African Journal of Agricultural Research Vol. 5(13), pp. 3021-3028, 4 July, 2011
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X ©2011 Academic Journals

Full Length Research Paper

Participatory farmer evaluation of stem borer tolerant maize varieties in three maize growing ecologies of Kenya

Ouma J. O.[1]*, M. Odendo[2], C. Bett[3], H. De Groote[4], S. Mugo[4], C. Mutinda[1], J. Gethi[3], S. Njoka[1], S. Ajanga[2] and J. Shuma[5]

[1]Kenya Agricultural Research Institute, Embu P. O. Box 27-60100, Embu, Kenya.
[2]Kenya Agricultural Research Institute, Kakamega, P. O. Box 169, 50100, Kakamega, Kenya.
[3]Kenya Agricultural Research Institute, Katumani P. O. Box 340-90100, Machakos, Kenya.
[4]International Maize and Wheat Improvement Center (CIMMYT) P. O. Box 1041-00621, Village Market, Nairobi, Kenya.
[5]Kenya Agricultural Research Institute, Mtwapa, P.O. Box 16, 80109, Mtwapa, Kenya.

Accepted 19 November, 2010

Insect resistant maize for Africa (IRMA) project aims at developing and deploying insect resistant maize varieties to reduce grain losses due to insect pests. As part of incorporating farmers' perceptions to improve the adoption of the developed varieties, participatory approaches were adopted. The paper analyses farmer's preferences of maize germplasm developed through conventional breeding. This paper uses data collected from evaluations conducted at the end of 2006 April and October rains season. Nine stem borer resistant maize varieties were evaluated alongside six commercial checks in the moist transitional zones (East and West) at taselling and harvest stage, while in the dry transitional zone and dry mid altitude zones, six new varieties were evaluated together with four commercial checks at harvest stage. Each variety was assessed on a scale of 1(very poor) to 5 (very good) based on key criteria generated in earlier group discussions with farmers and overall score. Data was analyzed using ordinal regression model of Social Package for Social Sciences (SPSS). At the Dry Transitional (DT) zone, CKIR06007 and CKIR06008 were more preferred to the checks based on overall score. CKIR06008 was also more preferred on yield and tolerance to insect pest criteria, while CKIR04002, CKIR06009, and CKIR04003 were perceived more superior to local check based on tolerance to insect pests. In the DM altitude zone, CKIR06008 was better on yield attribute. Three varieties namely CKIR04002, CKIR06007, CKIR06009 were superior on stem borer tolerance attribute. In moist transitional zone Embu only CKIR06005 was more preferred ($p<0.01$) to the check at harvest stage in April 2006 and October rains season based on early maturity. While there was no preference for the new varieties at vegetative stage in Embu in October rains 2006 season, a number of new varieties CKIR06001, CKIR06002, CKIR06003, CKIR06004, and CKIR06005 were more preferred based on early maturity at harvest in October rains 2006 season. In the moist transitional zone (west) CKIR06004 had good attributes in terms of cob size at taselling stage in April rains 2006. We conclude that farmers perceive some varieties to have good tolerance to insect pests in addition to good yield and early maturity, which are critical attributes to the farmers in the adoption of new varieties.

Key words: Farmers perceptions, maize, stem borer tolerant varieties, ordinal regression.

INTRODUCTION

Among the insect pests attacking maize crop in Africa, the lepidopteran stem borers are by far the most injurious (Youdeowi, 1989), due to individual damage and their diversity. Yield losses in areas with chronic borer problems vary between 10-70% (Mulaa, 1995; De Groote, 2002). 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

*Corresponding author. E-mail: j_okuro@yahoo.co.uk

and deployment of insect resistant maize could make a difference, the Insect Resistant Maize for Africa (IRMA) project was launched to address the problem of stem borers. Several instances exist where huge investments have been made to develop improved agricultural technologies that were not eventually adopted by the target population (Becker, 1995; Kormawa, 1999; Emad, 1995). Many such situations have often been associated with technologies developed using the top-bottom approach, characterized by the involvement of the target population only when the development of the technology has been finalized by scientists and would not normally involve the farmers.

The main reasons for lack of adoption of technologies developed by the scientists alone border on lack of fitness into the resources (land, labour, capital, management, etc.) available to the target population and the failure to take into account the local experience and needs of the target population (Warren, 1991). Such technologies are therefore inappropriate. This explains the limited farmer adoption of technologies derived from on-station research (Wortmann, 1992; Giller, 1994; Becker, 1995). The emphasis in farmer participatory research is to enable farmers to make their own analysis and decisions based on their own perceptions and criteria. It is also important that the participatory approach also includes a double feedback: from the farmers to researchers and from the researchers to the farmers. The importance of farmer participatory research in reorienting technology development, accelerating adoption and creating wider impacts in smallholder farming has also been documented (Pretty 2001; Johnson 2003).

The objective of this paper is to demonstrate the usefulness of farmer participatory research in the evaluation of nine stem borer resistant maize varieties alongside six local checks in the Moist Transitional Zone (East and West) and six stem borer resistant maize varieties and 4 local checks in the Dry Transitional Zone and Dry Mid altitude Zone. The paper would lead to the knowledge of new maize varieties that need to be further tested, multiplied, and extended to the farmers.

METHODOLOGY

Germplasm tested

The Insect tropical synthetics, open pollinated varieties (OPVs) were developed in CIMMYT Mexico from lines with high general combining ability (GCA), high planting density tolerance, and resistance to the South western corn borer (*Diatraea gradiosella* Dyar) and fall armyworm (*Spodoptera frugiperda* JE Smith) as described by Mugo (2006). The hybrids were developed using lines from the CIMMYT multiple borer resistant (MBR) populations tested for resistance against the African stem borer (*Busseola fusca* Fuller) and *C. partellus* and other adapted inbred lines. During the First rainy season 2006, in Moist Transitional (MT) zone (East), three OPVs (CKIR04002, CKIR04005, CKIR04006) and six hybrids (CKIR06001, CKIR06002, CKIR06003, CKIR06004, CKIR06005, CKIR06006) were tested together with Embu composite (EMCO), an open pollinated variety and five hybrids (H513, Pannar 5243, SC Simba, PHB3253, and H614D), while in October rains season 2006 with the exception of CKIR06006, which was replaced by (MBR) C5B, the same sets of new varieties were used. However, four new commercial checks (KSPT94, WH403, WS909 and H623) were used in addition to H513 and PHB3253. In Dry Transitional Zone (DTZ) and Dry Mid altitude Zone (DMAZ) three OPVs namely CKIR04002, CKIR04003 and CKIR04005 and three hybrids namely CKIR06007, CKIR06008 and CKIR06009) were evaluated alongside local checks, Dryland Hybrid 1 (DH01), Katumani composite B, WS103, DLC1 (Makueni/ DH04. Similar sets of stem borer tolerant varieties and local checks evaluated in Moist Transitional Zone (MTZ) (East) were used in Moist Transitional Zone (West).

Testing sites

Evaluations were conducted in four sites in the Moist Transitional Zones (MTZs) (East and West). Similarly, the evaluations were conducted in four sites in the Dry Transitional and Mid Altitude Zones (Figure 1). The first rainy season starts in March-July and the second rains in October to December. While the first rains are more reliable in the MT Zones (East and west), the converse is true for the DT zones. The evaluations were conducted in August 2006 and February 207 at the conclusion of the first and the second rainy seasons, respectively.

Treatments and evaluations

A 5x3 alpha lattice design with three replications in two 5 m long row plots was adopted. Row spacing was 75 cm, while plant spacing was 25 cm giving a plant density of 53,000 plants ha-1. Two seeds were sown per hill and later thinned down to one plant per hill. Fertilizer rates of 60 kgN and 60 kg P2O5 ha-1 were used with nitrogen being applied in two applications: at the time of planting and one month after planting. The fields were kept free of weeds by hand weeding. In April rains 2006, each of the varieties were planted in two lines. However, this was increased to 5 lines to allow farmers to have meaningful appreciation.

Group discussions were conducted to review the criteria for selection of the maize varieties at different stages of the crop growth, particularly at vegetative and harvest stage prior to the evaluations. The criteria identified as important in the selection of maize varieties were: yield, maturity, cob size, cob fill, cob diameter, grain size, and husk cover, tolerance to insect pests, tolerance to diseases, and tolerance to lodging, grain texture, and ear placement. The criteria were incorporated in a questionnaire together with information regarding socioeconomic characteristics of the households. Farmers were first asked to fill in information on socioeconomic characteristics, prior to introducing them to the objective of the evaluation. Each farmer rated the 1st and 2nd replications for each variety on scale of 1 (very poor) to 5 (very good) based on their criteria. An overall score for each variety was also given except in Moist Transitional Zone (west).

Data analysis

Farmer scores were ordered categorical data, for which the appropriate analysis is ordinal regression (Coe, 2002). The proportional odds regression model was used, which calculates the cumulative probabilities that a response variable Y falls in category i or below, for each possible i, where I refers to ordered categories. The estimate arrived at is the log odds ratio which equals to the log (odds of one treatment being high verses low/odds of another being

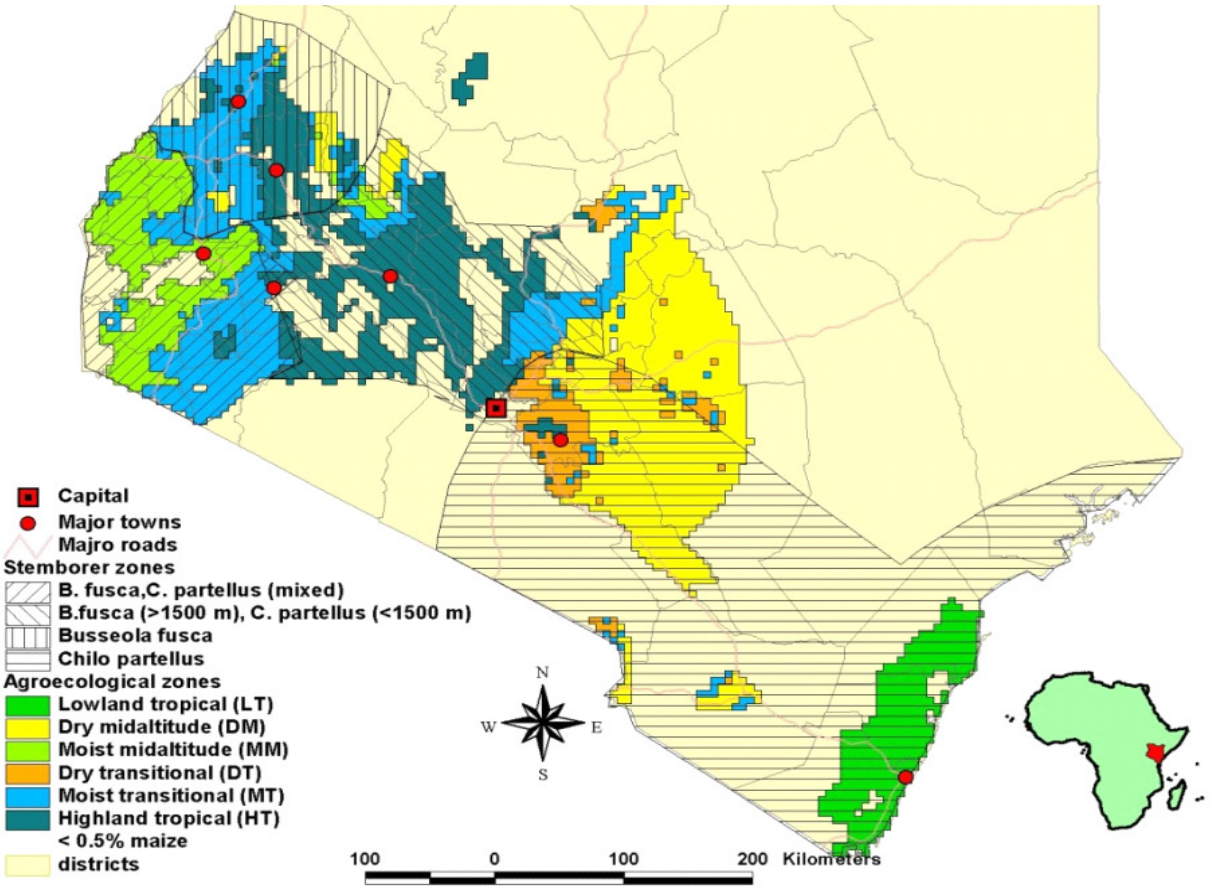

Figure 1. Maize agroecological zones and stem borer distribution.

high verses low) (Coe, 2002). The following reduced model was estimated:

$Yj = f(Xj)$

where Y is overall farmer evaluation, score from 1-5 of treatment Xj

Suitable checks were used in each of the maize ecologies. In the Dry Transitional and Dry midaltitude zones, DH01 was used as the check, while WH403 and H513 were used in MTZ (west) and MTZ (east) respectively.

RESULTS

The results of the evaluations in the two growing seasons of 2006 in the DTZ, DMAZ, MTZ (East and West) are shown in Tables 1 to 8, Generally most of the new stem borer tolerant maize varieties were less preferred to the controls in the maize ecologies in the two growing seasons based on overall score and key attributes:, yield, stem borer tolerance and early maturity. In October rains season, at Katumani in the Dry Transitional Zone. In the Second rainy season, at Katumani in the DTZ (Table 1 and 2), a number of a number of new varieties were noted with remarkable attributes. CKIR06008 was singled out as having better yield and stem borer tolerant attributes than the control (DH01). CKIR06008 was also perceived to be better than the control on overall score together with CKIR06007. Three varieties namely, CKIR06009, CKIR04002, and CKIR04003 were considered better than the control on account of tolerance to insect pests.

At Kiboko, in the Dry Midaltitude Zone, CKIR04002 was more preferred to Katumani, the control on overall score and yield attributes in first rainy season 2006 (Table 3). In Second rainy season, 2006, three varieties namely CKIR04002, CKIR06007, CKIR06009 were more preferred to the control on stem borer tolerance attribute, while CKIR06008 was more preferred to the control on yield attributes (Table 4). In the moist transitional zone (MTZ (East)), except for CKIR06005 which was more preferred ($p<0.01$) to the control at harvest in first rainy season 2006 on early maturity attribute, none of the other new maize varieties had better attributes than the control (Table 5). Similarly in second rainy season, CKIR06005, CKIR06005 was more preferred to the control based on early maturity criteria. Other varieties perceived to have better early maturity qualities than the control were CKIR06001, CKIR06002, CKIR06003 and CKIR06004

Table 1. Appreciation based on overall score, yield and tolerance to stem borers attributes at harvest stage at Katumani in first rainy season, 2006.

	Overall		Yield		Stem borer tolerance	
Varieties	**coefficient**	**SE**	**coefficient**	**SE**	**coefficient**	**SE**
CKIR04002	-0.919	0.331	-0.189	0.372	-0.090	0.364
CKIR04003	-3.030	0.367	-1.952	0.395	-1.159	0.358
CKIR04005	-2.120	0.343	-1.316	0.375	-1.040	0.356
CKIR06007	-2.740	0.357	-2.575	0.437	-0.338	0.358
CKIR06008	-2.908	0.363	-2.539	0.437	-0.385	0.360
CKIR06009	-3.008	0.366	-3.560	0.583	-0.807	0.355
DH04	0.952	0.342	1.522	0.470	1.402	0.444
Katumani	-0.186	0.327	0.852	0.423	0.778	0.402
WS103	-1.527	0.336	-0.189	0.378	-1.109	0.357
DH01	0.00	0.00	0.00	0.00	0.00	0.00
Log likelihood	118.725		58.154		76.275	
x2	32.043		7.127		21.342	

*** Significant at 1%, ** significant at 5% and * significant at 10%.

Table 2. Appreciation based on overall score, yield and tolerance to stem borers attributes at harvest stage at Katumani in Second rainy season, 2006

	Overall		Yield		Stem borer tolerance	
Varieties	**coefficient**	**SE**	**coefficient**	**SE**	**coefficient**	**SE**
CKIR06007	0.934**	0.419	0.176	0.414	0.239	0.408
CKIR06008	0.903**	0.418	0.735*	0.419	2.101***	0.429
CKIR04002	0.615	0.417	0.264	0.415	1.245***	0.415
CKIR04003	0.343	0.416	-0.558	0.413	0.699*	0.41
CKIR06009	0.114	0.416	0.11	0.414	1.142***	0.414
CKIR04005	-0.721*	0.418	-0.872**	0.414	0.566	0.409
DH04	0.195	0.416	0.206	0.414	1.769	0.423
Katumani	0.283	0.416	-0.362	0.413	0.81	0.411
WS103	0.169	0.416	0.037	0.414	1.046	0.413
DH01	0.00	0.00	0.00	0.00	0.00	0.00
Log likelihood	138.302		141.57		154.4	
x2	22.409		22.882		33.341	

*** Significant at 1%, ** significant at 5% and * significant at 10%.

Table 3. Appreciation based on overall score, yield and tolerance to stem borer's criteria at harvest stage in first rainy season, 2006.

Varieties	**Overall**		**Yield**		**Tolerance to stem borer**	
	coefficient	**SE**	**coefficient**	**SE**	**coefficient**	**SE**
CKIR04002	1.160***	0.457	1.663**	0.822	-1.427***	0.489
CKIR04003	-3.265***	0.527	-2.844***	0.586	-2.095***	0.529
CKIR04005	-2.481***	0.479	-2.340***	0.540	-1.427***	0.489
CKIR06007	-3.062***	0.511	-3.310***	0.652	0.256	0.507
CKIR06008	-.743	0.443	0.152	0.551	-1.671***	0.500
CKIR06009	0.552	0.442	0.318	0.566	-1.427***	0.489
DH01	1.227	0.459	1.287	0.712	-0.668	0.477
DH04	-4.244	0.628	-3.057	0.613	-1.803	0.507
WS103	0.913	0.449	0.970	0.652	-0.455	0.479
Katumani	0.000	0.000	0.000	0.000	0.000	0.000

Table 3. Continued.

log	84.488	33.481	39.454
x2	17.107	0.000	0.000

*** Significant at 1%, ** significant at 5% and * significant at 10%.

Table 4. Appreciation based on overall score, yield and tolerance to insect pests criteria at harvest stage second rainy season, 2006.

Varieties	Overall		Yield		Tolerance to stem borer	
	coefficient	SE	coefficient	SE	coefficient	SE
CKIR04002	1.032	0.718	0.641	0.649	1.972***	0.677
CKIR04003	0.480	0.712	0.696	0.650	0.370	0.657
CKIR04005	0.166	0.708	0.712	0.650	1.019	0.661
CKIR06007	-0.910	0.701	0.612	0.649	1.303**	0.664
CKIR06008	1.172	0.720	1.859***	0.670	1.292	0.664
CKIR06009	-0.684	0.702	0.523	0.648	1.137*	0.662
DH01	-0.391	0.703	0.997	0.654	0.774	0.658
DH04	-1.133	0.702	0.111	0.645	-0.167	0.661
WS103	0.176	0.708	0.168	0.645	0.931	0.660
Katumani	0a	.	0a	.	0a	.
Log	98.524		102.293		98.524	
x2	32.079		29.029		32.079	

*** Significant at 1%, ** significant at 5% and * significant at 10%.

Table 5. Appreciation based on overall score, yield and early maturity attributes at harvest stage in first rainy season 2006.

Variety	Overall		Yield		Maturity	
	Estimate	SE	Estimate	SE	Estimate	SE
CKIR04002	-2.178	0.58	-2.437	0.6	-0.073	0.53
CKIR04005	-3.591	0.59	-2.977	0.6	-0.702	0.53
CKIR04006	-2.772	0.58	-2.723	0.6	0.187	0.532
CKIR06001	-1.06	0.58	-1.384	0.6	0.655	0.537
CKIR06002	-2.66	0.58	-2.238	0.6	-1.38	0.534
CKIR06003	-1.578	0.58	-0.91	0.5	-0.598	0.53
CKIR06004	-1.591	0.58	-1.731	0.6	0.812	0.539
CKIR06005	-1.577	0.58	-1.066	0.5	1.493***	0.557
CKIR06006	-1.422	0.58	-1.317	0.5	-0.648	0.53
EMCO	-3.57	0.59	-3.579	0.6	-0.473	0.53
Panner5243	-3.565	0.59	-2.401	0.6	-1.641	0.537
PH 3253	-2.733	0.58	-2.285	0.6	-0.801	0.53
614D	-1.864	0.58	-1.298	0.5	-1.477	0.535
SC SIMBA	-0.969	0.58	-0.379	0.5	-0.958	0.531
H513	0.00	0.00	0.00	.	0.00	0.00
log likelihood					230.026	
x2					82.468	

*** Significant at 1%, ** significant at 5% and * significant at 10%.

(Table 6).

In moist transitional zone (West), overall scoring was not done in the two growing. However, the results of the farmers' groups' discussions preceding the evaluations showed that yield and maturity are the most important attributes criteria in determining choice of new maize

Table 6. Appreciation based on overall score, yield and early maturity criteria at harvest stage in second rainy season, 2006.

Varieties	Overall		Yield		Maturity	
	Estimate	SE	Estimate	SE	Estimate	SE
MBR C5 B	-0.715	0.287	-0.933	0.28	0.451	0.278
CKIR04002	-2.447	0.294	-2.609	0.29	-0.22	0.277
CKIR04005	-1.589	0.288	-2.109	0.29	0.047	0.277
CKIR04006	-0.898	0.287	-1.646	0.28	0.341	0.278
CKIR06001	-0.604	0.287	-1.356	0.28	0.472*	0.278
CKIR06002	-0.32	0.287	-0.494	0.28	0.804***	0.28
CKIR06003	-0.451	0.287	-0.692	0.28	0.581**	0.279
CKIR06004	-0.161	0.288	0.071	0.29	0.8***	0.28
CKIR06005	0.443	0.292	-0.059	0.29	1.163***	0.284
H623	-0.577	0.287	-0.681	0.28	-0.916	0.278
KSTP94	-0.523	0.288	-0.386	0.28	-0.356	0.278
PH3253	-0.226	0.289	-0.427	0.28	0.285	0.278
WH403	-0.688	0.287	-1.368	0.28	0.052	0.278
WS909	-2.074	0.291	-2.873	0.29	-0.503	0.277
H513	0.00	0.00	0.00	0.00	0.00	0.00
Log likelihood	310.274		306.53		292.321	
x2	94.557		80.466		65.919	

*** Significant at 1%, ** significant at 5% and * significant at 10%.

Table 7. Appreciation based on yield, maturity, and tolerance to insect pests' criteria at taseling stage in first rainy season 2006 season.

Variety	Yield		Maturity		Tolerance to insect pests	
	Estimate	SE	Estimate	SE	Estimate	SE
CKIR04006	2.182***	0.708	-1.341	0.69	-0.19	0.684
CKIR04002	1.676**	0.696	-0.241	0.68	-1.251	0.695
CKIR06006	1.209*	0.688	1.393**	0.72	-0.403	0.685
CKIR06001	0.442	0.686	2.069***	0.74	0.835	0.694
CKIR06004	0.148	0.688	0.939	0.71	-0.283	0.684
CKIR06003	0.085	0.688	0.214	0.69	1.211*	0.703
CKIR04005	-0.182	0.69	0.298	0.69	0.308	0.686
CKIR06005	-0.562	0.693	-1.133	0.69	-0.622	0.687
CKIR06002	-1.621	0.7	-0.027	0.68	-1.251	0.695
WH403	0.00	0.00	0.00	0.00	0.00	0.00
Log likelihood	102.001		104.117		106.22	
X2	29.465		37.631		41.814	

*** Significant at 1%, ** significant at 5% and * significant at 10%.

varieties. These were consequently used in the analysis of farmer's preferences. At vegetative stage, in April rains 2006 season, CKIR06006 was more preferred on yield and maturity aspect than the control. While CKIR04006 and CKIR04002 were preferred on yield criteria, CKIR06001 was more preferred on maturity and CKIR06003 on tolerance to insect pests (Table 7). In October rains season 2006, CKIR06004 was more preferred to the control on cob size attribute, while CKIR06005 was more superior on maturity attribute (Table 8).

DISCUSSION

Did we identify new and promising stem borer tolerant maize varieties through this process? The results of the evaluations in the second rainy season in the DTZ in the Dry Transitional zone indicates that one new maize variety, CKIR06008 was perceived to be better than the control on key attributes: yield and stem borer tolerance. This is an important candidate for release for adoption by farmers in the DT zone. Other varieties that exhibited stem borer tolerance but poor yield attributes than the

Table 8. Appreciation based on maturity, cob size and pest tolerance criteria at taseling stage in Second rainy season 2006.

Variety	Maturity		Yield		Pest tolerance	
	Estimate	SE	Estimate	SE	Estimate	SE
CKIR06004	0.978**	0.428	0.561*	0.292	0.153	0.29
CKIR06005	0.949**	0.428	0.179	0.292	0.093	0.29
CKIR04002	0.728*	0.425	-0.031	0.292	0.353	0.29
CKIR04005	0.612	0.424	-0.571	0.292	-0.109	0.29
CKIR06001	0.494	0.423	0.065	0.292	0.288	0.29
CKIR06003	0.262	0.422	-0.332	0.292	0.029	0.29
CKIR04006	0.228	0.422	-0.576	0.293	-0.077	0.29
CKIR06002	0.214	0.422	-0.365	0.292	-0.073	0.29
CKIR06006	0.116	0.421	0	0.292	-0.301	0.29
H513	0.664	0.425	-0.715	0.293	-0.24	0.29
H623	0.21	0.422	-0.73	0.293	-0.846	0.29
KSTP94	0.325	0.422	-1.154	0.295	-0.655	0.29
PH3253	0.119	0.421	1.124	0.294	0.183	0.29
WS909	-0.001	0.421	-0.271	0.292	0.353	0.29
WH403	0.00	0.00	0.00	0.00	0.00	0.00
Log likelihood	231.271		281.941			
X2	43.898		51.314			

*** Significant at 1%, ** significant at 5% and * significant at 10%.

control need to be improved on yield aspect to broaden the range of available varieties to the farmers in the ecologies. It is worth noting that the second rainy season in the DTZ is more reliable in the zone and results obtained in this season are more conclusive than in the first rainy season season.

CKIR06008 was also consistently perceived better than the control in the DMA zone on yield attribute, further suggesting the stability of the variety. In the Moist Transitional zone (East), CKIR06005, was consistently perceived better than the control in the two growing season. However, since it did not prove better than the check on stem borer tolerance, further research need to be carried out. Similarly, in the moist MTZ (West) more stem borer tolerance varieties need to be evaluated and combined with improved yield and early maturity attributes for better adoption. It is also important to note that inconsistencies in the results could perhaps be attributed to comparing OPVs and hybrids together. Maize varieties with different genetic potential require to be evaluated separately. Although some promising materials were identified, the methodology resulted in a large body of often inconsistent data that are difficult to interpret.

Conclusion

Farmers perceive some varieties to have good tolerance to insect pests in addition to good yield and maturity attributes, which are critical to the farmers in the adoption of new varieties. The varieties consistently perceived to have good attributes on tolerance to pests alongside other key criteria such as yield and early maturity need to be further tested, multiplied, and extended to the farmers for increased maize productivity.

AKNOWLEDGEMENTS

We thank the Syngenta Foundation for Sustainable Development for the financial support through the Insect Resistant Maize for Africa Project. Many Technicians from CIMMYT and Kenya Agricultural Research Institute, extension staff from the Ministry of Agriculture, and farmers contributed to this paper, to all whom we are grateful.

REFERENCES

Becker M, Ladha JK, Ali M (1995). "Green manure technology: potential, usage, and limitations: A case study for lowland rice. Plant Soil, 174: 181–194.

Coe R (2002). Analyzing ranking and rating data from participatory on-farm trials. In M.R. Bellon and J. Reeves, eds., Quantitative Analysis.

of Data from Participatory Methods in Plant Breeding, Mexico, D.F.: CIMMYT, pp. 44-65.

De Groote H (2002). Maize Yield Losses from Stem borers in Kenya. Insect Sci. Appl., 22: 89-96.

De Groote H, Siambi M, Friesen D, Diallo A (2002). Identifying Farmers Preferences for New Maize Varieties in Eastern Africa, in Bellon, M.R., and J. Reeves (eds.). 2002. Qualitative Analysis of Data from Participatory Methods in Plant Breeding. Mexico, DF: CIMMYT.

Emad A (1995). "An assessment of the impact of agricultural technology on output in the rainfed farming areas in Jordan. Arbeiten zur Agrarwirtschaft in Entwictlunslanderern, Wissenschaftsverlag Vaul

Kiel KG, Dissertation, veroffentlicht mit Genehmigung der Agrarwissenschaftlichen Fakultaet der Christian-Albrechts-Universitaet, Kiel, Germany.
Giller K, McDonagh JF, Cadisch G (1994). Can biological nitrogen fixation sustain agriculture in the tropics? In Soil Science and Sustainable Land Management in the Tropics. Eds. J.K. Syers and D.L.Dimmer. University of Newcastle upon Tyne, UK, pp. 173–191
Johnson N, Lilja N, Ashby J (2003). Measuring the impact of user participation in agricultural and natural resource management research. Agric. Syst., 78: 287–306.
Kormawa PM, Kamara, AY, Jutzi SC, Sanginga N (1999). Economic evaluation of using mulch from multipurpose trees in maize-based production systems in south-western Nigeria. Exp. Agric., 35: 101-109.
Mugo S, Bergvinson D, DeGroote H, Songa J (2006). Evaluation ofOpen Pollinated Maize Varieties for Resistance to Chilo Partellus in Dryland Mid-Altitudes and Coastal Lowlands of Kenya. Proceedings of the 10th KARI Biennial Scientific Conference 12-17 November 2006, KARI Headquarters Nairobi Kenya.
Mulaa MA (1995). Evaluation of factors leading to rational pesticide use for the control of the maize stalk borer, Busseola fusca (Lepidoptera: Noctuinidae) in Trans-Nzoia district. Ph.D. Thesis, University of Wales.
Pretty J, Hine R (2001). Reducing food poverty with sustainable agriculture: a summary of new evidence. Final report from the SAFEWorld Research Project. University of Essex, Cochester, UK.
Warren D (1991). Using indigenous knowledge in agricultural development. Discussion Paper, vol. 127. The World Bank, Washington DC.
Wortmann C (1992). Agriculture technology evaluation – some considerations. In: Proceedings of a Working Group Meeting on SoilFertility Research for Maize and Bean Production Systems of the Eastern Africa Highlands. 1 – 4 September, Thika, Kenya, pp. 49–58.
Youdeowi A (1989). Major arthropod pests of food and industrial crops of Africa and their economic importance. In Biological Control: A Sustainable Solution to Crop Pest Problems in Africa, ed. JS Yanninek, HR Herren, pp. 51–60. Ibadan, Nigeria: Int. Inst. Trop. Agric., p. 210.