Comparing and Integrating Farmers' and Breeders' Evaluations of Maize Varieties in East Africa

While Kenyan farmers still grow many traditional maize varieties, they increasingly face soil, pest and environmental constraints to crop productivity. Most of the popular improved varieties were released more than 15 years ago, and an 18-year-old variety still accounts for half of the maize seed sales. The International Maize and Wheat Improvement Centre (CIMMYT), therefore, started a breeding program in East Africa where farmers are engaged much earlier in the selection process, leading to the evaluation of entries by many people in several locations. The approach requires a more systematic and quantitative methodology than the classical participatory approach, where farmers are only asked to evaluate varieties at the very last stages. Farmers and multidisciplinary teams have now collaborated for more than three years, trying different approaches and updating the methods continuously.

Sufficient material is currently available to begin a critical review, pertaining to three key questions:

» Are the methods appropriate and appreciated by all partners involved?

» Is the information gathered complementary to classical breeders' selection data?

» Does the method improve the selection and increase the adoption rate?

THE AFRICA MAIZE STRESS PROJECT

The Africa Maize Stress (AMS) project was initiated to develop varieties and crop practices for high stress environments, in particular drought, low nitrogen and pests. The initial project covered the whole of Subsaharan Africa, and special methods were developed to breed for drought resistance. In Zimbabwe, in particular, CIMMYT studied the physiology of drought tolerance in maize, and developed a method for on-farm participatory variety selection. In Kenya, the breeding effort started in 1997.

In 1999, a set of 50 promising varieties was selected for the semi-arid areas. During this year, the first Participatory Rural Appraisals (PRAs) were conducted to understand farmers' selection criteria and perceived constraints in maize production, including pest problems. In 2000, the first on-farm trials were conducted. In the 2002 National Performance Trials (NPT), four of the varieties outperformed the local check. The project provided farmers' and breeders' evaluations, but preliminary analysis reveals large discrepancies between farmers' and breeders' evaluation.

HOW THEY DID IT

The breeders selected entries that yield well and were early maturing, two negatively correlated traits. In Kenya, more than 1,000 varieties were tested simultaneously under optimal conditions of fertilizer and water and under stress conditions without fertilizer and with irrigation cut off prematurely. Several observations were used, in particular concerning yield, the anthesis-silking interval (strongly correlated with drought tolerance), leaf senescence (negatively correlated with drought tolerance), number of ears per plant (strongly correlated with high yield), resistance to disease, and others. CIMMYT has developed a special software where all observations were entered, and this software calculated a combined breeders' index, which is general score representing breeders' preferences.

The PRAs were organized in communities nearby Kenya Agricultural Research Institute (KARI) research stations where the varieties are being developed. During these PRAs, farmers described the criteria they used for maize variety selection, the major constraints they faced, and the major pests. At the end, they were asked for their interest in participating in variety evaluation and the period when they would like to come and see the varieties.

In 1999, the first evaluations were conducted in four stations of KARI. In 2000 and 2001, a mother and baby approach followed. All entries were compared together in a central plot, and farmers tried out subsets under their own conditions.

SOLICITING FARMERS' SELECTION CRITERIA

Farmers mentioned a wide range of criteria and their ranking differed substantially between sites and groups. Early maturity and yield, however, were the criteria mentioned by all groups in all sites. Mentioned by more than half of the groups, the second group of important criteria included yield-related characteristics such as cob size and grain size, other grain and cob characteristics, and drought tolerance. Other criteria mentioned by at least three out of seven groups were pest and disease resistance, taste and processing characteristics.

After the group discussions, farmers were asked if they were interested in evaluating the varieties being tested. In all the four sites, farmers were enthusiastic to evaluate the varieties in question. They expressed preference in evaluating them twice: once in the vegetative stage (preferably at tasseling), and once at harvest. Visits were organized accordingly.

On-Station Evaluation The trials were conducted in four KARI research stations in the arid and semiarid areas. In each station, 50 new entries were tested, laid out in small blocks, two rows of five meters for each entry. The statistical design was an alpha lattice design. Special software was used for the randomization and calculation of a breeders' index, a linear function of different variables such as yield, anthesis-silking interval, cob aspects and others, depending on the breeders' strategy. The index has a scale of 0 to 1. The lower the index, the better the variety is considered for the traits included.

Farmers evaluated the new varieties on the station by using an evaluation form with a line for each variety, and a column for the qualities mentioned as selection criteria to check if the variety was considered good for that criteria. The farmers were invited twice: at tasseling, to score for early maturity and drought tolerance; and at harvest, to score for cob size, well-filled cob, and yield. In both instances, farmers were also asked to give an overall evaluation.

The breeding program calculated the selection index for all varieties, resulting in a rank. A number of varieties had to be discarded because of undesirable traits, resulting in a final list of varieties to be continued in the next cycle.

CENTRAL OR MOTHER TRIALS

In the following season, 16 varieties were retained and tested in a central locationthe mother trial-and subset on farmers' fields-the baby trials. In the mother trials, farmers ranked 10 varieties higher than the local check, Katumani, while breeders ranked 11 better. However, there was no statistical correlation at the 5% level between the overall score of the farmer and the selection index of the breeders.

To further analyze the relationship between the farmers' and the breeders' order of preference, each evaluated variety was mapped in a two-dimensional diagram, where the horizontal axis represents the farmers' rank and the vertical axis represents the breeders' rank (Table 1). The table shows how variety V31 (or according to the breeders' code: EE-EAC-31) was selected first by farmers, but came only sixth in the breeders' evaluation. Varieties acceptable to both groups could be found at the top left corner. Three varieties were appreciated: V31, V33, and V21. Two more acceptable, but not outstanding varieties, were V16 and V46.

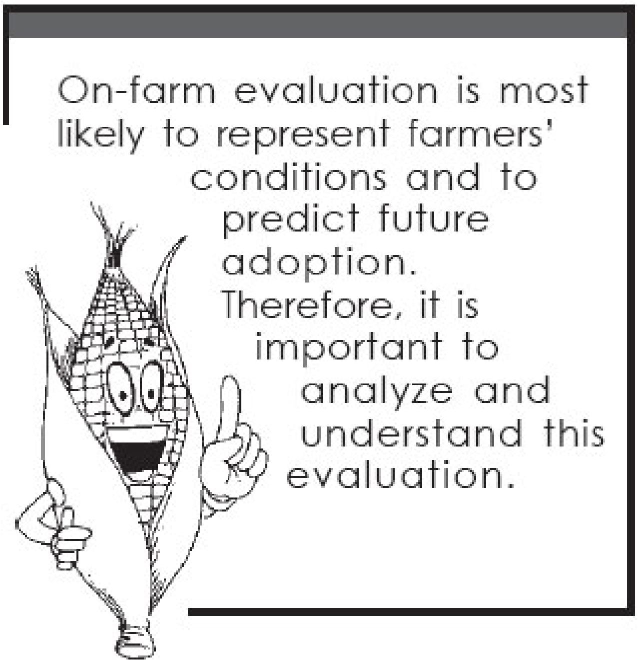
Table 1. Order of Top 12 Varieties (V1-V50) as Ranked by Farmers and Breeders Compared to the Local Check KCB (Katumani Composite B)

Breeders' Ranking	Farmers' Ranking										
	1	2	3	4	5	6	7	8	9	10	11
1			V21								
2											
3											
4		V33									
5							V16				
6	V31										
7						V46					
8											
9											
10										V9	
11									V13		
12											

Note: The breeders' name of the lines is EE-EAC-1 to EE-EAC-50, for "Extra Early- East and Central Africa"

BABY TRIALS

The same varieties were also tested on-farm under farmers' conditions, in blocks of four at a time. At harvesting, 11 varieties were overall evaluated by farmers as better than the best local check, and seven did better in more than one location. It was also remarkable that local varieties scored substantially higher in the overall evaluation. This indicated that factors other than yield play an important role. The overall evaluation could be seen as a farmers' selection index. To decompose this index, the overall score at harvest was regressed on the score of the individual criteria: yield, well-filled cob, cob size and vigor. Yield had the highest coefficient (0.5), followed by vigor (0.2) and well-filled cob (0.2). Cob size was not significantly different from zero.



The results show that the model predicts a large amount of the variation (R2=62%) but some elements are not captured by the individual criteria, showing the importance of including an overall evaluation score.

The individual coefficients represent how much the overall evaluation increases with an increase of the score of an individual criterion. When the score for yield of a variety increases by one, its overall score increases by 0.5; when the score for vigor increases by one, the overall score increases by 0.2, all other factors equal.

Thus, the coefficients can be considered as the weights of a selection index. The non-significance of the criterion "large cob" comes a bit as a surprise after the group discussions, but it does make sense because larger cobs do not necessarily bring more or better food to the table. The results show how farmers' selection index can be approximated and then compared with the breeders' index to make the breeders' index more responsive to the farmers' needs.

CONCLUSION

The participatory methods clearly show how classical breeding has difficulties responding to farmers' preferences, but so far the two approaches have not converged in a method suited to both. Scientists like to control many factors and they can state with high accuracy that under these very controlled circumstances a limited number of traits have improved. The problem arises when these highly controlled circumstances might not represent farmers' conditions and the limited number of traits might not represent farmers' preferences. This becomes very clear from the very poor correlation between farmers' and breeders' evaluation. The exercise, however, provides very useful insights to bring the two together by improving the methodology of both breeders' and farmers' evaluation.

The breeders' index could be improved through changing the functional form (linear is not always appropriate) and the variables included and/or the weights attached to different variables (too much weight is placed on yield). Breeders should be more transparent, explain their choices and engage in discussions with farmers to compare their respective preferences.

Asking farmers to define their criteria and then scoring new varieties on a numerical scale turned out to be very convenient in data collection, although cumbersome in the analysis. The criteria could use some harmonization, so farmers' responses at different sites could be classified in the ame number of categories, which would simplify the analysis of farmers' evaluation of new varieties. For farmers' evaluation on-station or in mother trials, high variability needs to be taken into account by inviting farmers in larger numbers (at least 50). To make a speedy analysis possible, sufficient resources should be made available to people with sufficient training. The analysis should then be included in the selection of varieties for the next cycle.

The baby trials need some serious rethinking. In this example, the data is not very useful: the variance is very high, the sample size is small, and a lot of data was lost, both through bad weather and poor organization. The experience indicates that enough resources have to be made available to allow for regular visits to assure the quality and quantity of the data and a swift data entry and analysis. The process could be improved by increasing the data collected by the farmer, through wellstructured questionnaires and proper training so farmers can fill them in themselves. A simplified yield measurement by farmers should also be tried out. In the baby trials, farmers could include more evaluation criteria than is possible in the mother trials, and these data would be very useful for improving the selection index.

Finally, the experience has shown that farmers are happy and eager to participate in selecting new varieties. The methodology still needs work, but it is clearly showing some promise to bring breeders' and farmers' selection more together. The collaboration between breeders, farmers and social scientists shows promise in improving the selection procedure by taking into account the farmers' preferences at the early stage of the process.

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