though everybody was invited to participate, only certain farmers chose to do so. One of the issues of participation is that, by definition, it entails a bias because participants are those who are willing to participate. In the Punjab, for example, wealthy farmers are more likely to participate and to buy. Nonetheless, a systematic monitoring of the participants was conducted to identify possible biases. Finally, it was noted that all materials sold were local landraces, though not necessarily from the communities where the participants lived. The materials were chosen to represent the regional landrace diversity.