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Full Length Research Paper

Maize varieties and production constraints: Capturing farmers' perceptions through participatory rural appraisals (PRAs) in Eastern Kenya

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Maize is the major staple food for most Kenyan households, and is grown in almost all agro-ecological zones. To assure that new technologies fit farmers' needs and conditions, Participatory Rural Appraisals (PRAs) were undertaken in the moist transitional zone of Eastern Kenya, as part of a nationwide study. The results of group discussions in five communities of the zone show that farmers grow a wide range of varieties. Eleven improved varieties were grown, the most popular being Makueni, an improved Open Pollinated Variety (OPV) (grown by 71% of the farmers), followed by Pioneer hybrid PHB3253 (57%), and Kenya Seed Company's hybrids for the mid-altitudes: H511 (50%) and H512 (30%). A third of the farmers (31%) grow local varieties. To select their maize varieties, farmers reported 14 criteria, especially high yield, early maturity, tolerance to weevils, and good yield in both rainy seasons. The two major constraints were a cash constraint (to purchase inputs), low or erratic rainfall, low technical knowledge, the high cost of seed, low soil fertility and stem borers. Stem borers were by far the most important pest, ranked in the top three by all groups, followed by chaffer grubs, squirrels, termites and weevils. Indigenous control methods are the most popular, with only a quarter of farmers using chemical control. Farmers estimate that stem borer infestation decreases yields by 33 to 80%, and would be very interested in resistant varieties. The liberalization of the seed market has clearly been successful in the study zone, and the number of stockists and available new varieties increasing fast. However, seed quality and the lack of control is a major concern, as is the lack of credit.

Key words: Maize, participatory rural appraisal (PRA), Kenya, pest.

INTRODUCTION

Maize continues to be the major staple food in Kenya, with an average per capita consumption of 103 kg per year (Pingali, 2001). Maize also accounts for more than 20% of all agricultural production and for 25% of agricultural employment (Government of Kenya, 1983; Government of Kenya, 1997). Smallholders produce about 70% of the nation's maize, while large-scale commercial farms contribute a significant proportion of the marketed maize (Government of Kenya, 1983, 1997). The maize research program in Kenya has developed high yielding varieties suitable for different ecologies, resulting in high adoption rates by farmers. However, food production has continued to lag behind the high population growth. Stem borers have been identified as one of the most destructive pests of maize limiting productivity gains in maize. In Kenya alone, farmers estimate crop losses due to stem borers at 13% of their harvest, amounting to 400,000 tons of maize with a value of US $76 million (De Groote, 2002). Only a small proportion of farmers use insecticides to control stem borers, mainly because of its high cost and labor requirements.

In view of the magnitude of the damage caused by stem borer, and the importance of maize to food security and agricultural economy, the development and deployment of insect resistant maize could make a difference.

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Table 1. The communities that participated in the PRAs in the moist transitional zone of eastern Kenya.

District	Division	Location	Village	Latitude (decimal degrees)	Longitude (decimal degrees)	Number of farmers
Embu	Nembure	Gaturi South	Muconoke	-0.36780	37.20520	10
	Kyeni	Karurumo	Kathunguri	-0.25543	37.37670	11
Muranga	Kiharu	Gikindu	Mirira	-0.45261	37.12109	22
			Kambirwa	-0.45237	37.12196	16
Kirinyaga	Mwea	Nyangati	Nyangati	-0.35937	37.21429	19
Meru Central	Nkuene	Mituuguu	Mituuguu	-0.06225	37.47800	22
Total						100

For this purpose, the Insect Resistant Maize for Africa (IRMA) project was launched in 1999 by the International Maize and Wheat Improvement Center (CIMMYT) and the Kenya Agricultural Research Institute (KARI). The goal of the project is to increase maize production and food security by significantly reducing crop losses through the development and deployment of insect resistant maize varieties, to assure that there is demand for new varieties, their development and deployment should be preceded by an understanding of the farming system, of the criteria farmers use to select varieties, and of the constraints farmers face. Researchers need to engage in a dialogue with farmers, to make sure their technologies are appropriate and, above all, that farmers are interested in them. Farmer evaluations are very important, especially since the selection objectives and criteria of farmers can be different from those used by scientists.

Therefore, farmers' evaluations ensure that scientist's design, test and recommend new technologies in the light of information about farmer's criteria for the usefulness of innovation (Ashby, 1990). To understand the farmers' conditions and preferences for new maize varieties, the IRMA project undertook Participatory Rural Appraisal (PRA) in major maize agroecological zones of Kenya (De Groote et al., 2004). This paper reports in detail on the PRAs that took place in the moist transitional zone of Eastern Kenya, East of the Great Rift Valley, in April 2001 in five different sites in the Moist Transitional Zone. The specific objectives were:

i) To understand the maize varieties farmers currently grow and the criteria farmers use to select those varieties,
ii) To understand the constraints to production and technology adoption as farmers' perceive them, and
iii) To understand farmers perception of field and storage pests losses.

METHODOLOGY

PRAs are a common and popular set of methods to incorporate farmers' and other stakeholders' perception in the development of new technologies (Chambers, 1994; Werner, 1993). The most prominent technique is structured group discussions, following common guidelines or check lists, which typically include ranking of constraints and problems faced. PRAs have been shown to be a convenient technique to capture farmers' perceptions of pest problems and their opinion on proposed pest control methods (De Groote, 2001). Unfortunately, PRAs are often perceived as "quick and dirty" methods, and their results are rarely published, but stay in the gray literature.

Therefore, this study was started with an extensive review of existing studies conducted in the area, obtained by visiting agricultural offices in the target zone. Reports of previous PRAs conducted in the area were analyzed to avoid duplication and focus the discussion between farmers, researchers and extension staff. The review was followed by interviews with key informants and, finally, group interviews with farmers from representative villages. A multistage sampling procedure was used to select the study villages. Out of the ten districts that fall whole or partly in the moist transitional zone, the four major maize growing districts were selected: Embu, Kirinyaga, Meru Central and Muranga. Lists of all the divisions in the selected districts were established, and for each district one division was selected at random. In Embu District, two major maize growing divisions out of five: Nembure and Kyeni were randomly selected. Similarly, one location was selected randomly from a list of all locations in the selected divisions, and subsequently one sublocation and one village, was also selected at random (Table 1).

Once the villages were selected, the local agricultural extension officers organized the venue and the dates for the Participatory Rural Appraisals. The PRAs were conducted in school compounds or on a farm. A checklist was used to guide the discussion and farmer's responses were written down on flipcharts, for everybody to follow. In total, PRAs were organized in 6 villages in 4 districts, and in total 100 farmers participated, both men and women. The information collected included maize varieties grown, the criteria for their selection, the main constraints to maize production, with special reference to pests and diseases and, in particular, the stem borers. The discussions, in mixed groups of farmers were facilitated by the local extension officers and research officers and were conducted in the local language. The criteria for maize variety selection were scored on a scale of 1 (of minor importance) to 3 (very important), and the maize varieties scored on a scale of 1 (very poor) to 5 (very good) for all the criteria that were mentioned in that particular village. General production problems and pest problems were also ranked and scored. Since the pest problems were originally ranked without conducting a scoring exercise, a derived score was constructed. Ranks 1, 2, 3 and 4 were attributed scores of 5, 4, 3, and 2 respectively, while ranks 5 and below scores of 1. Missing ranks were assigned a score of zero.

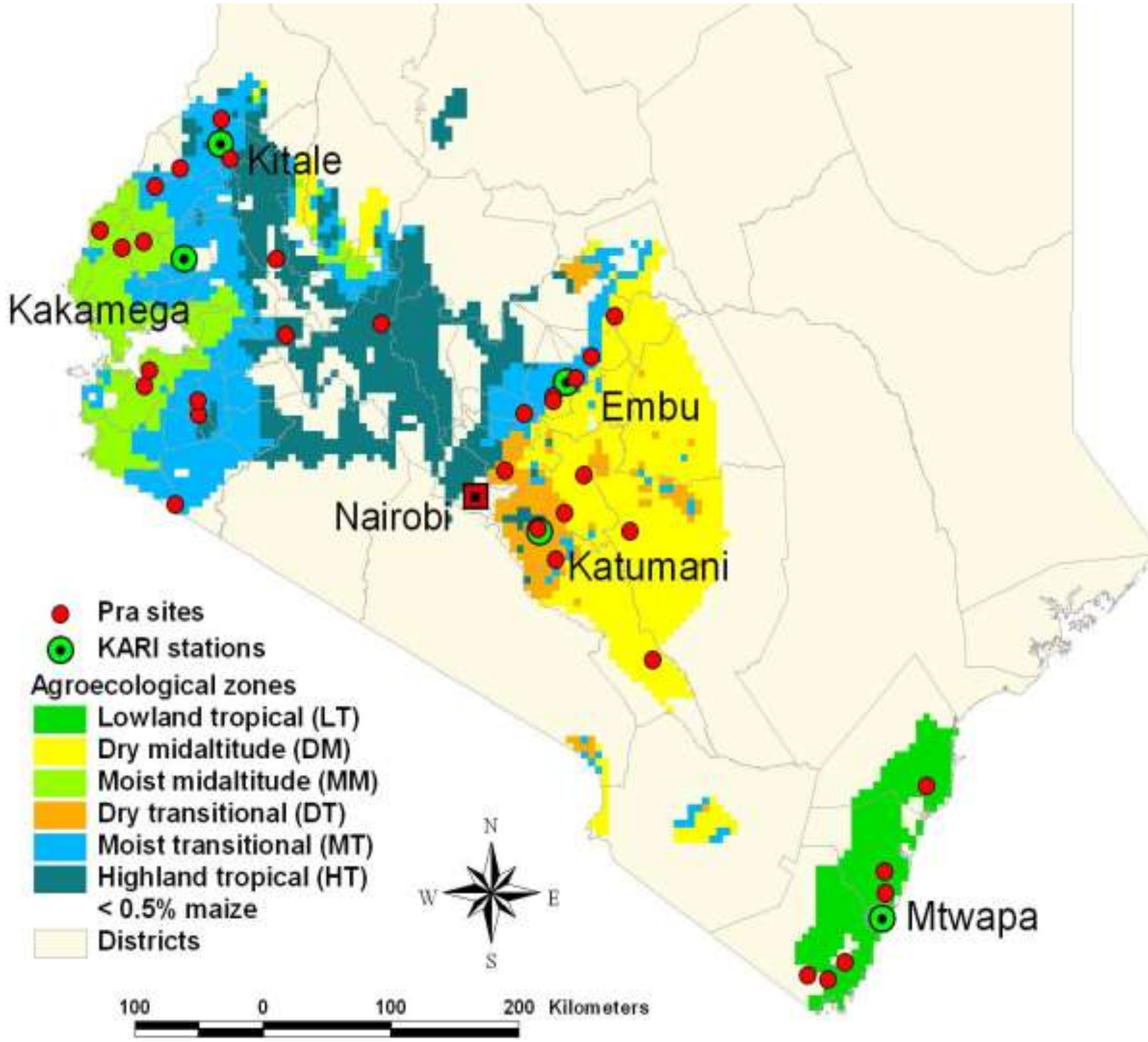

Figure 1. Map of Kenya with the agroecological zones and the PRA sites.

Study area: The eastern moist transitional zone

The study area covers the eastern part of the moist mid-altitudes, as defined on the basis of the Kenya Maize Data Base (KMDB) (Hassan, 1998). This area falls partly in seven districts: Embu, Kirinyaga, Maragua, Meru South, Meru Central, Muranga, and Nyeri (Figure 1). To estimate the population of the zone, the census data of those divisions that fall mostly in the zone were used (CBS, 2001), producing an estimate 1.6 million people. Similarly, the area of those divisions was estimated at 6330 km^2, and the population density can be estimated at 250 persons/km^2. A large proportion of the population is found in the dairy/tea and coffee zones (Jaetzold and Schmidt, 1983). The average farm holding is approximately 2 ha, with an overall per capita agricultural land-holding of 0.5 ha. The area has a diversity of agro-ecological conditions. The region has five major soil types, *Nitosols, Andosols, Vertisols*, *Ferrosols, and Cambisols*. The soils and agro-ecology of the area are greatly influenced by the presence of Mount Kenya and the Nyandarua ranges. The moist transitional zone lies at an altitude of around 1500 m above sea level, annual mean temperature is about 20°C and annual rainfall varies from 1000 to 1,400 mm. The rainfall pattern is bimodal: the long rains fall between March and June, while the short rains fall between October and December (Jaetzold and Schmidt, 1983). About 65% of the rains come during the March rains and in some years end in July/August with scanty showers locally known as *gathano* rains.

The zone is characterized by complex farming systems with annual and perennial crops, both for cash and food, as well as livestock. The major cash enterprises are tea, dairy and, until recently, coffee. Coffee is no longer considered an important cash crop. The problems experienced in the sector have reduced farmers access to credit and cash compelling farmers to turn to other cash earning crops such as Macadamia (*Macadamia tetraphylla*) and Miraa (*Catha edulis*) -particularly in parts of Embu District. Although cash crops predominate the farming systems, food self sufficiency is considered important and most farmers grow maize, beans, potatoes, bananas and other food crops. These crops occupy more than 50% of the arable land. Maize is the main food crop and there is a perception in the region that a family without maize grain is food insecure. The study area produces an average of 17,843 tons of maize and per capita consumption averages 45 kg (Table 2).

Table 2. Population and maize production in the study area.

District	Population (000)	Maize production (tons/year)	Yield (tons/ha)	Food security (kg maize/person/year)
Kirinyaga	455	26,057	1.08	57.27
Embu	277	9,720	0.54	35.09
Muranga	351	16,056	0.85	45.74
Meru Central	500	20,010	0.65	40.02
Total	1,583	71,843	0.78	44.53

Table 3. Percentage of farmers growing different maize varieties in the eastern moist transitional zone.

Maize varieties	Muranga		Kirinyaga	Embu		Meru	Mean
	Mirira (N=22)	Kambirwa (N=16)	Nyangati (N=19)	Kathunguri (N=11)	Mituuguu (N=22)	Muconoke (N=10)	
Makueni	100	100	5.3	100	19	100	71
PHB3253	68	69	15	55	42	90	57
H511	55	38	37	18	53	100	50
Local	18	100	0	36	31	0	31
H512	23	25	15	0	19	100	30
CG4141	41	56	0	0	3	30	22
KCB	50	0	21	0	44	0	19
Pan 5195	0	0	15	0	69	0	14
H625	0	0	0	0	0	80	14
H513	0	0	0	0	0	70	12
H614	0	0	0	0	0	60	10
EMAP11	0	0	0	0	39	0	7

Except for local, the rest of the maize varieties are improved varieties.

RESULTS

Maize varieties planted

Farmers of the area grow a wide range of varieties, from local and improved OPVs, over old hybrids from Kenya Seed Company (KSC) to newly introduced hybrids from Pioneer and Cargill. In total, 11 improved varieties were counted, and the number of improved varieties per village ranges from three to eight. Four of the six villages grew local varieties. On average, Makueni was the most popular maize variety grown. It is an improved OPV, developed by KARI for early maturity and produced by the Kenya Seed Company (KSC). It was grown by 71% of the farmers (Table 3). It was the most popular because of the ease of obtaining own seeds from previous harvest, early maturity, small grains which makes it suitable for roasting, preparing local dishes such as '*githeri*' (mixture of maize and beans) and '*ugali*' (maize flour cake) and less prone to storage pest.

The second most popular variety across all the villages was the Pioneer variety PHB3253, a recently introduced hybrid for the mid-altitudes. It is grown by 57% of the farmers. It is high yielding, the grains are easy to thresh and it does not require high rainfall. However, farmers noted that the cobs rot easily when there is high rainfall. Next in popularity are the KSC hybrids for the mid-altitudes: H511 (50% of the farmers) and H512 (30%). A third of the farmers (31%) grow local varieties. At least 50% of the farmers responded that they purchased certified maize seed once every main planting season and planted recycled seed for the next two to three seasons. The reasons cited for seed recycling were;

(1) Shortage of cash to buy seed every growing season,
(2) Unavailability of preferred maize varieties at planting time,
(3) Poor quality seed,
(4) Limited information on the right type of seeds to plant, and
(5) The perception that certified maize seed have no yield advantage over recycled seed. This latter point may require validation through on-farm trials.

Farmers' criteria for maize variety selection

An attempt was made to understand the characteristics

Table 4. Rank and scores of criteria in maize variety selection.

Districts	**Muranga**				**Kirinyaga**		**Embu**				**Meru Central**		**Total**	
Villages	**Mirira**		**Kambirwa**		**Nyangati**		**Kathunguri**		**Muconoke**		**Mituuguu**		**Mean score[b]**	**Number of groups mentioning criterion**
Criteria	**Rank**	**Score**	**Rank**	**Score[a]**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**		
High yield	2	3	1	3	3	3	1	3	2	3	1	3	3	6
Early maturing	1	3	3	3	1	3	2	2	1	3	4	2	2.7	6
Drought tolerant	3	2	4	3							2	3	1.3	3
Easy threshing	5	1											0.7	3
Resistance weevils	4	2	6	1	6	2	3	1			9	1	1.2	5
Good yield in long and short rains			2	3	2	3			3	2			1.3	3
Good taste			7	1			3	1	5		5	2	0.7	3
Low soil fertility					4	2	2	2	4	1			0.8	1
Ease seed							3	1					0.2	1
Good husk cover											8	1	0.2	1
Tolerant to MSV											3	3	0.5	1
Tolerant to stem borers											6	2	0.3	1
Good market											7	1	0.2	1
Good for Muthokoi[c]											10	1	0.2	1

[a]The score is based on a scale of 1 to 3: 3=very important, 2=of medium importance, 3= of low importance, 0 (not mentioned)=not important; [b]To calculate the mean score, criteria that were not mentioned in a group were given a score of zero for that group; [c]*Muthokoi* is a local Kamba dish (maize seed coat is removed and mixed with beans).

farmers consider important in selecting their maize varieties. Farmers first listed their criteria, and then ranked and scored them (Table 4). The scoring was based on a scale of three to one (3 for very important, 2 for criteria of medium importance, and 1 for those with low importance). Criteria that were not mentioned by a group were given score 0 for that group, to make averages possible. Farmers mentioned 14 selection criteria, but only three are mentioned by more than three groups: 1) high yield, 2) early maturity and 3) resistance to weevils. Only two were considered very important over all sites: yield (scoring an average of 3, the maximum) and early maturity (average score of 2.7). Good yield in both seasons and drought tolerance are the next most important criteria. However, they are only mentioned in half of the sites, leading to an average score of 1.3. Resistance to weevils, on the other hand, was mentioned by 5 out of 6 groups, although it was usually considered to be of medium or minor importance, resulting in an average score of 1.2.

Good yield on both seasons was considered medium to very important in 3 sites (average score 1.3). Other criteria mentioned in three sites, although with low or medium importance, are tolerance to low soil fertility and good taste. All other criteria were only mentioned once, and only two received a score higher than 1: tolerance to Maize Streak Virus (score of 3) and tolerance to stem borers (score of 2). Other criteria, only mentioned once and with low importance (score of 1) are easy threshing, ease of getting seed, good husk cover, and good cooking qualities. After establishing the selection criteria, farmers were asked to judge their varieties according to the same criteria. A scale of 1 (very poor) to 5 (very good) was used. The results are presented in Table 5; the first column present the score on yield, the second on early maturity, and so forth. The last column presents a weighted average,

Table 5. Scores of maize varieties; across all villages.

Varieties	High yield	Early maturing	Tolerance to drought	Tolerance to weevils	Tolerance to low fertility	Good threshing	Good taste	Tolerance to MSV	Tolerance to stemborer	Husk cover	Good market	Weighted mean
H513	5	5			3							4.8
EMAP11	5	4	3	5		4		5		5	5	4.4
Makueni	4.2	3.9	4.3	2.3	2.5	3	4	4	3	1	0.2	3.7
CG 4141	3.7	4.3	3.3	2		4	4	4	3	5	1.7	3.7
PHB 3253	4.8	3	3	1.6	3	4	4	4	3	5	1	3.5
KCB	3	5	3.5	1.5		4	2	3	2	1	0.5	3.4
Local	2.4	3	3.3	4		2	2	2	3	5	5	2.9
H625	5	1			1							2.8
H614	5	1			1							2.8
H511	4	2.6	2.7	1.6	3.5	1	2	1	3	5	1	2.8
H512	3.4	1.8	1	2.6	3	2	4	1	2	5	1.3	2.5
Pan 5195	3	1.5	2	2.5	1	3		5		4	2	2.4
Weight of criteria	3	2.7	1.3	1.2	0.8	0.7	0.7	0.5	0.3	0.2	0.2	

weighted by the average importance score from Table 4, and presented on the last line. These average results should, however, be treated with caution, since varieties are only scored by those groups that grow them. The top two varieties, H513 and EMAP11, are only grown at one site, but the farmers there gave them top scores for both yield and early maturity. Moreover, each group only rated the varieties for the criteria they found important. Therefore H513, for example, was only rated on 3 criteria.

From the varieties widely grown, the variety Makueni or DLC (Dryland composite), an OPV developed by KARI at Katumani, scores best. It receives good scores for yield, early maturity, and the highest score for drought tolerance, although it does not seem to have a good husk cover. The hybrid CG4141 (developed by Cargill, now Monsanto/DeKalb) receives the next highest average score. No particular traits jump out, it just does well all over the board. The next variety, Pioneer's hybrid PHB3253, on the other hand, scores very well on yield but only average for early maturity and drought tolerance, and poor for weevil tolerance. Katumani Composite B (KCB B) only scores average on yield, but does very well on early maturity, and well on a number of secondary criteria, giving it a fairly good overall score. The local varieties score less than average on yield, and only average on early maturity. But they receive the best weevil resistance score of all reported varieties. So, although the use of local varieties has been reduced over the years, indicating the success of breeding efforts, local varieties still fill an important niche, as indicated by the number of farmers growing them.

Constraints to maize production as perceived by farmers

Farmers were also asked to rank the constraints they perceive as limiting maize protection. To compare the ranking of the different groups, derived scores were calculated. Ranks 1, 2, 3 and 4 were attributed scores of 5, 4, 3, and 2 respectively, while ranks 5 and below received scores of 1. Where constraints had not been mentioned by the group, they were assigned a score of zero. The derived score make it possible to create a general ranking (Table 6). The results differ substantially between groups, although two constraints are generally mentioned in the top three: 1) cash constraint and 2) rainfall. Overall, shortage of cash for the purchase of inputs such as seed and fertilizer comes out as the most important constraint, mentioned in four out of five villages, and ranked first to third.

This confirms the results of previous Participatory Rural Appraisals (Micheni et al., 1998). Low or erratic rainfall comes out a clear second: it is also mentioned in four out of five villages, and it is ranked from first to sixth

Table 6. Rank and derived score of maize production constraints for each village.

Constraints	Muranga				Embu				Meru		Overall	
	Mirira		Kambirwa		Kathunguri		Muconoke		Mituuguu			
	Rank	Derived score [a]	Rank	Derived score	Rank	Derived score	Rank	Derived score	Rank	Derived score	Mean score	Number of groups mentioning constraint
Cash for inputs	1	5	2	4	3	3	2	4	0	0	3.2	4
Low or erratic rains	6	1	3	3	1	5	3	3	0	0	2.4	4
Low technical knowledge	0	0	1	5	0	0	1	5	7	1	2.2	3
High cost of seed	2	4	0	0	0	0	0	0	1	5	1.8	2
Low soil fertility	5	1	5	1	3	3	5	1	4	2	1.6	5
Stem borer damage	3	3	0	0	2	4	0	0	6	1	1.6	3
Weed infestation	0	0	0	0	2	4		0	2	4	1.6	2
Poor quality seeds	6	1	4	2	6	1	4	2	5	1	1.4	5
Low price of farm produce	6	1	0	0	8	1	0	0	3	3	1	3
Cut worm damage	6	1	6	1	7	1	6	1	0	0	0.8	4
Termite damage	4	2	0	0	0	0	0	0	0	0	0.4	1
Chaffer grub attack	6	1	0	0	0	0	0	0	0	0	0.2	1
Maize Streak Virus		0		0		0		0	5	1	0.2	1
Poor quality fertilizers	0	0	0	0	0	0	0	0	8	1	0.2	1

[a] Derived score: Ranks 1,2,3 and 4 are attributed a scores of 5,4,3,and 2 respectively, while ranks 5 and below receive a scores of 1.

constraint. The next two constraints are lack of technical agricultural knowledge on crop management, and the high cost of seed. They are mentioned by only two or three groups, but usually in the first two, giving them a high derived score. Other studies have reported similar problems particularly rains, stem borer, low fertility, chaffer grubs, weeds, streak, termites, cutworms, weevils (Hassan, 1998).

Perceived pest problems in maize

Farmers were asked to list the major pests of maize, and rank them in order of importance. According to the farmers, the major pest by far was the stem borer. It was ranked among the top three pests by all groups (Table 7).

The next two pests were chaffer grub and squirrels, again mentioned by all groups. Chaffer grubs were ranked between first and sixth, dependent on the groups, while squirrels were ranked between second and seventh. The next most important pests were termites and weevils, mentioned in three and four villages respectively. Termites, although only mentioned in three villages, were ranked first to fourth, while weevils were mentioned in four villages, but were ranked between third and ninth. Birds were mentioned by all groups, but not considered very important. Some of the less important pests were cutworms, crickets, grasshoppers and moles. Other pests mentioned by three out of five villages were aphids and thieves.

To compare the importance of the pests over all villages, derived scores were again calculated and averaged, as for the constraints ranking (Table 7). The results of the scoring exercise showed that stem borer was by far the most important (with an average score of 4.4). Only three other pests (chaffer grub, squirrels and termites) received an average score of 2 or higher. Weevils, aphids, birds, and humans were other important pests that scored between 1 and 2.

Knowledge and practices concerning stem borers

To gather more information for the Insect Resistant Maize for Africa (IRMA) project, farmers were engaged in a discussion on stem borers.

Table 7. Major maize pests ranked and scored for each village.

Pests	Muranga				Meru		Embu				Overall	
	Mirira		Kambirwa		Mituuguu		Kathunguri		Muconoke		Mean score	Number of groups mentioning constraint
	Rank	Score [a]	Rank	Score	Rank	Score	Rank	score	Rank	Score		
Stem borer	2	4	1	5	1	5	1	5	3	3	4.4	5
Chaffer grub	6	1	3	3	2	4	5	1	1	5	2.8	5
Squirrels	2	4	2	4	7	1	4	2	7	1	2.4	5
Termites	1	5	-	0	4	2	3	3	-	0	2	3
Weevils	3	3	4	2	9	1	-	0	4	2	1.6	4
Birds	7	1	7	1	10	1	5	1	2	4	1.6	5
Aphids	8	1	-	0	8	1	-	0	1	5	1.4	3
Thieves	5	1	-	0	12	1	2	4	-	0	1.2	3
Rodents	4	2	-	0	-	0	-	0	5	1	0.6	2
Earthworms	-	0	-	0	3	3	-	0	-	0	0.6	1
Dogs	8	1	-	0	-	0	7	1	-	0	0.4	2
Monkeys	-	0	-	0	11	1	-	0	8	1	0.4	2
Cut worm	-	0	5	1	-	0	-	0	-	0	0.2	1
Moles	-	0	-	0	6	1	-	0	-	0	0.2	1
Crickets	-	0	-	0	5	1	-	0	-	0	0.2	1
Grasshopper	-	0	-	0	-	0	-	0	6	1	0.2	1
Porcupine	-	0	6	1	-	0	-	0	-	0	0.2	1

[a] Derived score: Ranks 1,2,3 and 4 are attributed a scores of 5,4,3,and 2 respectively, while ranks 5 and below receive a scores of 1.

They were asked in particular what factors they know that influence the presence of stem borers, and how much damage they estimate stem borers cause. In most of the study villages, farmers associated the occurrence of stem borers mainly to drought (mentioned in three out of six villages), lack of rotation (mentioned in three villages) and limited control measures (all villages). Drought is perceived by farmers to increase stress to the plant, which is therefore more easily damaged by the stem borers. Limited crop rotation on the other hand increases the buildup of pests and particularly in the crop residue. Other factors that increased the occurrence of stem borer were presence of weeds (which can act as an alternative host for pests) and use of farmer seeds from previous harvest.

Farmers used a number of methods to control stem borers, ranging from use of insecticides such as Bulldock (active ingredient: beta cyfluphrin) and Marshall (active ingredient: carbosufan), weeding, crop rotation. Several local methods are also very popular: ash mixed with fine soil applied in the funnel or a combination of soil, ash and tobacco. Other studies (Matiri et al., 1996) report the use of *mathira* (*Gricidia latifolia*) leaves and water concoction applied in the funnel ground *muthiga* bark, mixed with pepper and water and the concoction applied in the funnel as control measures. Local methods were the most popular control measures across all the sites.

Chemical use was reported in two out of five villages. Farmers in the five study villages were asked to estimate the average number of bags of maize that can be obtained from a field uninfected with stem borer and a field infested with stems borers. Yield estimates for an uninfected field ranged from 1.8 to 3.3 tons/ha (or, in the way it was expressed by farmers, 8 to 15 bags of 90 kg per acre), while yields of infected fields ranged from 0.7 to 1.8 tons/ha (3 to 8 bags/acre). The estimated crop loss in an infected field ranges

Table 8. Farmers yield loss estimate

Village	Yields (bags/acre[a])		Yield (tons/ha)		Yield loss (%)
	Protected	Unprotected	Protected	Unprotected	
Kathunguri	8	5	1.8	1.1	38
Muconoke	12	5	2.7	1.1	58
Mituuguu	15	3	3.3	0.7	80
Kambirwa	10	5	2.2	1.1	50
Mirira	12	8	2.7	1.8	33
Mean	12	5	2.7	1.1	52

[a] 1 bag=90 kg, 1 acre = 0.40469 ha.

from 33% in Mirira and 80% in Mituuguu (Table 8). These results should be interpreted carefully; they express the yield loss for infested fields only, not the average yield loss.

Conclusion

The results of the PRAs show that farmers grow a wide range of varieties, and that they are willing to try and purchase new varieties, as the uptake of new hybrids show. Local varieties are still very popular, indicating that there is room for the introduction of new varieties. However, the farmers use a varied and complex set of selection criteria. To assure new varieties fit these criteria as well as the physical and socio-economic conditions, participatory methods of variety selection are indicated. Farmers are particularly interested in early maturing but high yielding varieties that do well in difficult environments, in particular erratic rainfall, low soil fertility and low external inputs. The problems in the coffee sector and the economy in general have reduced the access to cash, and credit for inputs is hard to come by. There should be an interest for both OPVs and hybrids. Stem borers are clearly the major pest problem of the area, causing serious losses. Since pesticide use is limited, farmers would be very interested in pest resistant varieties. Alternatively, farmers use a number of local methods, and it would be very interesting to analyze their efficacy to explore ways of improving on them.

The liberalization of the seed market has clearly been successful in the area, with an increased number of stockists and new varieties spreading fast. However, seed quality is a major concern, and quality control needs to be emphasized. A major hindrance to technology adoption is the lack of credit. Given the experience in other countries, there seems to be a large and unexplored market for microfinance. Studies of existing informal credit groups and policies to encourage micro-finance development are indicated. Overall, the develop-ment of insect resistant maize should be encouraged. The varieties would respond to farmers' demands and conditions, although care should be taken to make sure they really fit. Participatory variety selection is therefore indicated.

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REFERENCES

Ashby JA (1990). Evaluating Technology with Farmers: A Handbook Centro International de Agricultura Tropical (CIAT), Cali, Columbia.
Chambers R (1994). The origins and practice of participatory rural appraisal. World Dev., 22: 953-969.
De Groote H (2002). Maize Yield Losses from Stemborers in Kenya. Insect Sci. Appl., 22:89-96.
De Groote H, Friesen D, Siambi M, Diallo A (2001). Participatory plant breeding guidelines for the AMS on-farm trials for 2001 in East Africa. Mimeo.
De Groote H, Okuro JO, Bett C, Mose L, Odendo MO, and Wekesa E (2004). Assessing the demand for insect resistant maize varieties in Kenya combining Participatory Rural Appraisal into a Geographic Information System. In L. Sperling, et al., eds. Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement: An Africa-wide Exchange of Experiences. Proceedings of a workshop held in Bouake, Ivory Coast. May 7-10, 2001. CGIAR Systemwide Program on Participatory Research and Gender Analysis, Cali, Colombia, pp. 148-162,
Government of Kenya (1983). National Development Plan (1984 -1988) Government Printer, Nairobi, Kenya.
Government of Kenya (1997). National District Development Plan (1997-2001) Government Printer, Nairobi, Kenya.
Hassan RM (1998). Maize technology development and transfer: a GIS application for research planning in Kenya. Appendix C. The potential for generation and adoption of technologies by zone and major research theme, p. 210.
Jaetzold R, Schmidt H (1983). Farm Management Handbook: Natural and Farm Management Information Vol.II/B. Nairobi: Ministry of Agriculture and Livestock Development and GTZ. .

Matiri FM, Murithi FM, Ouma JO, Ndubi JM (1996). Assessment of Adoption of Maize Production Technologies in Meru District, Kenya Proceedings of the First KARI Socio-Economics Conference. Nairobi, Kenya: Kenya Agricultural Research Institute.

Micheni AN, Kariuki I, Gethi M, Rees (1998). (1999 eds) Participatory rural appraisals of the farming systems of eastern Kenya: Kenya Agricultural Research Institute.

Pingali PL (2001). CIMMYT 1999-2000 World Maize Facts and Trends. Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sector CIMMYT, Mexico, D.F.

Werner J (1993). Participatory Development of Agricultural Innovations Deutsche Gesellschaft fur Technische Zusammenarbeity, Eschborn, Germany.