African Journal of Agricultural Research Vol. 5(8), pp. 758-763, 18 April, 2010
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR09.609
ISSN 1991-637X 

*Full Length Research Paper*

# Evaluation of maize (*Zea mays* L.) genotypes as a component of integrated stem borer (*Chilo partellus* Swinhoe) management in coastal region of Kenya

**S. O. Ajala*, A. M. Nour, K. Ampong-Nyarko and M. O. Odindo**

International Centre of Insect Physiology and Ecology(ICIPE), Mbita Point Field Station, P. O. Box 30, Mbita, South Nyanza, Kenya.

Accepted 15 March, 2010

**A study was conducted at six sites of Kenya Coastal region to evaluate candidate maize genotypes for inclusion in stem borer IPM package for the area. Stem borer infestation/damage during the trial period were rather low but nonetheless, significant differences were observed between the insecticide (Carbofuran) and/or *Bacillus thuriengiensis* (*Bt*) treated plots and the control. Yield loss due perhaps to levels of tolerance of the genotypes varied from 7 to 23%. Generally, varietal crosses were higher yielding than the open pollinated populations with grain yield itself being primarily influenced by number of ears harvested per plot. Therefore, tendency towards prolificacy also determined the choice of ICZ5, IC92M2 and IC92M5 as possible candidates.**

**Key words:** Maize, stem borer control.

## INTRODUCTION

Adoption of Integrated Pest Management (IPM) technologies in most part of Africa is on a *la carte* basis with farmers choosing those that suit their socio-economic circumstances. However, a basic component of an IPM package is the crop genotype with emphasis being on the inherent resistance of such genotypes in addition to other desirable attributes. The reason for this is not far fetched; host - plant resistance does not require any additional cost or input to perform. However, host-plant resistance *per se* does not guarantee absolute protection nor eliminate some level of yield loss due to damage by the pest, therefore, some form of protection to guarantee further yield loss protection is required. In situations where resistant genotypes are not available, rational use of insecticides or bio-pesticides is an alternative and recognized IPM option (Jacques, 1983). Cook (1988) and Schulthess and Ajala (1999) suggests that a holistic plant-health approach in integrated crop and pest management as well as the management of the agro-ecosystem make agricultural production more sustainable.

At the ICIPE, an IPM project for stem borer control was initiated in the coastal region of Kenya in 1991 and had as part of its objective the assessment of the relative contribution of different IPM components to yield loss reduction. The components considered were host-plant resistance, biological control using the bacterium *Bacillus thuriengiensis* (Bt) and strip-relay intercropping. The study reported herein is the evaluation of candidate maize genotypes as component of IPM strategies aimed at managing stem borer in the coastal region of Kenya.

### MATERIALS AND METHODS

Ten pre-selected maize genotypes were chosen for further evaluation in six sites of the coastal region of Kenya in the long (March - July) raining season of 1993 and in three of the six sites in the short (August – November) raining season of the same year. Performances of the genotypes were determined *a priori* in earlier trials at the Kenyan coast. Characteristics of the maize genotypes are presented in Table 1.

Eight of the genotypes comprising five varietal cross hybrids and three open pollinated populations were developed for resistance to the spotted stem borer (*Chilo partellus* Swinhoe) at ICIPE while the other two, Pwani Hybrid 1 and Coast Composite are the commercially released varieties of Kenya seed company commonly

*Corresponding author. E-mail: S.AJALA@cgiar.org.

**Abbreviations: IPM,** Integrated pest management; **Bt,** *Bacillus thuriengiensis*.

**Table 1.** Characteristics of the ten maize genotypes evaluated as candidates for integrated stem borer control in coastal region of Kenya in 1993.

| Genotype | Source | Type | Colour | Maturity | Reaction to stem borer |
|---|---|---|---|---|---|
| ICZ3 | ICIPE | OPP | White | Early | Resistant |
| ICZ5 | ICIPE | OPP | White | Medium | Resistant |
| IC92M1 | ICIPE | VC | White | Medium | Resistant |
| IC92M2 | ICIPE | VC | White | Medium | Resistant |
| IC92M3 | ICIPE | VC | White | Medium | Resistant |
| IC92M4 | ICIPE | VC | White | Medium | Resistant |
| IC92M5 | ICIPE | VC | white | Medium | Resistant |
| ICZ4 | ICIPE | OPP | Yellow | Medium | Resistant |
| Pwani Hyb.1 | KSC | VC | White | Medium | Not known |
| Coast Comp. | KSC | OPP | White | Late | Not known |

OPP = Open pollinated population, VC = Variety cross hybrid, KSC = Kenya seed company.

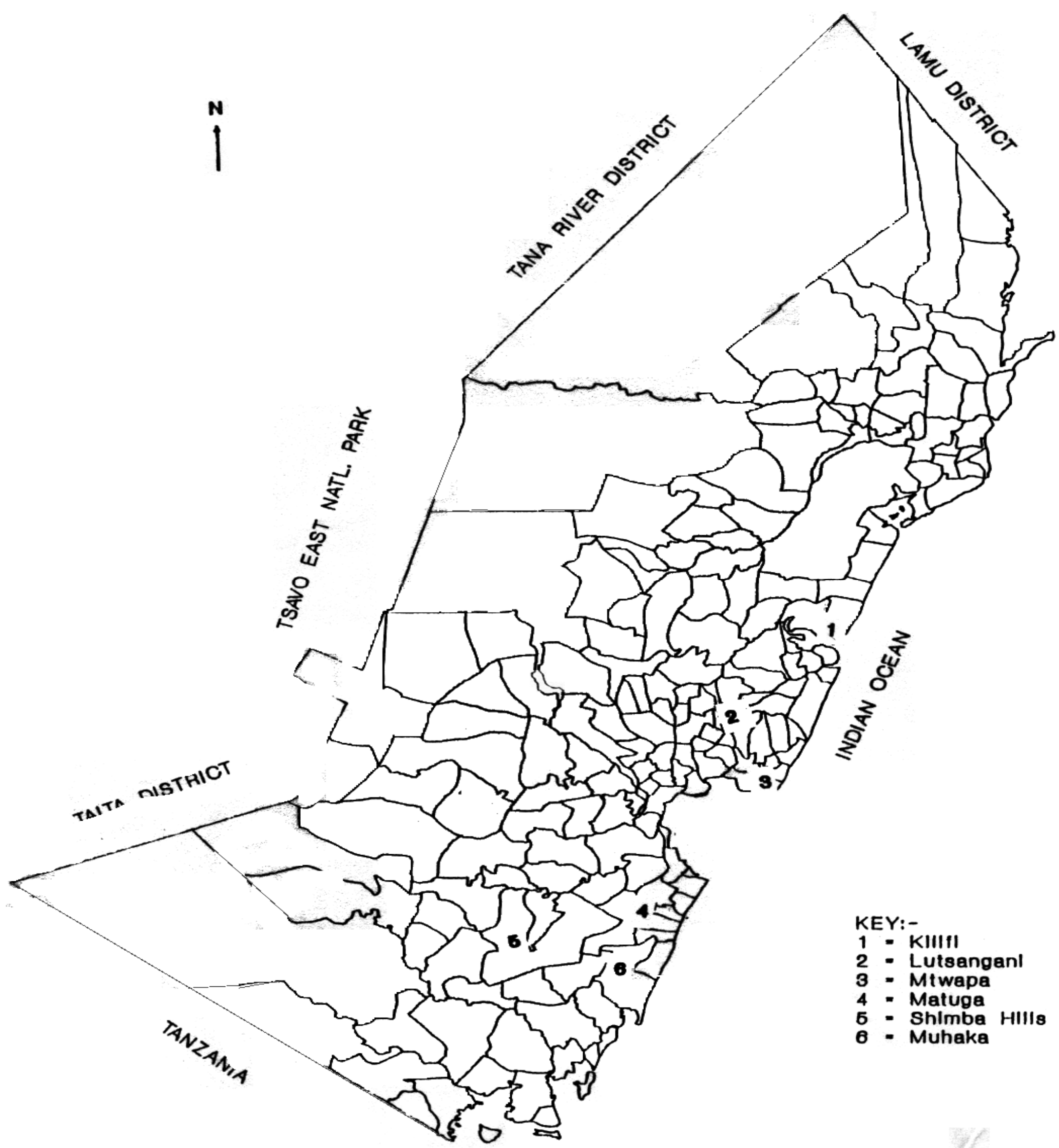


**Figure 1.** Map of kwale/Killifi districts of Kenya showing the study sites.

**Table 2.** Mean squares from combined ANOVA for stem borer damage parameters, grain yield and its components of 10 maize genotypes evaluated in six coastal region sites of Kenya in 1993.

| Source | df | Foliar damage | Dead heart | Stem tunnelling | Plant ht. | Stand count | Ear no | Moisture | Grain yield |
|---|---|---|---|---|---|---|---|---|---|
| | | | ----------(%)---------- | | (cm) | | | (%) | (t/ha) |
| Env. (E) | 5(1) | 1731.08** | 333.50** | 56.92** | 36613.03** | 65182.58** | 52995.45** | 128.54** | 145.45** |
| Rep/E | 12(4) | 312.93 | 48.17 | 3.55 | 1061.26 | 424.86 | 495.90 | 11.83 | 3.20 |
| Entry | 9 | 167.69** | 13.79 | 30.85 | 37797.09** | 289.93** | 320.21* | 37.62** | 5.97** |
| Hyb | 5 | 65.31 | 8.71 | 18.34 | 5768.76** | 240.23* | 310.43 | 28.63** | 1.58 |
| OPP | 3 | 393.60** | 19.74 | 60.32 | 99527.98** | 468.60** | 295.56 | 51.06** | 5.25** |
| Hyb. Vs OPP | 1 | 1.61 | 21.38 | 5.01 | 12746.10** | 2.45 | 442.97 | 42.24** | 30.07** |
| Entry × E. | 45(9) | 43.55 | 12.40 | 9.61 | 341.38 | 116.11 | 135.84 | 5.77 | 1.70* |
| Error A | 108(36) | 45.36 | 11.27 | 15.77 | 437.04 | 120.95 | 144.19 | 4.15 | 1.06 |
| Trt. | 2 | 8321.33** | 211.87** | 537.18** | 2470.22** | 428.76* | 1627.30** | 1.40 | 31.07** |
| Trt. × Entry | 18 | 23.15 | 9.53 | 13.16 | 211.24 | 58.19 | 40.53 | 4.65 | 0.42 |
| Trt × Entry x E. | 90(18) | 29.00 | 9.51 | 12.64 | 171.62 | 44.41 | 70.25 | 3.09 | 0.37 |
| Error B. | 240(80) | 32.21 | 11.55 | 9.97 | 271.77 | 86.68 | 102.71 | 3.32 | 0.46 |
| CV (%) | | 30.29 | 107.99 | 30.16 | 10.30 | 12.81 | 15.92 | 11.26 | 19.19 |

*, ** = Significant at P = 0.05 and 0.01, respectively. OPP = Open pollinated population.
+ Values in parenthesis represent corresponding df for stem tunnelling.

grown in the area.

The six evaluation sites are as presented in Figure 1. Kilifi, Lutsangani and Mtwapa are in the Kilifi (3.38S 39.51E, 210masl) district of the Kenyan Coast while Matuga, Shimba Hills and Muhaka are in the Kwale (4.11S 39.27E, 270masl) district of the Indian Ocean coast of Kenya. Mtwapa is a Kenya Agricultural Research Institute (KARI) station while the Kilifi trial was planted at the Kilifi Institute of Agriculture grounds. Lutsangani is a major maize growing plain land and also used by the KARI Mtwapa station.

The other three sites located within Kwale district are Muhaka, Shimba Hills and Matuga. Matuga is a sub-station of KARI Mtwapa, while Muhaka is the field station of the ICIPE. Shimba Hills is the trial site of the Kenya Ministry of Agriculture, Livestock Development and Marketing, a colla-borating partner of the Scientists – Extensionist - Farmer alliance. Three treatments com-prising the use of a systemic insecticide - Carbofuran, an aqueous spray of a biocontrol agent, the bacterium *Bt* and a control having no protection were super-imposed on the genotypes in each site. In effect, trials were laid out in a split plot design with genotype as the main plot and treatment as the sub plot using three replications in each site.

A minimum of six row plots per entry was planted in each site except for Shimba Hills where two row plots were used but entries had a common border. Row length in each site was 17 m, sub-divided into three contiguous 5m sub-row with lm in between. Carbofuran was applied on the first 5m sub-row while *Bt* was sprayed on the second. The third 5 m sub-row served as the control. The genotypes and treatments were randomised in the other two replicates. About 3 g, obtained as thumb and forefinger pinch of Carbofuran was applied in the funnel of leaf whorl at about 3 and 7 weeks after plant emergence while for treatments involving *Bt*, foliar spray of *Bt* spore suspension was applied concurrently with the insecticidal application in each site.

Data obtained for all sites except for the short rainy season plantings which were not successful due to erratic rainfall, included foliar damage and dead heart symptoms estimated as proportions of plants showing the damage per plot, stands and ear number per plot at harvest, moisture content of grains at harvest and grain yield adjusted to 14% moisture content. Extent of stem tunnelling due to stem borer damage was estimated asthe proportion of plant height for only two locations of Muhaka and Matuga. Combined analysis of variance (ANOVA) for split-split plot design for all the traits was performed. Data obtained for foliar damage, dead heart and stem tunnelling were transformed to their respective arcsine values for ANOVA, but correlation and stepwise multiple regression analyses were performed using entry mean across sites from the untransformed data.

## RESULTS

Mean squares due to entries and treatments were significant in nearly all instances. The comparison between hybrid entries and their open pollinated counterparts was significant for height, moisture and grain yield (Table 2).

A few significant interactions were obtained with the important ones being entries x environment interaction for grain yield and treatment x environ-ment interaction that was significant for almost all

**Table 3.** Mean of the damage parameters, grain yield and its components of 10 maize genotypes evaluated in six coastal sites of Kenya in 1993.

| | Traits | | | | | | |
|---|---|---|---|---|---|---|---|
| **Treatment** | **Foliar damage** | **Dead heart** | **Stem tunnelling** | **Plant ht.** | **Stand count** | **Ear No.** | **Grain yield** |
| | | -------------%------------ | | (cm) | | | (t/ha) |
| Carbofuran | 4.93 | 0.48 | 2.74 | 164.19 | 73.85 | 67.10 | 4.01 |
| Bt | 15.50 | 0.69 | 2.68 | 158.63 | 70.94 | 61.51 | 3.25 |
| Control | 17.25 | 1.17 | 6.06 | 157.17 | 73.28 | 62.38 | 3.33 |
| SE (0.05) | 1.10 | 0.07 | 0.36 | 4.72 | 0.54 | 0.66 | 0.09 |

traits. Damage levels for all treatments were rather low, nonetheless and as expected, the control treatments involving no protection had more foliar damage when compared with the Carbofuran treatment. Extent of dead heart and stem tunnelling were similar for Carbofuran and *Bt* treated plots but lower than the control. However, there was no real difference between *Bt* treated plots and the control for foliar damage, plant height, number of ears and grain yield. In general, trials treated with Carbofuran had lower levels of damage, were taller, produced more cobs and consequently, more grain yield per plot (Table 3). However, the damage levels of dead heart and stem tunnelling though significant among treatments were low with a maximum of about 1% for dead heart and 6% for stem tunnelling across treatments (Table 3). Grain yield was significantly and negatively correlated with the damage parameters of foliar damage and dead heart and positively with ear number (Table 4). Ear number was significantly and negatively correlated with foliar damage but not with dead heart. In addition, stepwise multiple regression of grain yield on other traits revealed that yield was affected more by number of ears harvested and moisture content with the equation of Y = -7.01 + 0.11 Ear Number + 0.21 Moisture % ($R^2$ = 0.69**). Ear number alone had $R^2$ = 0.54**. The hybrid entries were generally higher yielding than the open pollinated populations and yield loss due to insect attack on the genotypes varied from 6.81% for ICZ4 to 22.91% for IC92M3 (Table 5).

## DISCUSSION

Effects of spotted stem borer infestation on maize plants include foliar lesions caused when the neonate larvae commence feeding on the leaves upon hatching, and if the feeding extends to the meristematic region, plants develop dead heart. Older instars larvae bore into the stem and cause extensive stem tunnelling (Ajala et al., 1994). The cumulative effect of the damage is yield loss as amplified by the significant correlations obtained between proportion of plants showing foliar damage and dead heart with grain yield. However, correlation coefficient between stem tunnelling and grain yield was not significant despite the fact that stem tunnelling is adjudged to be the most important damage parameter causing yield loss (Barrow, 1987; Ajala, 1994). But, it should be noted that correlation is a bivariate relationship that only consider association between two variables without considering character association *inter se*. Therefore, significant correlation obtained between foliar damage and stem tunnelling is an indication that the damage parameters are inter-related. Ajala and Saxena (1994) had earlier confirmed this interrelationship. Nonetheless, the relatively low damage suggests that extent of yield loss, a measure of tolerance, would be more useful in selecting desirable genotypes. However, the role of other insects in reducing grain yield cannot be overlooked because a number of other foliar feeders such as beetles and armyworm observed in the field could have contributed to the level of yield loss between Carbofuran treated plots and the untreated control.

Among the drawbacks involved in the use of *Bt* as an insecticide are its short residual activity being highly sensitive to extremes in ultraviolet light and its level of specificity (Leong et al., 1980; Beegle et al., 1981; Jacques, 1983; Mugo et al., 2002). The *Bt* strain used in this study was developed for control of lepidopterous pests, especially the spotted stem borer *Chilo partellus* (Swinhoe) and have been proved in the screen house (Brownbridge, 1991, 2001). Therefore, comparable yield levels obtained for the control and *Bt* treated plots despite the *Bt*'s effect in reducing levels of dead heart and stem tunnelling may be due to such short residual activity thus predisposing the crop to other later infesting insects. Intercropping of maize/cowpeas or cassava is known to reduce levels of stem borer infestation on the maize crop and the mechanism involved worked out (Ampong-Nyarko et al., 1994). In effect, actual levels of yield loss obtained by comparison of treated and untreated plots in monocrop can be reduced further in intercrop systems thus, a holistic approach that looks closely at the farming system and maximises levels of interaction within it, is needed to effectively manage insect pests. In effect, levels of yield loss alone obtained in a monoculture of treated- untreated system may be inadequate in selecting genotypes for an integrated control. Other criteria will include the genotypic ability to yield adequately in mixed cropping without antagonising other crop species. For example, a rather tall and leafy genotype though high yielding and with little yield loss in monocrop may actually

**Table 4.** Correlation matrix of stem borer damage parameters and agronomic traits of maize varieties evaluated in six coastal areas of Kenya in 1993.

| Trait | Dead heart | Stem tunnelling | Plant height | Stand count | Ear number | Grain yield |
|---|---|---|---|---|---|---|
| Foliar lesion (%) | 0.46* | 0.53** | 0.19 | -0.10 | -0.65** | -0.54** |
| Dead heart (%) | | 0.48* | -0.27 | -0.04 | -0.38 | -0.56** |
| Stem tunnel. (%) | | | 0.30 | 0.24 | -0.21 | -0.20 |
| Plant ht. (cm) | | | | 0.45 | 0.05 | 0.29 |
| Stand count | | | | | 0.62** | 0.37 |
| Ear number | | | | | | 0.73** |

*, ** = Significant at P = 0.05 and 0.01, respectively.

**Table 5.** Mean grain yield (t/ha) and yield loss estimates (%) of 10 maize genotypes evaluated in the coastal region of Kenya under three stem borer control regimes in 1993.

| | Treatments | | | |
|---|---|---|---|---|
| Genotypes | Carbofuran | Bt | Control | +Yield loss (%) |
| ICZ3 | 3.36 | 2.75 | 2.79 | 16.97 |
| ICZ5 | 3.85 | 3.07 | 3.14 | 18.44 |
| IC92M1 | 4.37 | 3.39 | 3.41 | 21.97 |
| IC92M2 | 4.44 | 3.36 | 3.48 | 21.62 |
| IC92M3 | 4.06 | 3.04 | 3.13 | 22.91 |
| IC92M4 | 4.21 | 3.29 | 3.59 | 14.73 |
| IC92M5 | 4.36 | 3.69 | 3.55 | 18.56 |
| ICZ4 | 3.23 | 2.81 | 3.01 | 6.81 |
| Pwani H1 | 4.20 | 3.61 | 3.84 | 8.57 |
| Coast Comp. | 4.01 | 3.51 | 3.37 | 15.96 |
| SE (0.05) | 0.13 | 0.10 | 0.10 | |

+ Expressed as difference between Carbofuran and control treatment.

be useless in intercrop because it shades out other crops in competition thereby reducing the economic value of intercrop system.

Among the varietal cross hybrids, genotypes with comparable yield levels for the treatments are IC92M2, IC92MS and the hybrid check Pwani Hybrid 1. If only the control treatment is considered, then IC92M4 becomes a choice candidate. For the open pollinated populations, ICZ5 was comparable to Coast Composite in yield but, the later is rather too tall and late maturing. Other yield parameters are however, useful for selection purposes. For example, number of ears harvested was the primary determinant of yield in the materials used in this study and in several other studies involving tropical maize genotypes (Ajala, 1992). Prolificacy is a highly desirable trait in maize. Genotypes with tendency towards prolix-ficacy will normally produce a well-filled cob under high population density as obtainable in monocrop systems. However, under low density as usually obtained in inter-crop systems, the genotype tends to produce more than one well-filled ear per plant. Thus prolific genotypes have yield advantage in intercrop systems. Three genotypes (ICZ5, IC92M2 and IC92M5) known to have the added advantage of being prolific at low density were thus selected in this study. Although ICZ5 was not as high yielding as the other two varietal crosses, its advantage as an open pollinated population is that remnant harvest can sometimes be used as seed thereby saving the grower the recurrent expenditure of procuring seeds yearly.

## REFERENCES


Ajala SO (1992). Selecting maize (*Zea mays L.*) lines for better adaptability to small-farm environments. J. Genet. Breed. 46: 215-220.

Ajala SO (1994). Maize *(Zea mays* L.) stem borer *(Chilo partellus* Swinhoe) infestation/damage and plant resistance. Maydica 39: 203-206.

Ajala SO, Saxena KN (1994). Interrelationship among Chilo partellus damage parameters and their contributions to grain yield reduction in maize *(Zea mays* L.). Appl. Entomol. Zoo. 29/4: 469-476.

Ampong-Nyarko K, Seshu Reddy KV, Saxena KN (1994). Chilo partellus (Swinhoe) (Lep., Pyralidae) oviposition on non-hosts: a mechanism for reduced pest incidence in intercropping. Ecology 15(4): 469-475.

Brownbridge M (1991). Native *Bacillus thuringiensis* isolates for the management of lepidopterous cereal pests. Insect Sci. Appl. 12: 57-61.

Brownbridge M (2001). Greehouse trials of new *Bacillus thuringiensis* isolates for the control of Chilo partellus larvae in Sorghum. Phytoparasitica 29(4): 292-298.

Beegle CC, Dulmage HT, Wolfenbanger DA, Martinez E (1981). Persistence of *Bacillus thuringiensis* Berliner insecticidal activity on cotton foliage. Environ. Entomol. 10: 400-401.

Cook JR (1988). Biological control and holistic plant- health care in agriculture. Ann. J. Altern. Agric. 3: 51-62.

Mugo S, Taracha C, Bergvinson D, Odhiambo B, Songa J, Hoisington D, McLean S, Ngatia I, Gethi M (2002). Screening Cry proteins produced by Bt maize leaves foir actvity against Kenyan maize stem borers. pp. 102-105. In D.K. Friesen and A.F.E. Palmer (Eds). Integrated approahed to higher maize productivity in the new millenium. Proc. Seventh Eastern and Southern Africa Regional Maize Conference, 5-11 Feb. 2002. Nairobi, Kenya.

Jaques RP (1983). The potential of pathogens for pest management control, Agric. Ecosys. Environ. 10: 101-126.

Leong KLH, Cano RJ, Kubinski AM (1980). Factors affecting *Bacillus* thuringiensis total field persistence. Environ. Entomol. 9: 593-599.

Schulthess F, Ajala SO (1999). Recent advances at IITA in the control of stem borers in West and Central Africa. pp. 35-52. In Badu-Apraku, B, M.A.B. Fakorede, M. Ouedrago and Quin (Eds). Strategy for sustainable maize production in West and Central Africa. Proc. Regional Maize Workshop, IITA-Cotonou, Benin Republic, 21-25 April 1997. WECAMAN/IITA