Improvement of maize for resistance to biotic and abiotic stresses in Mid-altitude areas of Kenya.

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Abstract

Maize (Zea mays L.) is third most important cereal crop in the world after wheat (Triticum aestivum L.) and rice (Oryza sativa L.) (FAO, 1991). In Kenya, maize is the single most important food crop, being the only cereal crop grown in every part of the country ranging from the lowlands to the highlands. Apart from being the single most important stable food crop, it is also a provider of livestock feeds. Despite its importance, however, maize yields remain low due to a number of factors, which include, amongst others, low levels of soil fertility, moisture limitation, diseases and insect pests.

At the Kenya agricultural Research Institute (KARI)-Embu the project focuses on screening for resistance to two stem borers i.e Chilo partellus and Busseola fusca. So far, 6 varieties have been bred and released while many more are in the National Performance Trials (NPT). These varieties have been bred for various stresses especially stem borer infestation.

Key words

Screening, stemborers, maize, infestation.

Running title: improvement for biotic and abiotic stresses in maize.

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Introduction.

The mid-altitude ecology has two distinct rainy seasons with the maize programme initially started to improve on grain yield. However, surveys done in 1994 indicate that while yield potential of released varieties remain at 5.00 Tha^{-1}, production on-farm is dismal at about 1.5 Tha^{-1}. The situation reflects worrying yield gaps that need attention. Research into these problems indicate that constraints such as low - levels of soil fertility, moisture limitation, diseases and insect pests are serious impediments to exploiting available genetic potential of germplasm in the region. Developing maize genotypes with tolerance to drought is complex; largely due to polygenic nature of inheritance of the trait, low frequency of tolerance alleles in most germplasm and difficulties involved in field evaluations. For Kenya, the options are to improve non-adapted but drought tolerant populations for local adaptation, improving locally adapted elite germplasm for drought and formation of new breeding germplasm through introgression.

A number of studies have been reported which give information on the resistance levels of some maize genotypes to C. partellus which can be used in management of the pest (Omolo,1983)

The medium maize programme is principally concerned with the improvement of grain yield, biotic factors such as diseases, insect pests, weeds (striga spp) and abiotic stresses which include drought and low Nitrogen.. Insect pests pose the greatest challenge amongst the biotic factors whilst drought is the problem in the drier parts of the country (KARI/CIMMYT database, 1994). At KARI-Embu the project focuses on screening for resistance to the two most devastating species of stem borers namely, Chilo partellus and Busseola fusca.

Materials and Methods

Screening was done using germplasm from the international centre for maize and wheat improvement (CIMMYT) , the Zimbabwe Harare Mid-altitude breeding programme central nursery. The materials which included inbred lines were infested with about 30 first instar larvae from moths of larvae reared on artificial diet (Ochieng et al., 1985) at the fourth leaf stage and later scored for foliar damage where 1= the least damage and 9= the worst. At harvest time the stems were split in the middle longitudinally to estimate the extent of stem tunneling. They were scored on a scale of 1-12 , 1 being the least damaged whilst most damaged splits were given a score of 12.

When the plants had flowered a 50 % score was taken as the tassel date i.e the number of days from germination to the time half of the plants in a row had flowered. Yield was taken as the shelled grain adjusted to 12.5 % moisture content (Vivek et al. (2003). Grain texture was taken as as the degree of dentness before shelling was done, inbredlines showing good reaction to insect infestation (both Chilo partellus and Busseola fusca) were used to constitute hybrids and synthetics for the mid-altitude areas (1,200-1,800 m asl). The materials so generated were mainly double crosses, 3 way crosses which performed as well as the commercial checks-H513 and PHB 3253- these two being the best of the mid-elevation commercial maize varieties. The best of these materials were submitted to Kenya Plant Health Inspectorate Services (KEPHIS) - a regulatory body that deals with testing and release of new varieties in Kenya- for the National Performance Trial (NPT) , 2003. The materials were planted at eight sites which represent the Kenyan mid-altitude ecology. Apart from screening these materials (both inbred lines & the newly developed varieties) for the insect damage parameters, they were also rated for blight (1-5) & rust (1-5). The mid - elevation sites where the materials were tested include- Busia, Kirinyaga Technical Institute (KTI)-(Central Kenya), Embu (Eastern Kenya), Kimaeti (Western Kenya), Kithoka (Eastern

Kenya), Muguga (Central Kenya), Siaya (Western Kenya) and Wambugu (MT. Kenya region).These sites are at an elevation of 1200-1800 metres above sea level (Masl).

Data analysis was done using fieldbook statistical models (Marianne Banziger and Bindiganavile S. Vivek, 2007).

Results &Discussion

Results from Table 1.0 indicate that lines screened for resistance to *Chilo partellus* and *Busseola fusca* had moderate resistance as well as good for foliar diseases such as blight and rust. Compared to the susceptible check which had an 8.2 and a7.2 for *Busseola* damage and *Chilo* , respectively, the new lines rated below 6.0 for the two insect species damage. On a scale of 1-5 the inbred lines rated very well for both blight and rust, two diseases that are an impediment to maize production in the area. Table 2.0 shows grain yield from materials developed from the inbred lines with crosses from other materials adapted to mid-elevation. In Tables 2.0 & 3.0, newly developed maize varieties showed good yield performance ranging form 7.0 to 13.0 Tons per hectare and flowering dates of 70 days. The commercial hybrids which are very popular in the region (H 513 & PHB 3253) gave yields ranging from 5.64 & 6.75, respectively. The flowering dates of the commercial hybrids were not significantly different from the new varies at 69.00 To 69.50 compared to 65.00 to 72.50, with only one variety getting to 74.00 (Table 2.0). This meant that most of the new varieties were not only impressively early but also of very high yielding nature. Even a synthetic(ABCDEFGH, later released as Embu synthetic) bred for resistance to insect infestation was as good as the commercial hybrids grown in the region (Table 3.0). Most of the new materials bred for Mid-altitude ecology were flint to semi-dent which are the preferred grain texture by farmers in the region. The commercial hybrids (H513 & PHB 3253) were mainly of dent grain texture (Table 4.0) . This showed that the commercial hybrids were of inferior grain quality. In Table 5.0, materials tested by KEPHIS indicated superior performance of 9.06 to 22.36 % in terms of grain production above mean yield of commercial checks. After all these research work, varieties which were 10-20% better than commercial checks were released for various stresses in the region.

Acknowledgements

This research study was facilitated by the Regional Nursuries of CIMMYT and the Co-ordinated Ecosystem Breeding (CEB) work funded by the Rockefeller Foundation. The paper was published with the permission of the Director of Kenya Agricultural Research Institute (KARI).

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Table1.0: Mean foliar damage scores on maize artificially infested with both Busseola and Chilo 1st instar larvae (LR,1999)

Pedigree	Mean Busseola score (!-12)	Mean chilo score (!-12)	Blight score (1-5)	Rust Score (!-5)
MIRT C4 Bco F2 bulk	**3.5**	**2.8**	**2.0**	**2.5**
ITSI T Am GI F2 bulk	**4.3**	**5.7**	**2.5**	**2.0**
ITSI T Am AI x B2 F1 bulk	**4.3**	**3.7**	**2.0**	**2.0**
ITSI T Am A2 x B1 FI bulk	**5.2**	**3.3**	**2.0**	**2.0**
ITSI T Bco G2 F2 bulk	**5.0**	**4.5**	**2.5**	**2.5**
ITSI T Bco G3 F2 bulk	**5.2**	**3.0**	**2.0**	**2.0**
ITSI T Bco AI x B1 F1 bulk	**4.7**	**4.8**	**2.0**	**2.5**
ITSI T Bco A1 x B2 F1 bulk	**5.2**	**4.8**	**2.0**	**2.5**
ITSI T Bco A2 x B3 F1 bulk	**6.5**	**3.5**	**2.0**	**2.0**
ITSI T Bco B2 x A2 F1 bulk	**4.2**	**5.3**	**2.0**	**2.5**
ITSI T Bco B3 x A2 F1 bulk	**4.0**	**4.3**	**2.5**	**2.0**
INBRED A (Susceptible Check)	**8.2**	**7.2**	**2.5**	**2.0**
MUTINDA 10 (Resistant Check)	**6.2**	**5.7**	**3.0**	**2.5**
LSD at P= 0.05	**0.48**	**0.35**	**0.88**	**1.01**

Table 2.0: Yield (Tha^{-1}) and other agronomic traits at Embu, LR 2003

PEDIGREE	N	Yield	Tassel (days)
ABCDEFGH	2	7.40*	67.50
CXDXENT1	2	9.10	68.50
CXDXENT2	2	11.55	70.50
CXDXENT3	2	10.12	69.00
CXDXENT5	2	13.09	74.00
EMAP11 (Check)	2	6.99	69.00
EMCO (Check)	2	8.23	66.00
H513 (Check)	2	5.64	69.00
mean	2	8.90	69.36
C.V %	2	26.47	21.00
LSD	2	3.08	3.08

Table 3.0: Yield (Tha^{-1}) combined across two sites (Embu and Kaguru LR 2003

PEDIGREE	N	Yield
ABCDEFGH	4	7.77*
CXDXENT1	4	10.36
CXDXENT2	4	11.77
CXDXENT3	4	10.81
CXDXENT5	4	12.18
EMAP11 (Check)	4	8.12
H513 (Check)	4	9.31
Mean		9.85
C.V %		23.67
LSD		3.28

Table 4.0: Grain Texture from a strip test planted at three sites

Entry	Source	Grain Texture
Emb 206	KARI-Embu	Dent/flint
Emb 207	KARI-Embu	Dent
Emb 208	KARI-Embu	Flint
Emb 209	KARI-Embu	Dent/flint
Emb 210	KARI-Embu	Flint
Emb 211	KARI-Embu	Flint
Emb 212	KARI-Embu	Flint
Emb 213	KARI-Embu	Flint
Emb 214	KARI-Embu	Dent/flint

PHB 3253 (Check)	PIONEER	Dent
H513 (Check)	KSCO	Dent/flint

Table 5.0: Grain Yield (Tha^{-1}) across eight sites in NPT 2003

Entry	Busia	Embu	Kimaeti	KTI	Kithoka	Muguga	Siaya	Wambugu	mean	% al mear
Emb 208	11.5	9.8	8.3	6.0	6.3	2.2	6.3	8.0	7.3	22.3
Emb 209	11.5	10.2	9.4	6.2	4.6	3.5	6.4	5.8	7.2	21.8
Emb 207	10.8	10.1	9.4	6.4	7.0	3.1	4.7	5.0	7.1	19.26
Emb 206	8.8	10.5	7.5	5.5	7.0	2.2	3.9	6.2	6.9	9.06
Emb 204	8.5	6.6	7.0	5.5	4.8	2.5	6.7	6.1	6.0	0.74
Emb 203	8.9	6.4	5.5	4.7	3.3	2.2	4.9	6.0	5.3	
PH 3253 (Check)	6.6	6.6	7.1	5.5	5.8	2.7	5.5	7.1	5.9	
WS 909 (Check)	7.2	5.4	6.7	5.2	5.8	2.1	5.5	5.8	5.5	
H513 (Check)	6.6	6.3	6.3	4.9	4.3	2.2	4.7	7.4	5.3	
Mean	8.6	7.9	7.2	5.4	5.4	2.6	5.3	6.8	6.1	

CV%	**15.9**	**11.1**	**17.3**	**14.8**	**18.7**	**32.8**	**29.3**	**20.7**	**15.6**