Evaluation of Current and New Technological Options

Any technology or practice used by farmers represents a particular way to solve one or several problems. Each technology or practice responds to farmers' concerns in specific ways, which may be regarded as the *traits* or *characteristics* that define the technology or practice. Farmers can view some characteristics as positive or advantageous (i.e., as benefits) and others as negative or disadvantageous (i.e., as costs).

Any practice or technology entails trade-offs between its positive and negative traits. As a farmer from Chiapas once said when discussing maize varieties, "With each variety you gain in certain things but lose in others." He explained that with a modern variety, farmers gained higher yields, shorter duration, and less lodging, but they also lost something, because the variety required more inputs and more careful management. The choice of one technology/practice over others is greatly influenced by the balance between its positive and negative characteristics. Depending on the preferences, resources, and constraints that individual farmers face, a beneficial characteristic for one farmer may be a negative one for another, or the balance between positive and negative traits may be acceptable for one farmer but not for another.

Any new technology presented to farmers will either improve or substitute for the technological options they currently have. It is fundamental to identify these options and understand perceptions about the advantages and disadvantages of each one. Only then will researchers be able to assess the appropriateness of potential new technologies or practices, evaluate the likelihood that they will be adopted, and if necessary modify them to suit farmers' needs better. To identify gaps in knowledge and perceptions among those involved in the process of technological change, it is vital to understand not only farmers' perceptions but also those of other stakeholders in the research process, mainly the scientists and technicians proposing these new technologies.

This section presents several methods for identifying technologies that farmers presently use, eliciting and analyzing farmers' perceptions of their costs and benefits, and enabling farmers and researchers to evaluate new technologies together.

Eliciting Farmers' Perceptions of Technological Options

Goal: Identify the criteria used by farmers to assess available technological options.

Rationale: Farmers have several technological options at their disposal. They have perceptions of their advantages and disadvantages and therefore their trade-offs. Inherent in these perceptions are the criteria that farmers use to judge these technologies and most likely any new ones. It is important to know and understand these criteria if researchers are to identify new technological options of interest to farmers, including improvements to current ones.

Method: Define the problem to be addressed, such as inappropriate germplasm, infertile soil, or problems with pest management or crop storage. A group of informants from a community is assembled, ideally a mixture of people of different ages, resources, and genders. The first step is to identify the technological options that farmers recognize to deal with the problem of interest. For germplasm, this is relatively easy because the local crop taxonomy provides this information. For other problems—soil infertility, a pest, storage, and so on—it may be necessary to ask, for example:

What can you do to deal with this problem?

Or ask specifically: *What can you do to improve your soils? What do you do to control a particular pest? What do you do to protect your stored maize?*

The answers to this question are the options recognized by farmers. Researchers should try to be as inclusive as possible, and to elicit as many answers (options) as possible. At this stage it is not important to establish how important these are, but to have the most comprehensive list.

Then for each option identified, the interviewer asks:

What are its advantages?

What are its disadvantages?

The interviewer records all answers. It is important to identify responses that refer to the same concept, since people may express their ideas in different forms. This requires some judgement on the part of the scientist, but usually it is not difficult. (This is similar to what has been done for the local soil and crop taxonomies). Once this has been done, researchers should identify the underlying properties, characteristics, or concerns implied in farmers' responses. This last activity is a fundamental part of this method, since these characteristics, properties, or concerns are the basis for the criteria. It is important to express the criteria in terms that make sense to farmers. The following examples show how this method is applied for germplasm and soil fertility management.

Example for germplasm: The Oaxaca Project included a collection of landraces representing the maize diversity present in the region. As indicated earlier, the collection was based on the local crop taxonomy elicited from key informants in all communities sampled. Farmers donating the maize samples were asked about the advantages and disadvantages of each landrace they donated. Table 11 presents the local maize taxonomy and the advantages and disadvantages for the six communities that are the focus of the project. Note for example how farmers refer to an advantage with different terms:

Table 11. Perceived advantages and disadvantages of maize types, Oaxaca, Mexico

Type	Blanco (white kernel)				Amarillo (yellow kernel)		Negro (black kernel)	Belatove (red kernel)	Pinto
Subtypes	Tempranero (early)	Delatoba	Olote delgado (thin cob)	Blanco (generic)	Amarillo (generic)	Tepecente	None	None	None
Advantages	Early Good tortillas Thin cob Yields by volume White tortilla	Heavy Yields by volume Good storage Soft pasture	Yields by volume Easy to shell	Good tortillas Good production Not too delicate Heavy Yields by volume Low ear rot Good pasture Good for sale Withstand drought Easy to shell Good for consumption	Weight Good tortilla Tasty tortilla Withstands drought Yields by volume Withstands weeds Early Good yield Good storage Tasty atole Good yield Grows fast	Withstands pests A lot of grain	Good tortillas Early Tasty tortillas Color Tasty tlayuda Sweet atole Withstands cold	Good tostadas Very early Grows very fast	Good adaptation
Disadvantages	Low yield Small ear			Low yield High ear rot Poor storage	Poor storage Not widely consumed Difficult to sell		Attacked by pests Low yield Very difficult to sell	Low yield Little pasture	

"early" and "grows fast." The taxonomy has five maize types, based on grain color: Blanco (white), Amarillo (yellow), Negro (black), Belatove (red), and Pinto (multicolored). The white and yellow types were subdivided further into four and two subtypes, respectively. All answers can be grouped as characteristics related to a set of concerns: consumption, yield, sale, duration, adaptation, and response to biotic and abiotic stresses. These advantages and disadvantages were used to identify the criteria that farmers use to judge their maize. Table 12 presents these characteristics grouped by concern and then expressed as the criteria. The data show how important consumption characteristics are for these farmers. These criteria will be used later for comparing different varieties/ technological options.

Example for soil fertility management: The Chihota Project included feedback from farmers who had been evaluating three soil fertility improvement technologies: lime in combination with fertilizer; green manuring (velvetbean and sunnhemp), sole or intercropped with maize; and cereal legume rotations.

During these feedback sessions, farmers were asked about the advantages and disadvantages they perceived in these technologies (Table 13). All answers can be grouped as characteristics related to a set of concerns: impacts on soil fertility, fertilizer use efficiency, productivity, costs, labor and inputs, alternative uses for the crops, rainfall, and biotic stresses. These advantages and disadvantages were used to identify the criteria that farmers use to judge the technologies. Table 14 presents these characteristics grouped by concern and then expressed as the criteria.

Table 12. Characteristics and criteria used to judge maize types, Oaxaca, Mexico

Concern	Advantages	Disadvantages	Criteria
Consumption	Tasty tortillas		Taste of tortillas
	Tasty/sweet atole		Taste of atole
	Tasty tlayuda		Taste of tlayudas
	Tasty tostada		Taste of tostadas
	Easy to shell		Ease of shelling
	Good storage	Poor storage	Storage properties
	Good pasture	Little pasture	Production of pasture
	Soft husk (totomoxtle)		Husk quality
Yield	Good yield–weight		Yield by weight
	Good yield–volume	Small ear	Yield by volume
	Good yield (generic)	Low yield	
Duration	Early/ fast growing		Duration
Sale	Easy to sale	Difficult to sell	Ease of sale
Adaptation	Good adaptation		Adaptation
Abiotic stress	Withstands drought		Withstands drought
	Withstands cold		Withstands cold
Biotic stress	Withstands weeds		Withstands weeds
	Withstands pests	Attacked by pests	Withstands pests
	Low ear rot	High ear rot	Susceptibility to ear rot

Table 13. Perceived advantages and disadvantages of soil fertility improvement technologies, Chihota, Zimbabwe

	Lime with fertilizers	Cereal / legume rotations	Green manures
Advantages	Improves yields Crops grows well Improves soil structure Improves soil fertility Corrects pH Increases fertilizer efficiency Not expensive Cut costs of fertilizers Supresses weeds Early to assess	Residual fertility Reduced fertilizer use High yields Increased crop diversity Multipurpose use of legumes Disease control Early to assess	Improves soil fertility Cheaper than fertilizers Increase yields Can be used to feed cattle None
Disadvantages	Needs adequate rains Crops suffers if rains are late Damage soil if over-used Can be washed away by wind Still assessing None	Legumes affected by disease Poor germination Still assessing None	Not for human consumption Seed unavailable Labor intensive None

Table 14. Characteristics and criteria used to judge soil fertility improvement technologies, Chihota, Zimbabwe

Concern	Advantages	Disadvantages	Criteria
Soil fertility	Improves soil fertility Corrects pH Residual fertility Improves soil structure	Damage soil if over-used	Impact on soil fertility Impact on pH Impact on residual fertility Impact on soil structure Impact on soil if over-used
Fertilizer efficiency	Increases fertilizer efficiency Reduced fertilizer use		Impact on fertilizer efficiency
Costs	Not expensive Cut costs of fertilizers Cheaper than fertilizers		Cost vis-à-vis inorganic fertilizers
Inputs		Seed unavailable Can be washed away by wind	Ease of accessing inputs Chances of input loss
Labor demands		Labor intensive	Impact on available labor
Productivity	Improves yields Crops grows well High yields Increases yields		Impact on yield
Alternative uses for crops	Increased crop diversity Multipurpose use of legumes Can be used to feed cattle	Not for human consumption	Alternative uses
Rainfall		Needs adequate rains Crops suffer if rains are late	Interaction with rainfall
Weeds	Suppresses weeds		Impact on weeds
Germination		Poor germination	Impact on germination
Diseases	Disease control	Legumes affected by disease	Impact on/from disease

Comments: This method—whether it is applied to germplasm or another kind of technology—only provides an inventory of characteristics that farmers use to assess the technological options they know, although it is likely that they would use the same criteria to judge new options. This method is only descriptive. Researchers cannot assess which characteristics are more important for the farmer. Nor can they assess the importance of the characteristics in relation to the technological options available, particularly for those characteristics that can be delivered by several technologies (in other words, researchers cannot tell how much of a characteristic of interest, such as yield, is supplied by a particular variety or input). This information is important for determining which characteristics should be improved or to evaluate new technological options compared to current ones.

Comparing Different Technological Options

Goal: Systematically compare and analyze farmers' perceptions of technological options.[12]

Rationale: The previous method helps to elicit information on the advantages and disadvantages of technologies, on the implicit characteristics that farmers value in those technologies, and therefore on farmers' criteria for judging technological options. To compare and evaluate technological options in a systematic manner, however, it is necessary to assess the importance of each of these characteristics relative to each other (i.e., farmers' demand for these characteristics) and the extent to which each technology provides these characteristics (i.e., the technology supply of characteristics). A technological option that is better at supplying characteristics that farmers consider more important is more valuable than one that is inferior. Furthermore, even when a technological option is good at supplying certain characteristics, if these are not very important, its value is diminished.

Method: The previous method provided a list of characteristics that farmers valued, but it could not clarify how much the individual characteristics were valued relative to each other or how specific technological options provided each characteristic. In many cases, scientists add characteristics to the list of characteristics identified previously, based on their experience, even though farmers may not have identified them. In some instances, certain issues are not mentioned because they are obvious to informants, or informants simply fail to articulate or mention them. Clearly, the scientists' experience and common sense should complement the farmers'.

The exercise described here can be done with a group of farmers or individual farmers, a choice that has implications for the analysis (see comments below). It assumes that the relevant technological options have already been identified (e.g., maize varieties, soil improvement technologies, and so on).

First, researchers explain the objective of the exercise to the participants. The researchers make it clear that, in

12 The emphasis here is on the evaluation of technologies based on their characteristics. This method is particularly suited for crop varieties, which is the focus of the work described here. The reader is referred to CIMMYT (1988) for methods using other factors in technology evaluation.

discussions with them or with other farmers, they have identified a set of characteristics or issues that farmers find important in their technological options. Now they wish to know *how important* those characteristics are to farmers, since some are likely to be more important than others. Researchers can provide an example to make this point. Then they should note that not all of farmers' technological options perform equally well with respect to each of those characteristics (here another example may be useful). Therefore, researchers also want to know *how good or bad* farmers consider each of these options to be with respect to each characteristic.

Second, the interviewer asks farmers to rate the importance of each of the identified characteristics (in other words, to assess the demand of characteristics) by asking:

*How do you consider this characteristic (*e.g., yield, drought resistance*) to be: very important, somewhat important, or not important?*

This question is repeated for all characteristics identified as important. It is highly desirable to make cards, each illustrating one of the characteristics, and ask farmers to place each card in a pile corresponding to the rating they consider appropriate (very important, somewhat important, not important). Figure 6 presents a hypothetical example with cards. (Appendix 2 shows examples of cards used in the Oaxaca Project).

Third, farmers are asked to rate the performance of each technological option with respect to each characteristic as: very good, intermediate/acceptable, or poor[13] (assess the supply of characteristics). To do this, the interviewer asks:

How do you consider this option (e.g., variety A, velvet bean, lime) *to be in terms of its performance with respect to this characteristic* (e.g., drought resistance, increasing soil fertility)*: very good, intermediate, or poor?*

This question is repeated for all options and a given characteristic. Then the process is repeated for the next characteristic, and so on until no more characteristics remain to be discussed. It is desirable, since it simplifies the process, to use the cards from the second step in this method. Put them in a row (Figure 7). Above them, place three cards depicting the rating of performance (poor, intermediate, very good), perhaps shown as a frowning, straight, or smiling face, or thumbs up/thumbs down, or some other image adapted to the place where the research is being done. As shown in Figure 7, this card placement creates a matrix in which the first row displays the characteristics and the columns display the possible performance ratings.

Using cards that name or depict the options (with varieties you can use actual ears or panicles of specific varieties), researchers ask the farmers to place the card with the option (or the ear) in the row with the card with the characteristic and under the column for the appropriate performance rating. The results are noted.

The results from these ratings can be compared across different types or

[13] The rating has to be adapted to the characteristic. In some cases, "very good," "intermediate," or "poor" may not be the most appropriate way to rate a characteristic. If the characteristic of interest is the labor required for the technology to work properly, a more suitable rating may be "high," "intermediate," or "low."

Figure 6. Hypothetical example of cards rating the importance of maize characteristics.
Note: No order of importance is implied within a colum. Each column represents a pile of cards associated with the importance rating.

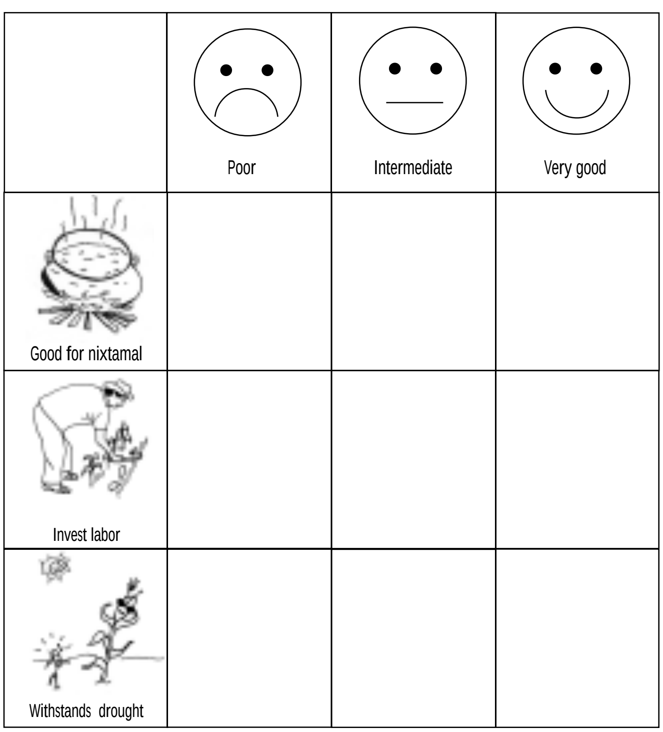

Figure 7. Example of a card layout to rate characteristics.

groups of farmers and/or varieties/ technological options using the average ratings. These average ratings can be used to compare and rank the importance of different characteristics to farmers (demand of characteristics) or to compare and rank the performance of different options with respect to each characteristic (supply of characteristics).

As mentioned previously, this rating exercise can be done with a group of farmers or individual farmers. The group strategy may produce a consensus on the ratings. There is no guarantee, however, that a consensus may be reached. If the group is heterogeneous, it is very likely that farmers may not agree on the importance of many characteristics, because each farmers faces different problems, may have different priorities, and therefore may value characteristics differently. In fact, identifying the disagreements and discussing them may provide important information on farmers' diverse priorities. Furthermore, in a group setting it may be difficult to analyze variation among individuals with different goals, resources, and constraints, and researchers will be more limited in their ability to generalize the results to other farmers. One strategy for gaining this information is to ask for a show of hands (voting) and record how each member of the group rates the importance of a characteristic and the performance of a technological option with respect to a characteristic. It may be useful to record the votes disaggregated by gender. This procedure provides a better idea of the variability in ratings across group members.

A second strategy allows statistical tests and inferences to be made if researchers have a random, representative sample from a population of farmers. The ratings can be combined with a typology of farmers, such as the wealth ranking, to analyze how different types or groups of farmers rate the characteristics (for example, which characteristics are important for poor or rich farmers, male or female farmers, farmers with and without machinery). The performance of different technologies with respect to each characteristic can be assessed statistically, which offers a better idea of the trade-offs involved (see example below).

A third strategy can be used if many groups are interviewed. Each group can be treated as an "individual" and the average ratings can be calculated across groups. Alternatively, if a show of hands is asked for each group and the results are recorded, individual votes within a group could be used for the analysis. Since there are many groups, this would lead to a large number of ratings. Researchers should be careful in applying statistical inferences to these techniques, however. If the sample of informants is not randomly chosen, researchers may violate the assumptions of the tests they want to apply, invalidating their results. However, these approaches provide a better idea of the variability present and still permit some basic parameters to be calculated, such as the average rating or percentage for each rating, at least for the participants and without claiming wider representation.

Example: This method was used in the Oaxaca Project to compare different maize landraces, based on the categories identified by eliciting the local crop taxonomy (presented earlier). The results for only one community, Santa Ana Zegache, are presented here for simplicity and because the results differed across communities.

The rating exercise was done as part of the baseline survey with a random sample of 40 farming households in the community. Male and female members of each household were interviewed separately. The list of characteristics included all the ones identified across the region. The reader should note that this list of 25 characteristics included characteristics that were not identified explicitly by farmers using the method to elicit their criteria. The additional characteristics were included because researchers thought that they would be important (in fact they were). The additional characteristics 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).

Analyzing the demand of characteristics

Table 15 compares the ratings for the importance of maize characteristics by men and women in farming households. The table reports the average rating, based on the following scale: 1 = very important, 2 = somewhat important, and 3 = not important.[14] A Wilcoxon matched-pairs

Table 15. Average ratings of importance of maize characteristics by males and females, Santa Ana Zegache, Oaxaca, Mexico

		Average rating			Top 5 characteristics	
Concern	**Characteristic**	**Males**	**Females**	**P-value[a]**	**Males**	**Females**
Consumption	Taste of tortillas	1.78	1.38	0.01	–	–
	Good for atole	1.80	1.55	ns	–	–
	Good for tlayudas	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

Note: ns = not significant.

[a] P-value associated with a Wilcoxon signed ranks test for two related samples.

[14] Appendix 3 shows what data for the demand and supply of characteristics look like.

signed ranks test (a non-parametric statistical procedure) was used to test for statistically significant differences between males' and females' ratings for a characteristic.[15]

A comparison of men's and women's ratings shows highly significant differences for most characteristics. Of the 25 characteristics, only seven had no statistically different ratings. Of the five top-rated characteristics, however, men and women coincided in three: tolerance to drought, yield stability, and low cash investment. Men also included storage properties and suitability as feed in the top five characteristics, and women included yield by weight and *nixtamal*[16] quality. These results also show that men and women value many characteristics: the average ratings for 14 and 17 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 that identified landraces to be distributed, it is very likely that the choices would have been of interest to them but less so for women. These results also have implications for breeding. Improvements in yield stability or tolerance to drought would be beneficial for both men and women, but any improvements that come at the cost of decreasing nixtamal quality could negatively affect women more than men, since women value nixtamal quality much more than men do.

The large number of characteristics rated as "very" 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 the characteristics they value. Therefore there may not be a "best" or "ideal" maize type. These farmers require a range of maize types, and this fact motivates the intervention of providing farmers with access to diversity in the Oaxaca Project.

Similar analyses can be done using any grouping or classification of farmers, such as a wealth ranking. Table 16 groups men and women separately by wealth rank and reports the average rating for each wealth rank (i.e., rich, medium, poor), 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 whether there were differences in the ratings—in other words, whether each rating for a characteristic was statistically equal or not among the three wealth groups.[17]

The ratings of characteristics among the wealth groups were not statistically

[15] The table reports the mean or average rating, from which it is 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 the one 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).

[16] Nixtamal is the dough used to make tortillas, which requires that the milled maize be soaked in water with lime.

[17] The table reports the mean or average rating, from which it is easier to identify differences and trends, but 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 16. Average ratings of importance of maize characteristics by wealth rank for males and females, Santa Ana Zegache, Oaxaca, Mexico

		Males by wealth rank					Females by wealth rank				
Concern	**Characteristic**	**Rich**	**Medium**	**Poor**	**Total**	**P-value[a]**	**Rich**	**Medium**	**Poor**	**Total**	**P-value[a]**
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	Produce with little labor	1.36	1.42	1.50	1.41	ns	1.92	1.77	1.67	1.81	ns
	Produce with little money	1.07	1.08	1.00	1.06	ns	1.15	1.23	1.17	1.19	ns

Note: ns = not significant.

[a] P-valule associated with a Kruskal Wallis one-way analysis of variance by ranks for males and females separately.

different.[18] Not surprisingly, for the top five characteristics all wealth ranks among men and among women coincided on the following: yield stability, tolerance to drought, and low cash investment. Men across all wealth categories coincided on storage properties. Women across wealth categories agreed on yield by weight; for poor women, 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" group, the introduction of a new variety more resistant to lodging may benefit them more than the other groups. On the other hand, if the "poor" group rates resistance to storage pests significantly higher, and a new variety has substantially lower resistance to these pests, the cost of adopting the new variety will be higher for the poor group than for the other groups.

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

Analyzing the supply of characteristics

Table 17 compares farmers' ratings of the performance of Blanco (white), Amarillo (yellow), Negro (black), and Belatove (red) maize types by gender group. For each characteristic identified earlier, each maize type was rated based on the following scale: 1 = very good, 2 = intermediate, or 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,[19] except for yield by weight, yield by volume, yield of tortillas, anthesis (days to male flowering), and days to be ready for 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 other types for all characteristics, except for having the longest duration. On the other end of the spectrum, the Belatove type is inferior to all other types, except for having the shortest duration. Amarillo and Negro are intermediate. The assessment shows a gradient of performance from Blanco to Amarillo, Negro, and Belatove. These results

[18] Except for the case of "good for tamales" among men, where the poor rated it higher than the rest.
[19] As with the demand of characteristics (Table 16), Table 17 for supply of characteristics reports the mean or average rating, which makes it easier to identify differences and trends, but the test used in each table 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 17. Average rating of the performance of different maize types for several characteristics of importance to male and female farmers, Santa Ana Zegache, Oaxaca, Mexico

		Males						Females					
Concern	**Characteristic**	**Blanco**	**Amarillo**	**Negro**	**Belatove**	**Total**	**Signif.[a]**	**Blanco**	**Amarillo**	**Negro**	**Belatove**	**Total**	**P-value[a]**
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
	Food 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 [b]	653.8	544.9	520.4	461.3	595.1	0.01	395.8	296.0	230.0	156.7	346.9	0.01
	Yield by volume [c]	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 [d]	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 [e]	79.9	74.6	62.9	60.0	74.6	0.00	74.0	65.9	53.5	45.0	68.9	0.00
	Harvest [f]	121.9	116.2	97.4	95.0	114.9	0.00	127.5	118.3	97.1	96.0	120.5	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

Note: ns = not significant.

[a] P-value associated with a Kruskal-Wallis ANOVA test for the ratings, except for yield by weight, yield by volume, yield of tortillas, anthesis, and harvest, which are associated with a parametric ANOVA.

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

[c] In kg/local unit of volume (almud).

[d] Number of tortillas/almud

[e] Number of days to anthesis (male flowering)

[f] Number of days for the crop to be ready for harvest

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 maize had a high yield, multiple uses, and was easy to sell, it also had the longest growing cycle. Its longer duration was a negative characteristic if the rains were delayed and it had to be planted late, because then the crop risked being exposed to drought and to frost. As noted, the other maize types had shorter growing cycles (white > yellow > black > red) and provided farmers with the flexibility to respond to the uncertain onset of the 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 men's assessments. For example, unlike men, 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 have to do with aspects of maize preparations they are responsible for making. Women provided much lower estimates for yield by weight and duration, but their ordering of these characteristics was similar to men's. An important difference is that they considered that Amarillo, Negro, and Belatove had higher stability than Blanco. In general they rated colored maize types much better 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 was not as strong among women as among men. Colored maize types may be more important for females than for males, and women may be playing an important role in their conservation.

The performance of any new variety introduced into this area of Oaxaca could be rated with respect to these characteristics by a panel of farmers to 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 white type currently in use 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.

Attainment index

Ideally these two types of ratings (demand and supply of characteristics) could be combined into a single measure to indicate how well a particular variety or technological option meets all of the interests and needs of a farmer or group of farmers. This attainment index[20] would aggregate the performance of a variety or technological option over all characteristics that are important to a farmer, while taking into consideration that the importance of the characteristics is not equal. Having very good performance for a characteristic that is very important for a farmer—in other

---

20 This concept and term have been used in the economics literature to describe the extent to which a service-provider meets customer expectations (Reed et al. 1991). The concept has also been used to explain the adoption of rice varieties (Sall et al. 1997).

words, it meets his/her interests or needs—is not the same as having very good performance for a characteristic that is only somewhat or not at all important. Generating an attainment index is a complex procedure that is rooted in economic theory and requires researchers to make assumptions about preferences. Although methods for producing an attainment index are beyond the scope of this manual, interested readers are referred to Reed et al. (1991), and Appendix 4 provides some of the author's personal reflections on this very important subject.

Comments: This method is particularly well suited for assessing crop varieties (as shown in Tables 16 and 17). In theory it should also be useful for other types of technologies, although experiences of its application to other technologies such as soil fertility improvement or pest management options are scant. Therefore the application of this method to those areas is still an open area of research.

The method described here used a scale with three levels. A scale with more levels (five, for example) could be used for the supply of characteristics. Such a scale could range from "very good" to "good," "intermediate," "poor," and "very poor." Going beyond five levels may be impractical, however. The more levels used, the more precise the results, but the exercise may become more difficult for farmers. Using a scale with more levels becomes particularly important when the technological options are very similar; it helps to distinguish among them.

This method is analogous to the matrix ranking method commonly used in participatory research. *Ranking* is more intuitive and easier to do with farmers than *rating* (ordering items from more to less important or from better to worse). However, if the number of options to be ranked is only one or is not the same for all informants, problems may arise. If there is only one option (for example, a farmer plants or knows only one variety), how can it be ranked? How can researchers compare the rankings of two farmers, one who grows two varieties and another who grows five?[21] Obviously this is not a problem if informants are presented with a similar number of options. Another potential difficulty is that several options can be ranked, but the best may still be considered inferior or vice versa (i.e., all options are inferior, but this is the least bad, or all options are very good, but this is the best). These issues cannot be addressed by ranking alternatives, so it may be preferable to rate them. The method presented here also ranks technological options, but it does so indirectly, based on the ratings.

Eliciting the Constraints on Using a Technology

Goal: Identify the factors that farmers perceive as constraining the use of a technology or practice.

Rationale: Even a well-known and appreciated technology may not be used by all of the farmers who want to use it. Factors beyond the specific characteristics of the technology may constrain its use. Although comparisons of different technologies provide some important information about these factors, it is useful to have a specific method to identify them.

---

[21] There are methods to standardize the rankings from different numbers of options; see, for example, Smith et al. (2000).

Method: Researchers identify which technologies or practices will be evaluated (see “Eliciting Farmers’ Perceptions of Technological options,” p. 50, for how to do this). An interviewer asks a set of key informants or focus groups:

What do you do, or what could you do, if anything, to solve a particular problem (for example, to improve a soil, cope with drought, and store the harvest in a way that protects it better from insects)?

The answers to this question provide a set of available technological options. For each of these options, the interviewer asks:

Has anyone among the group used the option?

What factors have limited your ability to apply the option?

If you did not apply that option, what were the reasons?

The answers should be compiled and tabulated for analysis.

Example: This method was used in the Chihota Project to understand the constraints to technologies that farmers recognize and could use to improve soil fertility. The technologies and their constraints were identified in the context of farmers’ own soil taxonomy (presented earlier). Table 18 shows the results of this exercise.

Table 18. Technological options available to farmers in Chihota, Zimbabwe to improve their soils, and the constraints they face, by local soil type

	Local soil type							
Technological option and constraint	**Jecha**	**Shapa**	**Rukangarahwe**	**Rebani / Doro**	**Mhukutu / Bukutu**	**Churu / Rechuru**	**Chinamwe**	**Rondo / Chidaka**
Apply termite mound soil								
Shortage of termite mounds		x		x		x		x
Shortage of labor to dig and move mound	x	x	x			x	x	
Labor intensive	x			x				x
No cart to move termite mound		x	x					
Low priority for the soil class			x					
Digging mound causes erosion		x						
Apply manure								
No cattle	x			x		x	x	
Shortage of draft power	x	x						
Garden has priority for manure applications	x	x	x					x
Apply fertilizer								
No cash to purchase	x	x	x		x	x		x
Lack of knowledge	x	x	x		x			
No cash to hire labor	x	x	x					x
Apply lime								
No cash to purchase	x	x	x		x	x		x
Lack of knowledge	x	x	x		x			
Early planting								
No cash to hire labor	x	x	x					x
Deep plowing								
Shortage of draft power	x	x						
Early plowing								
Shortage of draft power	x	x						
Fallow the land								
Shortage of arable land	x							
Raised beds								
Labor intensive to raise beds				x				

Source: Adapted from Bellon et al. (1999).

The constraints reflect a number of underlying themes. The two most common themes were 1) scarcity of inputs and lack of access to them (including local inputs, such as manure and termite mound soil, and purchased inputs, such as fertilizers and lime) and 2) scarcity of labor to apply inputs, caused by the labor-intensive nature of the operations, by the lack of labor, or by the lack of cash to hire labor. Other themes that emerged were the high priority given to alternative uses for inputs (farmers preferred to apply manure to gardens rather than field plots) and the low priority given to improving some soil classes (e.g., Rukangarahwe). The lack of implements and power were also cited as limitations, although these constraints related specifically to the practices of deep plowing and application of soil from termite mounds. Farmers also noted that the lack of land limited the frequency and duration of fallows. Several farmer groups mentioned that the lack of knowledge about application rates for fertilizer and the use of lime was a constraint.

Demonstration Fields and Field Days

Goal: Expose farmers to new technologies, such as varieties, practices, and inputs, and get farmers' feedback on the new technologies.

Rationale: If scientists, extension agents, or some other external agent would like farmers to evaluate or adopt new technologies, farmers need to get acquainted with these technologies in a way that costs them little money, time, and risk. Even before farmers can decide whether they want to experiment with a new technology or practice, they need to see it. Demonstration fields and field days are organized to accomplish this goal. The field days can also give scientists and extension workers information in a systematic way about farmers' perceptions of new technologies.

Method: Researchers, extension agents, or other interested groups (e.g., staff of non-governmental organizations) establish one or several demonstration fields, which may be located on farmers' fields or on experiment stations. The demonstrations may be established and managed exclusively by the researcher/extension worker or together with farmers.

The demonstration field is divided into plots containing the set of technologies to be shown to farmers. The technologies should be presented in a way that distinguishes them from one another as clearly as possible (for example, by partitioning the plots so that each technology is obvious to observers). The technologies should be laid out as simply as possible. Avoid complex designs that obscure the characteristics of each technology. *A demonstration field is not a complex multifactorial experiment.*

Good and sufficient information about each technology should be presented next to the plot it occupies.

Demonstration fields showing crop varieties are straightforward. Each variety is planted in plots of a few short rows (e.g., four rows, each 6 m in length). The plot is labeled with a sign giving the name the of the variety, its duration, yield, performance under drought, and any other information that may interest farmers. It is advisable to include commonly planted local varieties to facilitate farmers' comparisons between new and current varieties.

Showing the effects of inputs, rotations, and other agronomic practices in demonstration fields can be more difficult than displaying new varieties. For example, different levels of pest attack with different cultural control practices must be shown with numbers, even if there is a demonstration plot. The simplest and most recommended way is to plant adjacent plots with and without the input, rotation, or other practice, making it easier for farmers to judge the impact of each practice.

Often a goal of demonstrations is to show the impact of different rates of an input or of different inputs together. In this case, demonstration plots should be organized in an incremental way. To show the impact of different input rates, the first plot has the lowest input rate, the adjacent one the next rate, and so on. To help farmers compare the effects of several inputs together, the first plot includes just one input, the next includes two, and so on, until the last plot has the full package of inputs. The inputs should be ordered from the one with the highest return to investment to the one with the lowest return. It is important to remember that in some cases the input with the highest return may be the most expensive or difficult for farmers to obtain. In that case, the order of inputs should be adjusted from the one with the highest return to investment to the one with the lowest return, subject to the constraints faced by farmers.[22]

Demonstrations with technologies that involve impacts over more than one season (e.g., rotations, applications of lime) are even more complex to present, because the benefits do not accrue during the growing season when the demonstration is established. This means that the demonstration will need to be repeated the next season, which must be planned from the start.

Once the demonstration fields are established, field days can be organized for farmers to come and look at them. The number of participants is an important variable for the way these days are organized. If few farmers participate, a more in-depth discussion about each of the technologies can take place. With a large number of participants this usually is not possible.

Example for germplasm: An intervention of the Oaxaca Project was to provide farmers with access to the diversity of maize landraces present in the region. This diversity was represented by a set of 16 landraces and one improved variety chosen by farmers and scientists. Demonstration plots with these 17 materials were established in the participating communities. The aim of the demonstration was to enable farmers from each community to see the 17 materials, especially their plant and ear characteristics, and to purchase the ones they wished to experiment with. The varieties included ten with white grain, three with yellow grain, three with black grain, and one with red grain. They were planted in small plots, each with four rows, and grouped by color so farmers could compare them. Each plot had a sign giving the identification number for the variety and information on yield, plant height, and drought resistance. Figure 8 shows the layout of a demonstration field in the Oaxaca Project.

The demonstration plots were established under irrigation during the dry season. This schedule meant that the field day

22 This presupposes an economic analysis of the inputs under farmers' conditions.

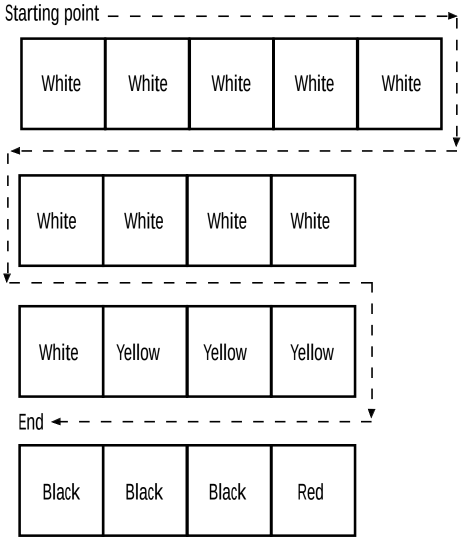

Figure 8. Layout of a demonstration field, Oaxaca Project.

Note: The color refers to the grain color of the maize planted in the plot.

could be held just before planting in the rainy season, so farmers who purchased a maize variety for experimentation could plant it soon after the field day.

For the field day, the two inner rows of each plot were harvested and the harvested ears were put next to the plot. Farmers were organized into small groups of five together with one guide (usually a student from the local agricultural school) to tour the demonstration. They were told beforehand that the purpose of the field day was to show them an array of maize varieties from the region and sell them any variety they found interesting. During the tour, the guide recorded farmers' opinions, positive and negative, regarding the varieties. Farmers were encouraged to note the identification numbers of the varieties they wanted to purchase. At the end of the tour they proceeded to a stand where the seed was offered for sale. The seed was sold at the price of local maize seed in the region. Sales were recorded along with information on the purchaser (name and address) so that researchers could follow up on the impact of this process.

Example for soil fertility management: An intervention of the Chihota Project was for farmers and researchers to establish a number of trials with new soil fertility improvement technologies developed by Soil Fert Net. Farmers managed the trials, and farmers and scientists designed them together. These trials were not typical scientists' trials but were simplified to fit farmers' interests and management. They had a dual role. On the one hand, they were a joint experiment between scientists and farmers to assess the technologies; on the other hand, they served as demonstration plots to expose other farmers to the technologies.

One of the technologies assessed was the use of lime together with nitrogenous (N) fertilizers, because low pH is an important problem in these soils. The trial/ demonstration plot had a simple design in which a maize crop was planted in a field of 0.1 ha. Half of the plot was treated with lime and the other half was not. The management was exactly the same for both halves of the plot in all other respects—variety, number, and timing of weedings, and fertilizer application.

Just before harvest, farmers from the village where this trial/demonstration plot was established were invited to visit it. The criteria that farmers used to judge the demonstration were the growth of the plant stand and how green the maize plants looked. Farmers could readily see the difference between applying and not applying lime. During the field day an interesting discussion took place about how to finance the purchase of lime. Farmers in the village were applying 8 bags of N fertilizer per hectare (ammonium nitrate and Compound D), for which they paid approximately Z$ 450/ bag. One bag of lime cost Z$ 60 and 8 bags were recommended. By sacrificing one bag of N fertilizer, farmers could pay for almost all the lime required. If there is a synergistic interaction between N fertilizer and lime in these soils, it may be worthwhile for farmers to buy the lime. It was decided that the next demonstration experiment should test the substitution of some N fertilizer for lime.

Other demonstrations of the liming practice were not so straightforward. They compared the farmers' rate of N fertilizer and lime with the management practices recommended by the extension service, which included a higher application of N fertilizers, potash, phosphate, and lime. Although the differences between plant stands in the two treatments were striking, it was impossible to identify how each input contributed to the overall result. Furthermore, farmers thought it would be difficult to purchase all of the inputs. For farmers who had strong financial constraints on purchasing inputs, the second type of demonstration ultimately proved less useful than the first one. An alternative for this type of demonstration is a layout in which farmers' practice and the extension recommendation are separated from the addition or lack of lime. This design should allow farmers to identify the impact of lime independently of the impact of other fertilizers and different fertilizer rates. Figure 9 shows a layout for this type of demonstration. Note that there are paths to access the different treatments and a central place to see the four treatments at the same time (the circle in the figure).

Comments: In many cases, experimental plots designed to fulfill scientists' experimental needs are used as demonstrations because research and extension systems lack the resources to mount special demonstrations. The problem with using experimental plots is that their randomized layout and testing of several factors often make it very difficult for farmers to draw lessons or conclusions about the technologies (treatments) displayed. To the extent possible this should be avoided.

It is important to keep a list of who attends a field day and to obtain at least some basic socioeconomic information on the participants (see the earlier section, "Minimum Set of Socioeconomic Indicators," p. 33). This information is useful for following up on the impact of field days on participants and for understanding the distribution of benefits among them.

Carrying Out Experiments with Farmers

Goal: Help farmers improve their own experiments by providing some basic training and guidelines (the experimental agenda and the process are completely in farmers' hands); or help farmers evaluate new technologies and practices selected jointly by farmers and researchers.

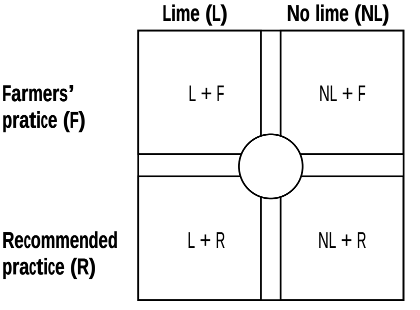

Figure 9. Layout of a demonstration field with two factors, Chihota project.

Rationale: Many farmers conduct experiments on their own, although their experiments usually differ from those of scientists in three ways: farmers usually do not include a control treatment, farmers may not keep all factors constant aside from the experimental factor, and farmers usually do not replicate experiments. An additional consideration is that farmers rely only on simple observation to judge the results of an experiment. These characteristics can make it difficult to interpret experimental results and derive clear conclusions. Scientists can help farmers improve their experiments.

Method: Rather than relying on a specific methodology, this process involves training farmers to conduct and interpret experiments, using the guidelines given in the following paragraphs.[23]

Test only one factor at a time. Researchers should not use a multifactorial experiment if they want farmers to learn from it. Multifactorial experiments are for scientists, not farmers. If there are several factors, each one should be tested independently in a different field or section of the field. Although some farmers can work with multifactorial experiments, they may need to be trained to understand what these are and how to interpret them.

Emphasize to the farmer the need for a control treatment. The scientist should explain to the farmer that a control treatment is important for interpreting the results of an experiment. If there are several independent experiments in different fields, researchers should use the same control treatment to facilitate comparisons and interpretation of the results. For example, if cattle manure applied at a specific rate is the common input used to maintain soil fertility, and researchers want to compare it to other inputs such as inorganic fertilizer, leaf litter, and termitaria, they should ensure that experiments with these alternative inputs include cattle manure as a control treatment.

Emphasize to the farmer that all conditions, except the experimental one, need to be kept equal in his/her field. The farmer can decide what those conditions should be, and they should be very clear in his/her mind. (Making a list of these factors together with the farmer is helpful.) An agronomist may object to having an experiment in which weeds are left to grow (if that is not its objective), but a farmer may consider that having a certain number of weeds reflects his/her normal conditions. What the farmer and the agronomist should understand is that having weeds is all right, as long as the experimental and control treatments have a similar number of weeds and weedy plots are a condition relevant to the farmer.

Establish which indicators and criteria will be used to judge the outcome of the experiment. Do not assume that farmers and scientists focus on the same indicators or have the same criteria to judge and interpret the outcome of an experiment. A farmer may focus only on how good or green a plant stand looks, while a researcher may want to look at the yield at harvest. One approach is to use the characteristics identified by eliciting farmers' perceptions of costs and benefits of a technology, described

[23] The author thanks José Alfonso Aguirre Gómez for sharing his ideas on farmer experimentation, which are the basis for these guidelines.

earlier. Another approach is for the scientist to discuss several questions with the farmer:

What do you expect from the experiment?

What elements would you focus on to judge it?

Under what circumstances would you judge one treatment to be better than the control?

The scientist may want to ask him/herself the same questions and compare the answers with those of the farmer. Ideally, farmer and scientist should reach consensus on these three issues, although differing perspectives are acceptable as long as both parties are aware of them.

Replicate an experiment among farms, not necessarily in the same field. As pointed out earlier, farmers usually do not replicate experiments across space. It is often assumed that farmers replicate experiments over time by comparing the present season's results with those of the previous season. From a researcher's perspective this may be a poor practice, because conditions change from one season to the next and the comparison may not be valid. From a farmer's perspective, it may not make sense to replicate an experiment across fields. Replications may appear to be a waste of resources, and in any event, farmers lack the statistical tools to identify relevant factors.

If it is considered important to replicate an experiment, however, it may be feasible to do so across farms. This strategy also entails problems, because experimental conditions vary across farms. One solution is for researchers to ask farmers with replicates of the same experiment to agree on the conditions that will be maintained constant. For example, with all farmers carrying out a particular experiment, reach an agreement on the following factors: the soil type (according to their local taxonomy); the placement of experimental plots; and the number of weedings, the method used, and their timing. The use of farmers' local soil taxonomy may help ensure that farmers with replicates put them in similar soils.

An interesting way of combining farmers' and scientists' experiments is the approach of the "mother-baby" trial (Snapp 1999; CIMMYT 2000). A research-managed trial is established in a central location, usually a village, with all of the technological options to be tested and appropriate controls and replication according to scientific standards (the "mother" part of the trial). Nearby, within easy access to farmers in the village, a set of farmers' experiments is established (the "babies"). These experiments include a subset of the technological options of the mother trial, they follow a simple design based on the guidelines presented earlier, and they are established and managed by farmers. The conditions and management of the baby trials should reflect farmers' circumstances and interests. This experimental layout yields results that are of interest and have credibility for both scientists and farmers.

Example: During field days in the Oaxaca Project, researchers learned that many farmers were skeptical about how the varieties would perform under their own management conditions, so researchers proposed a set of joint experiments with the varieties. They furnished the seed and a simple experimental design, and farmers provided the fields and the management. Initially the idea was that four farmers from each community would participate, but certain communities had more volunteers; eventually 29 farmers participated.[24] Each farmer agreed to plant three of the varieties included in the field day, plus one of his/her own varieties, and to manage them in exactly the same way. Each variety was planted in four rows of approximately 10 m. One of the varieties was a common check.

Researchers imposed no management conditions but systematically monitored and recorded what farmers did. During the growing season, researchers organized visits by one group of farmers to other groups in different communities so that they could assess the performance of the varieties under different environmental and management conditions and discuss the experiments with the other participating farmers.

At the end of the season, researchers and farmers harvested the plots together and measured the yield. The maize was harvested from two different 5 m sections taken at random from each of the two inner rows of each plot. Researchers measured the distance between rows, the distance between plants, and the number of plants planted per hole to determine planting density and extrapolate yield per hectare.[25] Farmers kept the harvested maize and rated the agronomic performance of the materials with respect to a set of traits (see "Analyzing the Demand of Characteristics" and "Analyzing the Supply of Characteristics," pp. 58-63). Farmers verified that the varieties worked well under their management and environmental conditions.

Comments: The main goal of experimenting with farmers is to address their information needs about new technologies and solutions to problems in a way that is relevant, cheap, systematic, and has low risk for them. Ideally, farmers' and scientists' interactions regarding experimentation will produce information that is credible but not too costly for all parties involved in the experimental process. This means simplifying the experimental design so that it does not take too much of farmers' time and labor, yet it produces results that are relevant to farmers and of interest to scientists. Although there is a compelling need for simplicity and ease of interpretation, these experiments can be useful for scientists and even subjected to certain statistical analyses. For example, the data collected in farmer experiments can be used to carry out a modified stability analysis (Hildebrand 1984; Kamara et al. 1996) (see Appendix 2 for an example).

Note, however, that some technologies do not lend themselves to this type of trial because they are very complex and interact with many different factors simultaneously, so by focusing on individual factors, one may not really get the "big picture."

Another approach for the interaction between farmers and scientists regarding farmers' experimentation is for scientists to provide new techniques and scientific concepts to fill key gaps in farmers' knowledge and not necessarily to change the farmers' own styles of experimentation.

24 All 29 farmers received seed, but 3 did not plant the experiments and another 6 harvested nothing because of pests, early frost, excess water, and lodging.

25 Researchers should be careful not to read too much into these extrapolated yields, because there is great variation within fields. The yields should be interpreted as indicative and compared only to others obtained through similar means.