Consolidating Experiences from IRMA I and II: Achievements, Lessons and Prospects

IRMA Project End-of-Phase II Conference

Program, Abstracts, Field Visits and Participants

A conference hosted by the Insect Resistant Maize for Africa (IRMA) Project of the Kenya Agricultural Research Institute (KARI) and the International Maize and Wheat Improvement Center (CIMMYT)

Nairobi Safari Club Hotel
Nairobi, Kenya
28-30 Oct 2008

CIMMYT

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KARI

The Kenya Agricultural Research Institute (KARI) (http://www.kari.org/) was established in 1979 with the express mission of increasing sustainable agricultural production by generating appropriate technologies through research, and disseminating these to the farming community. Inherent to this mission is the protection, conservation, and improvement of the basic resources, both natural and human. Such resources are critical for Kenya's agricultural development and expansion of the nation's scientific and technological capacity. KARI has an extensive history of productive collaborators with national and international institutes and universities, as well as with the private sector.

The Syngenta Foundation for Sustainable Agriculture (SFSA) provides major funding for the project. The Foundation is dedicated to fostering sustainable development in poor countries of the South through its support of programs and projects in the areas of sustainable agriculture, health, and social development. It is also an active player in development policy debate through its preparation and dissemination of research analysis. Further information about the Foundation may be found at its web site (http://www.syngentafoundation.com/**).**

CIMMYT® (http://www.cimmyt.org/) is an internationally funded, not-for-profit organization that conducts research and training related to maize and wheat throughout the developing world. Drawing on strong science and effective partnerships, CIMMYT works to create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources. Financial support for CIMMYT's work comes from many sources, including the members of the Consultative Group on International Agricultural Research (CGIAR) (http://www.cgiar.org/), national governments, foundations, development banks, and other public and private agencies.

The Insect Resistant Maize for Africa Project phase II (IRMAII), "Delivering products to Farmers" is the second phase of IRMA Project that was launched as a collaborative effort between CIMMYT and KARI. Its primary goal is to increase maize production and food security for African farmers through the development and deployment of maize that offers resistance to destructive insects, especially stem borers. To achieve this goal, project scientists will identify conventional and novel sources of resistance to stem borers and incorporate them into maize varieties that are both well adapted to Kenya's various agro-ecological zones and well-accepted by its farmers and consumers. Varieties and technologies that are appropriate for other African nations may be extended to them for their use.

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AGROVOC Descriptors	**Africa; Kenya; Maize; *Zea mays*; Biotechnology; Bt maize; stem borers; Food production; Food security; Pests of plants; Plant breeding; Pest resistance; Yield increases; Technology transfer; Innovation adoption**
Additional Keywords	**KARI; CIMMYT**
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Foreword

The Insect Resistant Maize for Africa (IRMA) project focuses on delivering insect resistance in a form familiar to farmers—the maize seed they plant. During the initial IRMA I project (1999-2003), produced source lines of the key Bt genes *cry1Ab* and *cry1Ba,* which are effective against the target pests spotted stem borer (*Chilo partellus*), Coastal stem borer (*Chilo orichalcocillielus*), Pink stem borer (*Sesamia calamistis*), and sugarcane borer (*Eldana saccharina*). These are the starting material needed to transfer the genes to the target germplasm in Kenya. The project established the necessary infrastructure and trained staff in Kenya to allow the safe introduction and handling of Bt maize. Germplasm containing good levels of conventional insect resistance were identified and are ready to be moved toward delivery to farmers. Baseline information required for proper targeting of insect resistant maize, development of appropriate insect resistance management of Bt varieties, and ex-ante impact assessments of products is now available. Finally, communication via various forms of media has been established, and educational materials developed, to enhance the acceptance of Bt varieties by a wide range of stakeholders.

IRMA II project (2004-2008) built on the successes of the IRMA I project, providing Kenyan farmers with their first conventional insect resistant maize varieties by 2006. The project design was based on a business model that ensured the products developed are delivered in a timely manner and addressed the needs of the customer-the Kenyan farmer. The plan employed a two-pronged approach: (1) development and release of conventional insect resistance in adapted Kenyan open pollinated varieties (OPVs) and hybrids, and (2) development and release of Bt-based insect resistant OPVs and hybrids.

To ensure the safe release and stewardship of these products, ten project themes run concurrently:

1. Bt maize event, development of Bt source line, & human health safety assessment
2. Development of conventional and Bt products and compositional analysis
3. Environmental impact assessment
4. Insect resistance management and contingency plans
5. Biosafety and regulatory issues
6. Intellectual Property rights (IPR) / Licensing
7. Seed production
8. Market assessment and analysis
9. Economic impact assessment
10. Communication and Promotion

Each theme was muitidisciplinary and involved a team of entomologists, biotechnologists, breeders, economists, communications experts, IP counsels, extension officers, policymakers, regulatory officials, and most importantly,

Kenyan farmers. The principal output of IRMA II was the delivery of maize germplasm products containing conventional and Bt-based insect resistance to Kenyan farmers.
Although IRMAII's primary emphasis was on delivering products, it also provided a number of "firsts" for Kenya: (1) the first Bt maize seed introduction, (2) the first Bt maize field trials; (3) a draft dossier of human health safety assessment, environmental safety assessment data for the *cry1Ab* and *cry1Ba* gene products, (4) an insect resistance management strategy for small scale farmers, (5) extensive experience for Kenyan scientists, officials, stakeholders, and farmers in the development, delivery, and stewardship of Bt-based insect resistant maize varieties. This was in addition to Kenya, through IRMA I, having established the first Biosafety level 2 Biosafety lab and the first Biosafety level 2 greenhouse in East Africa. A number of milestones were set against which progress was measured. These are in four broad categories: 1) facilities & permits, 2) breeding 3) environmental safety assessments, and socio-economic impacts.

The project was supported by the Syngenta Foundation for Sustainable Agriculture as the principal development partner, while the Rockefeller Foundation supported the variety development and seed activities in KARI and CIMMYT.

Significant progress was made in developing and delivering conventional stem borer resistant maize for Kenya. An unanticipated breakthrough was also made in the development of maize resistant to maize weevil (*Sitophilus zeamais* Motsch) and the larger grain borer (*Protephanus truncatus* Horn). Among the key milestones not met during IRMA II, due to technical, proprietary, and regulatory challenges was the development and delivery of Bt maize in Kenya. The experiences gained in Kenya and sharing of experiences and conventional germplasm with other countries in eastern and southern Africa will be the focus of the future. Meanwhile, it was thought necessary to consolidate experiences from IRMA I and II in terms of achievements, lessons and prospects through this IRMA Project End-of-Phase II Conference, held 28-30 Oct 2008, Nairobi, Kenya.

Conference Announcement

IRMA Project End-of-Phase II Conference
Nairobi, Kenya, 28-30 Oct 2008.

The International Maize and Wheat Improvement Center (CIMMYT) and the Kenyan Agriculture Research Institute (KARI) is pleased to announce the IRMA Project End-of-Phase II Workshop or IRMA Special Stakeholders Meeting with the theme "Consolidating Experiences from IRMA I and II: Achievements, Lessons and Prospects" to be held in Nairobi, Kenya, 28-30 Oct 2008.

Venue: Nairobi Safari Club Hotel**,** Nairobi, Kenya

Theme: Consolidating Experiences from IRMA I and II: Achievements, Lessons and Prospects

Objectives:

1. To report and review activities of IRMA I & II (1999-2008)
2. To report on achievements attained in IRMA I & II.
3. To consolidate experiences gained from developing insect resistant maize for Africa
4. To solicit views, ideas, and strategies from stakeholders for future development of insect resistant maize using conventional and biotechnology methods.

Presentations:

1. Opening speeches by project partner institutions
2. An invited keynote presentations on the future of insect pest control
3. Objectives, approaches and achievements by each of the 10 IRMA Project themes
4. Detailed reports on key specific research done within selected IRMA Themes
5. Invited presentations from non-IRMA institutions on the insect resistance technology, regulation of biosafety, maize value chain industry, and end users.
6. Posters from students supported by IRMA project and other research activities.

Participants:

Relevant KARI and CIMMYT Scientists and administrators, relevant Government of Kenya Institution representatives, farmer representatives, biotech consortium of Kenya, farmer association representatives, donor representatives, potential IRMA III partners, invited scientists, media, and students sponsored by IRMA.

Important dates:

28th August 2008	Confirmation of attendance
28th August 2008	Deadline for final title of paper and abstract
26th Sept 2008	Deadline for submission of full papers
10th Oct 2008	Deadline for submission of draft of posters

Organizing committee:
CIMMYT/KARI

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Program

Program for End-of-Project Conference (Special Stakeholders Meeting) - October 28-29, 2008

Day 1: **Tuesday, October 28, 2008**

08:00 Registration

08.30 ***Session I:*** ***Official Opening***
Chair: ***Mrs. Jane Otadoh, Assistant Director, Ministry of Agriculture, Kenya***
Rapporteurs: ***Dr. Simon T. Gichuki / Dr. Stephen Mugo***

08.30 ***Welcome and Introductions (Chairman)***

Remarks by Director General CIMMYT
Remarks by Executive Director, Syngenta Foundation for Sustainable Agriculture
Remarks by Director KARI
Official Opening – Dr. *Wilson Songa, Agriculture Secretary, MoA, Kenya*

09:15 **Keynote presentations**

The trend and future of biotech crops and insect pest control (**Dr. David Hoisington, DDG ICRISAT**)

09.45 *Tea Break / Viewing of posters/Group photograph*

Session II: ***IRMA Project Themes***
Chair: ***Dr. Chagema Kedera, MD KEPHIS***
Rapporteurs: ***Dr. James Gethi / Mrs. Catherine Taracha***

10:15 CIMMYT focus in light of global food and energy crisis (**Dr. Marianne Bänziger, Director CIMMYT GMP**)
10:30 Focus and status of crop biotech research in KARI (**Dr. Ephraim Mukisira, Director KARI**)
10:45 IRMA-Project: A review of 10 years from main donor perspectives (**Mr. Jost Frei, SFSA)**
11:00 Sharing experiences in support to development of agriculture in developing countries (**Dr. Joseph DeVries, RF**)

11.15 Structured discussions

Session III: ***IRMA Project Themes***
Chair: ***Dr. Joseph Mureithi, DDRT KARI***
Rapporteurs: ***Dr. Yoseph Beyene / Mr. Haron Karaya***

11:30 Development, introduction, and testing of public and private sector Bt maize events in Kenya (**S. Mugo, S.T. Gichuki, D. Hoisington, C. Taracha, A. Pellegrineschi, and M. Murenga**).
11:45 Introduction, development, testing and dissemination of conventional stem borer resistant maize germplasm for mid-altitude ecologies of Kenya (**S. Mugo, J. Gethi, J. Shuma, C. Mutinda, O. Odongo, S. Ajanga and J. Songa).**
12.00 A proposed insect resistance management strategy for Bt maize growing in Kenya **(M. Mulaa, D. Bergvinson, and S. Mugo)**
12:15 Experiences in introduction, testing and development of Bt maize under the biosafety regulatory system in Kenya **(S.T. Gichuki, M. Murenga, and S. Mugo)**

12:30 Structured discussions

13:00 ***Lunch Break/ Viewing of posters***

Session IV: ***IRMA Project Themes***
Chair: ***Mr. Kinyua MMbijjewe, Monsanto***
Rapporteurs: ***Dr. Charles Mutinda / Dr. Jedidah Danson***

14.00 Potential economic impacts of insect resistant maize in Kenyans farming ecologies **(O. Ouma, H. DeGroote, M. Odendo, C. Bett, W. Wanyama and D. Kengo)**

14:15 Where is the niche of Bt maize in Kenya's maize seed and grain markets? **(M. Odendo, H. DeGroote, O. Ouma, C. Bett, W. Wanyama and D. Kengo).**

14:30 Informal training of Kenya's research scientists, regulators and extension staff in biosafety research and development (**S. Mugo, S. T. Gichuki, M. Murenga and D. Hoisington).**

14:45 Developing appropriate biosafety facilities for research & development of Bt maize in Kenya **(S. Mugo, S. T. Gichuki and M. Murenga).**

15.00 Control of stem borers by Bt Maize in a biosafety laboratory, a biosafety greenhouse, and from the first confined field trials in Kenya (**S. Mugo, S.T. Gichuki, M. G. Murenga, C. N. Taracha, J. M. Songa, D. J. Bergvinson, A. Pellegrineschi and D. Hoisington).**

15:15 Structured discussions

15:45 *Tea break/Viewing of posters*

SESSION V: ***Detailed Presentations***
Chair: ***Prof. John Ndiritu, Dean Faculty of Agric. UoN***
Rapporteurs: ***Mr. James Ouma/ Mrs. Ruth Musila***

16:15 Bt *Cry1Ab* gene Event MON810 Bt δ-endotoxin controls of Kenyan maize stem borers in greenhouse containment trials (**S. Mugo, G. Murenga, S.T. Gichuki, K. MMbijjewe, H. Karaya, and A. Chavangi)**

16:30 Plant and other material disposal and post harvest monitoring from Bt maize testing facilities in Kenya **(Murenga M., Mugo S., C. Taracha, J. Mbithi, S.T. Gichuki, and W. Otieno)**

16:45 The Influence of transient feeding on Bt Maize on the interaction between the stem borer *Chilo partellus* Swinhoe (Lepidoptera: Crambidae) and the parasitoid *Xanthopimpla stemmator* Thunberg (Hymenoptera: Ichneumonidae) (**Obonyo, D.N., Lovei, G.L., Songa, J.M., Oyieke, F.O., Nyamasyo, G.H. and Mugo S.N**)

17:00 Testing and release of insect resistant maize varieties in Kenya through the national performance trials (**S. Mugo, R. Tende, J. Gethi, J. Shuma, C. Mutinda, O. Odongo, S. Ajanga, J. Ngeny, and E. Sikinyi**)

17:15 Structured discussions

17.45 End of Day 1

21:00 **Conference Dinner – Nairobi Safari Club** (In honor of Mr. Jost Frei, SFSA)

Day 2: **Wednesday, October 29, 2008**

SESSION VI: ***Presentations of key studies***
Chair: ***Dr. Catherine Mungoma, Zambia***
Rapporteurs: ***Dr. Sammy Ajanga / Ms. Dorkus Chepkesis***

08:00 Performance of stem borer resistant maize germplasm across environments in Kenya (**M. Murenga, S. Mugo, J. Gethi, J. Shuma, C. Mutinda, S. Njoka, O. Odongo, S. Ajanga and V. Kega**)

08:15 Experiences in rearing tropical stem borer species for use in conventional maize breeding for stem borer resistance in Kenya (**Kega, V., Songa J. and Mugo S.**)

08:30	Evaluation of host plant resistance for the control of post-harvest storage pests: maize weevil and larger grain borer **(P. Likhayo, S. Mugo, J. Gethi, J. Shuma, S. Njoka, and S. Ajanga).**
08:45	Screening crop and fodder species and varieties for their suitability for use as refugia (**M. A. Mulaa, D. Bergvinson, M. Gethi, B. Muli, J. Ngeny and S. Mugo**)
09:00	Experiences in effective communication on transgenic technology in Africa (**A. Wangalachi, S. Mugo and S. T. Gichuki**).
09.15	Participatory farmer evaluation of stem borer resistant maize varieties in three maize growing ecologies of Kenya **(O. Ouma, S. Mugo, J. Gethi, J. Shuma, C. Mutinda, S. Njoka, and S. Ajanga, M. Odendo, C. Bett, and H. DeGroote)**
09.30	Economics of insect resistant management strategies for Bt maize production in Kenya (**M. Wanyama, M. Mulaa, H. De Groote, and D. Bergvinson**)
10.45	Attitudes of Maize Processors and Distributors towards Genetically Modified Food in Kenya (**C. Bett and H. DeGroote)**
10:00	Possibilities of segmenting seed market to reach resource poor farmers with royalty free technology (**H. DeGroote, M. Hall, M. Odendo, M. Bänziger, S, Mugo, and O. Nyachae**)
10:15	The status of development of maize resistant to field and storage insect pests in Ethiopia in particular reference to maize stem borer *Busseola fusca* (Fuller) and maize weevil *Sitophilus zeamais* (Motsch) (**G. Demissie and A. Teshome**)
10.30	Structured discussions
10.45	*Tea Break / Viewing of posters*

SESSION VII: Presentations by Invited Institutions
Chair: Prof. George Siboe, Chair NBC
Rapporteurs: Mr. Mwimali Murenga/ Ms. Anne Wangalachi

11:15	The IRMA History (**J. Burgi**)
11.30	Status and provisions of Kenya's biosafety system and Biosafety Bill 2008 (**S. Abdulrazak and H. Macharia**)
11:45	Experiences of the private sector in development and dissemination of biotech crops (**P. Castaing and K. MMbijjewe**)
12:00	The BioAware initiative for biotechnology development in Kenya's agriculture (**W. Songa and S.T. Gichuki**)
12:15	Farmers views on biotech crops (**D. Nyameino - Cereal Growers Association**)
12:30	Structured discussions
01.00	*Lunch Break / Viewing of posters*

SESSION VIII: Presentations by Invited Institutions
Chair: Dr. Godfrey Asea, Head Maize Research, NARO, Uganda
Rapporteurs: Dr. Margaret Mulaa / Mr. Huxley Makonde

02.00	Seed industry views on biotech crops (**O. Nyachae - STAK**)
02.15	Experiences and creating awareness for biotech (**N. Olembo - ABSF**)
02:30	Media and public awareness and technology dissemination in Agriculture (**W. Ojanji)**
02.45	Structured discussions
03.00	*Tea Break / Viewing of posters*

SESSION IX: Discussions on way forward
Chair: Dr. R. Muinga, CD KARI-Mtwapa
Rapporteurs: Mr. Vincent Kega / Mr. Paddy Likhayo

03.30 New initiatives to scaling up conventional breeding in IRMA project in Central and Southern Africa **(Mugo S., De Groote H., Bänziger, M. and Gichuki S.T.)**

03.50 Way Forward

SESSION X: ***Closing Ceremony***
Chair: ***Dr. Macharia Gethi, CD KARI Njoro***
Rapporteurs: ***Dr. Hugo DeGroote & Mr. Charles Bett***

17:00 Remarks by SFSA (Mr. J. Frei)
Remarks by Director CIMMYT GMP (Dr. M. Bänziger)
Official closing speech (Dr. E. Mukisira, Director, KARI)

17:30 End of Day 2

21:00 **Dinner at Carnivore (Courtesy of SFSA)** – (Special presentation New initiative on variety dissemination by STAK – Mr. Obongo Nyachae & STAK members

Day 3: Thursday, October 30, 2008

07:30 ***Session XII:*** ***Field Trip***
Chair: ***Mr. Vincent Kega, Entomologist, KARI-Katumani***
Rapporteurs: ***Ms. Regina Tende / Mr. Jackson Shuma***

05:30 End of Conference

Posters

1. Quantitative analysis of Bt δ-Endotoxins in crosses involving tropical transgenic Bt maize inbred lines (**Murenga M., J. Danson, S. Mugo, and S. M. Githiri**)
2. Control of *Chilo partellus* stem borers by Bt maize δ-endotoxins in generations of tropical Maize (**Murenga M., S. Mugo, S. M. Githiri, J. Danson and F. Olubayo**)
3. Comparative studies on different stem borer populations for resistance development (**Tende R., S. Mugo, J. Nderitu, F. Olubayo, J. Songa, D. Bergvinson**)
4. Phenotypic diversity for morphological traits in Kenyan local coastal maize landraces (**Ndiso J. B., A. M. Kibe, R.S. Pathak, and S. Mugo**)
5. Phenotypic characterization of Kenya local coastal maize landraces (**Ndiso J. B., A. M. Kibe, R.S. Pathak, and S. Mugo**)
6. Effects of *Bacillus thuringiensis* Cry1a(C) δ-endotoxins on nitrogen fixing bacteria in clay soil in Kenya (**Makonde H.M., F.K. Lenga, D. Masiga, S. Mugo, and H.I. Boga**)
7. Agronomic traits of insect resistant lines and yield response of F1 hybrids under artificial stem borer infestation (**Karaya H., S. Mugo and K. Njoroge**)
8. The status of development of maize resistant to field and storage pests in Zambia (**Mungoma, C.**)
9. The status of development of maize resistant to field and storage pests in Uganda (**G. Asea**)
10. Status of insects in maize research in Kenya (**Gethi J., S. Mugo., V Kega., P. Likhayo. and M. Murenga**)
11. Distribution and impact of stem borers in Malawi – A Review (**Tembo Y. and V. Kabambe**)
12. The status of development of maize resistant to field and storage pests in Mozambique (**Fato P.**)
13. The status of development of maize resistant to field and storage pests in Zimbabwe (**Hikwa D.**)
14. The effect of maize stalk borer *Busseola fusca* (Fuller) on maize production in Tanzania (**Kitenge K.N.**)
15. Approaches to control of insect pests of maize in Uganda (**Otim, M., R. Molo, J. Alupo and G. Asea**)

Abstracts

FOCUS AND STATUS OF CROP BIOTECH RESEARCH IN KARI

[1]Mukisira, E. A.* and S. T. Gichuki[2]

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Abstract

For a number of years, KARI has been involved in research and development of various crops using different biotechnological tools. Tissue culture (TC) has been used for multiplication, virus cleaning and embryo rescue of bananas, sweetpotato, cassava, flowers, potato, vanilla and oilpalms. But as tissue culture developed products have been disseminated critical issues of quality and standards have been expressed by farmers. This is particularly as regards to virus diseases. This has led to efforts to develop efficient diagnostic protocols for diseases of vegetativelly propagated crops particularly bananas, cassava and sweetpotato. Molecular markers assisted selection (MAS) has been deployed in recent years to hasten the crop breeding process and shorten the time that superior varieties take to reach small scale farmers. In KARI the current efforts are on characterization and mapping of Maize Streak Virus (MSV) and Grey Leaf Spot (GLS) resistance genes in maize and their incorporation in available hybrids and OPVs. Targeted is also the development of drought tolerant maize and wheat varieties as well as diversity studies to quantify the genetic base for cassava and sweetpotato. For many constraints affecting key food crops in Kenya conventionally available technologies have not been able to provide sustainable solutions. In addition many small-scale, resource-poor farmers have been unable to access available technologies like insecticides and pestcides due to high costs. This is particularly affects the small scale subsistence farmers. Genetically modified crops could offer a possible solution to avail these technologies to small scale farmers. Efforts to develop biotech crops in KARI have been going on since 2000 for maize, cassava, sweetpotato and cotton. Significant progress has been made in these R&D efforts. Adequate background information on consumers' preferences and the technology are critical to the success of these projects. To achieve this progress KARI has involved other key players including farmers, scientists, extension, policy makers, media, consumers, private sector players and development partners. This is in line with agricultural value chain approach in agriculture research that KARI has adopted.

Keywords: Biotechnology, tissue culture, marker assisted selection, GMO

IRMA- PROJECT: A REVIEW OF 10 YEARS EXPERIENCE AS SEEN FROM MAIN DONOR PERSPECTIVE

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Abstract

During the past 10 years SFSA has supported the IRMA project as a public-private partnership project with over US $ 9.2 million. At the end of the second phase of the project it is an adequate moment to take stock of the achievements and challenges, to review and comment on the experiences made and obstacles encountered. SFSA sheds slight into different aspects as biology, surveys done, looks at the institutional and enabling environments, reviews project management structures and the human resources side as well as the field of information and communication. This review is done comparing guiding principles established at the start of the project. It also gives some recommendations for further possible phases to be carried out in the future in East and Southern Africa.

Keywords: IRMA Project, public-private partnerships

DEVELOPMENT, INTRODUCTION, AND TESTING OF PUBLIC AND PRIVATE SECTOR BT MAIZE EVENTS IN KENYA

[1]Mugo, S.*, S.T. Gichuki[2], D. Hoisington[3], C. Taracha[2], A. Pellegrineschi[4], and M. Murenga[2]

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Abstract

CIMMYT recognized the potential of biotechnology to develop robust germplasm for developing countries. However, to develop and deploy crops developed through biotechnology technical, regulatory, proprietary, and stewardship issues have to be addressed. Bt maize technology for stem borer control was the first technology to be adapted by CIMMYT several years before the first Bt maize was commercialized in the USA, due to the felt need from developing countries. Insect pests exert pressure; there are no appropriate and cost effective alternatives, while Bt technology was available. Bt maize technology controls lepidopteran stem borers without affecting humans, livestock and the environment, and has seen rapid rise in adoption and use globally. Suitable *Bt* genes were acquired from the private and public sector or synthesized and backcrossed into elite maize germplasm at CIMMYT-Mexico. The first generation events were tested against stem borers in Mexico. The second generation or "clean" Bt gene events, containing only the gene of interest and no antibiotic or herbicide resistance markers, were developed later to be shared with willing and capable developing country partners like Kenya. Bt maize events were introduced first in 2001 as cut leaves for testing against major Kenyan stem borers. Seeds were introduced later in 2004 to test in the biosafety level 2 greenhouse complex and in confined field trials in the open quarantine site. In all these, introductions were made in conformity with Kenya biosafety system as well as its plant quarantine procedures. Details of the development of the events, procedures of introduction and testing are covered in this paper and form useful source of information for those countries interested in similar work.

Keywords: Biosafety, Bt maize technology, Kenya, stem borers

INTRODUCTION, DEVELOPMENT, TESTING AND DISSEMINATION OF CONVENTIONAL STEM BORER RESISTANT MAIZE GERMPLASM FOR MID-ALTITUDE ECOLOGIES OF KENYA

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Abstract

Stem borers destroy an estimated 13.5% of farmers' annual harvest of maize. Host plant resistance, developed through breeding, is a preferred method to disseminate improved maize varieties due to its environmental safety, relatively low cost, safety, and ease of use by farmers. However, there are few stem borer resistant maize cultivars due to the challenges of developing and testing them. Development of conventional resistance in IRMA was initiated out of the realization that biotechnology approach might take longer due to regulatory challenges, and therefore not making it possible for farmers to access seeds in good time. . Evaluation of commercially available germplasm showed no resistance to stem borers and, therefore, stem borer resistant lines and synthetics from the CIMMYT multiple borer resistant population and other sources were introduced. A pedigree method of improvement has been used to develop new insect resistant inbred lines and adapted to the humid lowlands, mid-altitude dry, medium maturity and mid-late maturity maize growing ecologies of Kenya. Selection included a central nursery at Kiboko which also served as the main site for artificial infestation with Chilo partellus, with Embu serving the same purpose for Busseola fusca. Progenies developed here would be tested for local adaptation and the other locations to sample disease resistance at Embu and Kakamega, drought stress at Kiboko and Katumani, and low soil N at Kiboko and Kakamega. Resistant varieties with reduced leaf damage, stalk tunnels, increased leaf toughness, and higher grain yields which were observed under artificial infestation and protected conditions, as well as by farmer evaluations were identified. Superior varieties were taken through National Performance Testing for release. To date, nearly ten OPVs and hybrids have been released in Kenya, and we believe that the same approach could lead to the development of stem borer resistant maize in other countries. Details of introduction and development as well as testing and release are included in this paper.

Keywords: Conventional breeding, Maize, Kenya, stem borers

A PROPOSED INSECT RESISTANCE MANAGEMENT STRATEGY FOR BT MAIZE IN KENYA

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Abstract

A major concern of utilizing Bt maize technology is the likelihood of development of resistance to the Bt toxins by the target stem borer species. However, the rate of evolution of this resistance can be slowed or stopped through the use of appropriate insect resistance management (IRM) strategies. To reduce the possibility of resistance development to Bt maize, Kenya is developing IRM strategies to delay development of resistance, thereby extending the efficacy of the Bt maize technology. To be accepted by farmers, insect resistance management (IRM) strategies must conform to existing cropping systems, and the components must be economically viable, and socially acceptable to farmers. Based on research already conducted in Kenya, the most practical strategy for management of resistance in Kenya consists of 5 components: 1) Bt Maize variety with multiple forms of control and high expression levels that will kill all individual target pests, 2) Refuge that will maintain susceptible insect pests, 3) Monitoring and remedial action plans, 4) Sound Integrated Pest Management (IPM) practices and alternative control measures and 5) Education and training. Suitable crop species have been identified as suitable refugia for different farming systems and agro-ecological zones, including sorghum (*Sorghum bicolor* L), maize (*Zea mays* L.) and Napier (*Pennisetum Spp.*). The suitable refugia species can be used as structured refugia in areas where the natural refugia is less than 20%. Farmers were sensitized through stakeholder meetings and workshops. Their inputs were incorporated in t the development of the Bt maize refugia technologies to complement the researchers' efforts and to increase acceptability of the concept. This Paper discusses results from field and laboratory trials. Reports from farmer workshops and researchers also support the proposed IRM strategy for Kenya. Recommendations and the way forward for the most suitable IRM strategies are discussed.

Keywords: Refugia, monitoring, farming systems, IRM strategy, education, IPM

EXPERIENCES IN INTRODUCTION, TESTING AND DEVELOPMENT OF BT MAIZE UNDER THE BIOSAFETY REGULATORY SYSTEM IN KENYA

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Abstract

Sub-Saharan Africa remains the biggest recipient of food aid where 25% of the world's undernourished people are found. In Kenya, more than 2.5 million people are perpetually in need of food aid, largely due to a high population and low agricultural productivity. Developments of GM crops have the potential to increase the productivity and profitability of food production in diverse ways as has been demonstrated in more than 23 counties world wide. Kenya has initiated R&D in five GM crops (sweetpotato, cassava, cotton, sorghum and maize). To be able to carry out this R&D Kenya has developed a biosafety framework along the recommendations of the Cartagena Protocol. The country already has a biotechnology policy, a biotechnology awareness strategy and a biosafety bill is currently being enacted. Regulations for carrying out GM crops research are implemented by the Kenya Plant Health Inspectorate Services (KEPHIS) on behalf of the National Biosafety Committee (NBC) of the National Council of Science and Technology (NCST). The KARI-CIMMYT Insect Resistant Maize for Africa (IRMA) project operated under this regulatory system to introduce and test insect resistant Bt maize in the lab, greenhouse and in a confined field. In the process the project experienced various regulatory challenges which were successfully resolved. Key challenges included development and implementation of an internal biosafety mechanism as well as ensuring compliance to the national and international biosafety requirements. In addition the project learned major lessons for successful implementation of Biosafety experiments in the region. The IRMA project also significantly contributed to training of Kenyan scientists, technicians and regulators on conducting and handling GM trials. The project trials and facilities provided valuable training models to both national and international forums involved in developing biosafety frameworks for countries in the region. The project, therefore, provided major inputs in shaping and moving forward the biotechnology framework in Kenya. This paper reports on the challenges experienced by IRMA and lessons learnt in R&D of GM crops in Africa.

Keywords**:** Biosafety, regulatory, Kenya and GM crops

POTENTIAL ECONOMIC IMPACTS OF INSECT RESISTANT MAIZE IN KENYANS FARMING ECOLOGIES

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Abstract

The Insect Resistant Maize for Africa (IRMA) project is currently developing Bt maize for Kenya. So far, Bt genes with resistance to *Chilo partellus*, *Chilo orichalcociliellus*, *Eldana Sacharina*, and *Sesamia calamistis*, four of the five major stemborers were succesfully incorporated into elite CIMMYT maize inbred line (CML216) and tested in insect bioassays in Kenya. Participatory Rural Appraisals showed that stem borers are indeed major pest problems for farmers. Four seasons of on-farm crop loss assessment showed an average crop loss of 13.5%, or 0.4 million tons, valued at US$ 80 million. If the project manages to find a Bt gene that is effective to the fifth stemborer, *Busseola fusca*, adoption rates are likely to be high, and therefore the returns. Under standard assumptions, the economic surplus of the project is calculated at $ 208 million over 25 years (66% of which is consumer surplus) as compared to a cost of $5.7 million. Geographically, the project should focus on the high production moist-transitional zone. However, if such gene cannot be found, Bt maize technology would only be effective in the low potential areas, and adoption rates would be fairly low, although benefits would still exceed costs.

Keywords: Maize, Africa, genetically modified crops, Bt crops

WHERE IS THE NICHE FOR BT MAIZE IN KENYA'S MAIZE SEED AND GRAIN MARKETS?

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Abstract
Input and output markets play key roles in adoption of agricultural technologies. If farmers do not have efficient markets, they resist investing in new and more productive technologies and this constrains agricultural commercialization. Since Independence, the Government of Kenya, through its agencies, maintained extensive monopoly control over maize seed and grain marketing. Upon market liberalization in the 1990s, many new players, especially stockists and other traders entered maize seed and grain markets, respectively. However, little is known on types and amounts of the varieties sold by the stockists and maize varieties desired by farmers and other consumers. Yet such knowledge is essential for informed policy-making. Participatory Rural Appraisals (PRAs) were conducted to analyze attributes farmers consider in choosing maize varieties and to identify constraints farmers face in maize farming with a view to assessing the economic feasibility and likely niche of Bt in the six major maize growing agro-ecological zones of Kenya. Concurrently, a survey of a random sample of 61 stockists was conducted to identify major maize seed varieties sold by stockists and determine different quantities of maize seed sold by stockists in the zones. Results indicate that the key criteria for maize variety selection were high yields, early maturity and disease/pest resistance. The highland tropics agro-ecological zone had the highest sales of maize seed and H614 was the most popular variety, whilst the farmers' own seed of local landraces was the most popular in the moist-mid altitude zone. The 2-kg maize seed package was the most popular across all agro-ecological zones. Packaging and stocking of maize seed in accordance with farmers' package size preferences in different regions is likely to increase its demand. Estimation of the potential economic impact of Bt maize found that more than half of the total maize losses in Kenya occurred in the moist transitional zone, followed by the highlands. These are zones with the highest adoption rate and therefore deployment of Bt maize is likely to bring high returns in the two zones. Finally, integration of Bt maize into the Kenyan market requires deployment of Bt varieties with key attributes farmers' desire, public education on aspects of Bt maize and, formulation of enabling policy and institutional framework.

Keywords: Bt maize, markets, stockists, maize seed, varieties

TRAINING OF KENYA'S RESEARCH SCIENTISTS, REGULATORS, AND EXTENSION STAFF IN BIOTECHNOLOGY AND BIOSAFETY RESEARCH AND DEVELOPMENT

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Abstract

Biotechnology and biosafety are relatively new sciences that demand skills in its development, implementation and stewardship. As the Insect Resistant Maize for Africa (IRMA) project aimed at developing and deploying insect resistant maize developed using Bt technology, training of Kenyans involved in the development, use, and regulation of transgenic technology was necessary. The immediate need was met through informal approaches that involved (i) short term visits to locations within and outside Kenya where the technology was being developed, tested or used, (ii) short term courses of 1-2 days, and (iii) short term visiting scientist model of maximum of six months. Informal learning was found to be relevant in all facets of biotechnology and its applications. Formal MSc and PhD degree related trainings were also included. This resulted in a large numbers of scientists from Kenya Agricultural Research Institute (KARI) and other institutions, plant inspectors from Kenya Plant Health Inspectorate Service (KEPHIS), extension staff from the Ministry of Agriculture, Journalists from various media houses, farmers and other stakeholders exposed to the technology development regulation and use. We present detailed description of listed training courses issues related to the courses as well as assessments of the outcomes and impacts of these trainings.

Keywords: Biotechnology, biosafety, training

DEVELOPING APPROPRIATE BIOSAFETY FACILITIES FOR RESEARCH AND DEVELOPMENT OF BT MAIZE IN KENYA

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Abstract

Biotechnology and biosafety are relatively new sciences that require specific facilities for its development, implementation and stewardship. Biosafety has also raised passionate debates due to concerns on health, food safety, ethics, biodiversity and the environment.Kenya has regulatory requirements that dictate the development of biosafety facilities for development and testing of genetically modified (GM) crops. As the Insect Resistant Maize for Africa (IRMA) Project aimed at developing and deploying insect resistant maize developed using Bt technology, a biosafety level 2 laboratory (BL2 Lab), a biosafety level 2 greenhouse complex (BL2 BGHC), and an open quarantine site (OQS) were developed following specifications used in Kenya and internationally. Biosafety regulators in Kenya advised on their designs, supervised their construction, inspected and approved them for research on transgenic crops, monitors their management and the research carried out in them. The forms and functions of each facility are discussed here. The BL2 Lab is located at KARI Biotechnology Center in Nairobi and designed to carryout lab based tests involving insect bioassays. It's, therefore, designed with no vents to contain insect pests, insect killers, seamless surfaces, in addition to double door features of a BL2 facility. All insect bioassays to test Bt maize events against Kenyan stem borers as well as non-targets studies have been carried out here. The BL2 BGHC is at the same location as the BL2 Lab and designed to grow transgenic maize and other crops. It's designed to contain pollen and has a store for transgenic seeds. The BL2 BGHC cost USD175000 and was designed in a modular version that allows expansion without loss of biosafety features. Testing of public and private Bt maize events, studies on non-targets in the plant and in the soil as well as resistance management studies have been carried out here. It's the main store for transgenic seeds in KARI. The OQS site is located at Kiboko, 156 Km south –east of Nairobi along the Nairobi-Mombasa highway and designed to test transgenic maize under field conditions. The one hectare irrigated site is isolated at least 800m from other maize fields, has a secure fence and full time security. Measures are also taken to prevent escape of pollen and seeds from the site through cleaning, limited access, controlled pollination and proper disposal system. Testing of public Bt events have bee done here as are extensive studies on non-target organisms. Management, operations and maintenance of these facilities require trained personnel and are subject to supervision by regulators. These facilities have, however, enabled testing of Bt technology, provided models for others in Africa, and become focal points for training of research scientists, regulators, agricultural extension staff and other stakeholders for future development of biotechnology and biosafety in Kenya.

Keywords: Biotechnology, biosafety, transgenic maize, facilities

BT *CRY1AB* GENE EVENT MON810 BT δ-ENDOTOXIN CONTROLS OF KENYAN MAIZE STEM BORERS IN GREENHOUSE CONTAINMENT TRIALS

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Abstract

The rising food prices being a reflection of food scarcity could hit Kenya and other net food importer. A solution could be to increase production through adoption of technologies that increase productivity and minimize losses. Among these are stem borer resistant maize that could reduce annual grain losses by more than 10%. Previous testing of several public Bt maize events in Kenya did not show control of the African stem borer (*Busseola fusca* Fuller), an important stem borer species, without which stewardship would be compromised by the possibility of rapid development of resistance to Bt delta-endotoxins. This study was conducted to test Bt maize event MON810 as an option to control of all major stem borer species in Kenya and to compare its efficacy with public Bt maize events. Two Bt maize hybrids DKC8073YG and DKC8053YG both containing Bt event MON 810, which carries *Cry1Ab* gene were used in greenhouse containment trials. The hybrids together with controls were replicated 10 times and grown to the V6 and the V8 stages of growth. Infestations on whole plants were made at the two stages of growth with the spotted stem borer (*Chilo partellus* Swinhoe) and *B. fusca*. At each stage leaf samples were taken and leaf bioassays made with the two stem borer species namely; *Sesamia calamistis* Hampson and *Eldana saccharina* Walker. Bt maize Event MON810 hybrids showed resistance to all four stem borer species with very low leaf damage scores and very few surviving larvae recovered in the whole plant infestations and leaf bioassays. The Bt maize Event 223 showed some resistance to *C. partellus*, *S. calamistis*, and *E. saccharina* more than for the non-Bt hybrid. As expected, the public Bt maize Event 223 did not control *B. fusca*. This study demonstrated the efficacy of MON810 against the four major stem borer species in Kenya, both in the whole plant infestation and in the leaf bioassays. Deploying Bt maize Event MON810 may, therefore, not pose risks of development of insect resistance in its deployment and use and would, therefore, have plausible stewardship. However, the efficacy of Bt maize Event MON810 needs to be evaluated under field environments, where the plants and the pests can be subjected to natural conditions during the plant growth. It's also important to determine the effects of the resistance on the grain and stover productivity of the maize hybrids carrying Event MON810. Bt maize Event MON810 should, therefore, be tested in confined field trial at the open quarantine field site at KARI-Kiboko.

Keywords: Bioassays, Bt events, stem borer species, whole plant infestation

PLANT AND OTHER MATERIAL DISPOSAL AND POSTHARVEST MONITORING FROM Bt MAIZE TESTING FACILITIES IN KENYA

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Abstract

Biotechnology applications and its wide range of tools pose new challenges to governments to develop biosafety frameworkfor the safe and responsible use of the genetically modified organisms and their products. Despite the concerns, biotechnology specifically genetic engineering continue to be applied in improvement of crop quality and agronomic performance. Important traits namely: insect resistance, herbicide resistance, drought and salt tolerance, improved colors in fiber and flower crops, resistance to water logging, high nutritional value such as high vitamin A rice, and longer shelf lives have been incorporated into many plant species through transformation. KARI in partnership with CIMMYT IRMA project developed biosafety level II laboratory (BL2 Lab), biosafety level II greenhouse complex (BL2 GHC) facilities both in Nairobiand an open quarantine site (OQS) for confined field trials (CFTs) at Kiboko to test Bt maize. The BL2 GHC and the OQS users generate waste from transgenic plant material and their disposal should be done safely and responsibly. Plant and insect tissues from BL2 Lab are disposed by first tautoclaving, burning in an incinerator followed by burying the ashes in a pit. The bulky waste such as soil, and whole maize plants from the BL2 GHC is sterilized with a soil sterilizer, burned, and ashes buried. In the OQS, even more bulky wastes are generated over time. Disposal is by drying, burning with charcoal and liquid fuels and burying the ashes in trenches within the OQS. Post-harvest monitoring of the plots grown with Bt maize at the OQS is done following termination of the experiments. The period and regularity of monitoring is determined by the national biosafety committee. One year monitoring data for the first round of trials at the OQS indicate that the period for monitoring could be reduced drastically. The experience f of disposing Bt maize waste from research activities in the BL2 Lab, BL2 GHC and OQS and, how scientists, regulators and other stakeholders interact to ensure safe disposals and post harvest monitoring are presented in this paper.

Keywords: Waste, disposal, Bt maize, biosafety

THE INFLUENCE OF TRANSIENT FEEDING ON BT MAIZE ON THE INTERACTION BETWEEN THE STEM BORER *CHILO PARTELLUS* AND THE PARASITOID *XANTHOPIMPLA STEMMATOR*

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Abstract

The lepidopteran stem borer, *Chilo partellus* Swinhoe (Lepidoptera: Crambidae), is a major constraint to maize production in Africa. Transgenic (Bt) maize is under extensive research in Africa for stem borer control. With the possibility of the introduction of Bt maize into Kenya, it would be necessary to investigate the effects of Bt maize fed *C. partellus* hosts on important stem borer natural enemies. This study investigated the acceptance and suitability of Bt-exposed *C. partellus* for the development of *Xanthopimpla stemmator* Thunberg (Hymenoptera: Ichneumonidae) under laboratory conditions. Fourth instar *C. partellus* larvae were fed on Bt maize for 24h and upon pupation, subjected to parasitism by *X. stemmator*. Transient feeding of fourth instar *C. partellus* larvae on Bt maize caused a reduction in mean pupal mass of both female and male *C. partellus*, though the decrease in male pupal mass was not significant. Transient feeding on Bt maize had no significant effect on the number of probe wounds inflicted by the parasitoids on either male or female *C. partellus* pupae. Exposure of *X. stemmator* to hosts that had been subjected to transient feeding on Bt maize had no significant effect on host acceptance and successful attack. The proportions of dissected pupae that contained immature parasitoids or moths were unaffected by transient feeding on Bt maize. There was no significant difference in mean parasitoid development times between parasitoids from hosts fed exclusively on Bt maize vs. those subjected to transient feeding on Bt maize. However, significantly fewer parasitoid females emerged from hosts exposed to Bt than non-Bt maize. The longevities of the emerged parasitoid adults were unaffected. Transient feeding on Bt maize had no significant effects on hind tibia lengths and on FA values of the antennae, hind tibia or wing lengths. The adverse affects of Bt maize on the proportion of parasitoid females could compromise biocontrol potential by this parasitoid and it would be necessary to determine the performance of this parasitoid on possible alternate hosts.

Keywords: Parasitoid, *Xanthopimpla stemmator*, Bt maize, stemborer, *Chilo parteluus*, biocontrol

TESTING AND RELEASE OF INSECT RESISTANT MAIZE VARIETIES IN KENYA THROUGH THE NATIONAL PERFORMANCE TRIALS

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Abstract

Stem borers are a major constraint in maize production in Kenya, contributing to annual losses of 13.5%. Stem borer resistant (SBR) varieties can contribute to increased and stabilized production of maize in Kenya. To be commercialized, new crop varieties have to be tested and released through National performance trials (NPT) to ascertain their performance and value for cultivation as well as be approved as distinct from other varieties, be uniform in character and be stable in its reproduction and performance. A total of nine elite stem borer resistant open pollinated varieties (OPVs) and 13 elite stem borer resistant hybrids were tested in various NPT kits in Kenya (Early, medium, and mid-late maturities) during the 2004-2008 period under natural infestation . Testing was also done in special kits with artificial infestation. Through this process, a total of nine insect resistant varieties (3 OPVs and 6 hybrids) were released by the NPT committee for their outstanding performance for resistance to stem borers and yield as compared to the controls. These included KARI-Katumani OPVs CKIR04002 and CKIR04003 and hybrids KAT2006-1, KAT2006-2, KAT2006-3, KARI-Kakamega OPV KM 0403 and hybrids KM 0404 and KM 0406 and Embu hybrid EMB-215. Production of breeder seed of OPVs CKIR04002 and CKIR04003 and seed increase of parentals of released hybrids, is on-going to ensure seed are available to the farmers. A further four new hybrids are being tested in NPT 2008 for possible registration and development of descriptors of the parents of these new hybrids.

Keywords: NPT, Varieties, insect resistance

PERFORMANCE OF STEM BORER RESISTANT MAIZE GERMPLASM ACROSS ENVIRONMENTS IN KENYA

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Abstract
Maize is the principal staple food for the rural and urban resource constrained in the east and central Africa. It constitutes over 50% caloric intake from grain cereals. Maize yields in East Africa average 1.5 t/ha while the average farmer in most parts of Kenya gets about 1.1-1.3 t/ha. The low yields could be attributed to both abiotic (mainly drought) and biotic (diseases, insect pests and weeds) stresses. The major insect pests include lepidopteran stem borers, the larger grain borer *Prostephanus truncatus* Horn (Coleoptera: Bostrichidae) and maize weevils *Sitophilus zeamais* Motchulsky (Coleoptera: Curculionidae) with stem borers being the most important. Various commercial varieties and maize genotypes including three-way cross (TWC) hybrids at different breeding stages were evaluated for resistance to *Chilo partellus* and *Busseola fusca* at various maize ecologies in Kenya namely; Mtwapa, Kiboko, and Embu. The lines were from the multiple borer resistant maize populations and CMLs with MSV resistance. The experiments were laid out as 8 x 5 alpha-lattice design with 3 replications. The parameters considered for evaluation were grain yield, stem borer damage, cumulative tunneling, number of ears and numbers of rotten ears, etc. In almost all test sites, most of the commercial varieties were found to be susceptible to *Chilo partellus* and *Busseola fusca*, unlike the new TWC hybrids. The yield and agronomic traits of the TWC were comparable to commercial varieties. The promising genotypes should be promoted to further testing and be nominated into the national performance trials for farmers to access them soon.

Keywords: Genotypes, *Chilo partellus, Busseola fusca*

EXPERIENCES IN REARING TROPICAL STEM BORER SPECIES FOR USE IN CONVENTIONAL MAIZE BREEDING FOR STEM BORER RESISTANCE IN KENYA

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Abstract

Artificial infestation with stem borer larvae is critical in selection for resistance in maize. An insectary was supported to provide the insects for infestation at Kiboko and Embu where breeding maize nurseries for resistance to stem borer are grown, at five locations where testing for resistance under field conditions is conducted (KARI center Mtwapa, Kiboko, Katumani, Embu and Kakamega) and in Biosafety facilities (Biosafety level 2 lab, biosafety level 2 greenhouse complex and in the open quarantine site. Since starting in 2000, 1,723,020 black head eggs, 80120 neonates, and 1008 pupae have been supplied for use in the development of Bt maize germplasm. To determine the optimum development and delivery of stem borers, a study was done to identify the factors that determine the quality of mass reared stem borers. Some of these factors can be intrinsic or extrinsic to the colony. The intrinsic factors were studied in two seasons of 2007 short rains and 2008 long rains at KARI-Katumani insectary. These were from founder colonies of *Busseola fusca*, *Chilo partellus* and *Sesamia calamistis*. Life history parameters indicated that *C. partellus* took on average 44.2 days from neonates to egg laying mothswhen reared under artificial diet at 28 degrees centigrade and 77 % relative humiditywhile *S. calamistis* reared under the same conditions took 57 days and *B. fusca* took 60 days. The average numbers of eggs laid were 315.4 for *B. fusca*, 504.6 *S. calamistis* and 278.6 *C. partellus.* This was within limits to similar work done by other researchers. These findings have implications in timely supply of stem borers to the scientists carrying out field infestations. The time profiles indicate that the supply orders for *B. fusca* must be placed at least 68-70 days, *S. calamistis* 55 days and *C. partellus* 45 days before they can be collected for use. Allowances must also be made for *B. fusca* due to problems of diapause in larvae that might require feeding them naturally on maize or sorghum stems. Thus orders depending on numbers required must be submitted at least 90 days before the insects can be collected. Pupae taken were *B. fusca* (0.277g), *C. partellus* (0.081g), and *S. calamistis* (0.151g). This indicated that the quality of artificial diet and emerging adults was within what was expected. Extrinsic factors like microbial contamination of the insectary must be avoided. Field collections must also de devoid of parasitoids or infections. There is thus need to have well trained and motivated personnel. Agar is the most expensive item on the artificial diet composition. The price rose by 120% between 2001 and 2008, hence, there is need to screen for cheaper substitutes without compromising the quality of the diet. The cost of rearing one pupae has been found to be US$ 0.80 for *B. fusca* and US$ 0.32 for *C. partellus* and *S. calamistis* and this has important implications in costing. Feed back from the end users was also an important aspect of quality control.

Keywords: Artificial infestation, insect resistant, stem borer rearing, quality control, *Busseola fusca, Chilo partellus, Sesamia calamistis*

EVALUATION OF HOST PLANT RESISTANCE FOR THE CONTROL OF POSTHARVEST STORAGE PESTS: MAIZE WEEVIL AND LARGER GRAIN BORER

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Abstract

The maize weevil *Sitophilus zeamais* (Motsch.) and the larger grain borer *Prostephanus truncatus* (Horn) are major insect pests that cause significant losses to stored maize in the tropics. Grain harvests from improved maize varieties need tto be preserved. The resistance of inbred lines, open-pollinated varieties (OPVs) and hybrids to *S. zeamais* and *P. truncatus* was evaluated under laboratory conditions. Flour generation and weight loss by the feeding behavior of the insects of 50 g of grains were measured after a three months of incubation with 25 unsexed adult maize weevil of LGBs. Parent maize weevils were removed after 10-day oviposition period. Dust and weight loss susceptibility indices were computed for each maize genotype. Inbred lines had better resistance to *S. zeamais* compared to the OPVs and hybrid cultivars. A large proportion of the tested genotypes were susceptible to *P. truncatus*. The maize that showed resistance to *S. zeamais* was not necessarily resistant to *P. truncatus*, suggesting a difference in resistance mechanism against the two species. However, moderate resistance had been achieved in developing three-way-cross hybrids for the control of *P. truncatus*, a pest that causes far much more damage to stored maize than *S. zeamais*. The identified resistant hybrids will be useful to resource poor smallholder farmers in Africa.

Keywords: *Sitophilus zeamais*, *Prostephanus truncatus*, maize, post harvest pests

DEVELOPMENT OF THREE-WAY-CROSS HYBRID MAIZE FOR RESISTANCE TO *PROSTEPHANUS TRUNCATUS* AND *SITOPHILUS ZEAMAIS*

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Abstract

A gene bank accession code named Cuba/Guad from CIMMYT – Mexico, was found to have moderate resistance to *Prostephanus truncatus* Horn. A breeding programme was initiated at KARI Kibobo to use this source for resistance. Crosses were made with inbred lines adapted to the Eastern, Central and Southern region of Africa. The three-way -cross maize Hybrids formed from this programme were planted at KARI-Embu, Kakamega, Katumani, Kiboko and Mtwapa for agronomic performance over two seasons and then screened for resistance to two major stored products insect pests. Eight-four three-way-cross hybrids and six commercial checks were evaluated for resistance to *P. truncatus* and *Sitophilus zeamais* Motschulsky infestation, using shelled grain maize method. The method was preferred because it does not require intensive labour and is efficient. Two parameters, dust (flour) and grain weight loss percentages were measured and used to compute resistance indices. Results suggested that both dust and weight loss susceptibility indices (DSI and WSI, respectively) gave similar assessment of the hybrids resistance to the two insect pests, with commercial checks demonstrating generally lack of resistance. Thirteen of the developed hybrids showed high levels of resistance to the *S. zeamais* while only two exhibited moderate resistance to *P. truncatus* infestation. From this study, IRMA index values not greater than 5.0 WSI and 0.7 DSI for *S. zeamais* and 13.0 WSI and 10.0 DSI for *P. truncatus* are proposed as cut off indices and that the national release committees should require postharvest insect pests resistance index for every variety nominated.

Keywords: *Sitophilus zeamais*, *Prostephanus truncatus*, post harvest pests

SCREENING CROP VARIETIES AND FODDER SPECIES AND VARIETIES FOR THEIR SUITABILITY FOR USE AS REFUGIA

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Abstract

Insects are capable of developing resistance to all insecticidal agents including conventional insecticides, microbial pesticides, host-plant resistance traits and biological control agents. The primary strategy for delaying insect resistance is to provide the borers with a refuge of host plants that do not produce the Bt toxins. This strategy provides susceptible insects for mating with resistant ones that emerges from Bt maize fields, thereby maintaining resistance alleles in a heterozygous state. To select suitable crop species to serve as refugia, recommended forages, sorghum and maize varieties were evaluated for stem borer preference and survivorship in the laboratory and field in four locations in Kenya, during 2001-2006. Vegetation surveys were conducted in 15 districts of Kenya to quantify the area covered by natural refugia. Workshops were also held with farmers and extensionists to rank refugia species. The paper also discusses the farmers' criteria for ranking refugia and their preferences by gender in different locations of Kenya. Results from field and laboratory trials indicate highest egg production, survivorship and more exit holes in all sorghum, maize varieties and some forages. The Vegetation surveys indicated adequate natural refugia in most districts. Sorghum, non-Bt Maize, and improved Napier varieties (Kakamega 1 and 2) should be promoted as refugia in Kenya.

Keywords: Refugia, Vegetation surveys, farmers' criteria, Gender, laboratory Bioassays

EXPERIENCES IN EFFECTIVE COMMUNICATION ON TRANSGENIC TECHNOLOGY IN AFRICA: THE CASE OF THE IRMA PROJECT

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Abstract

The Insect Resistant Maize for Africa (IRMA) Project in its first and second phases aimed to produce stem borer resistant and locally adapted maize varieties using both conventional and biotechnology mediated methods, especially the Bt technology. The Bt technology involves use of a gene from the soil bacterium *Bacillus thuringiensis* (Bt) to create a transgenic maize variety. Transgenic technologies have been a controversial and emotive topic in recent years. It is necessary that for communication on these technologies to be effective, it should be accurate and balanced, seeking to dispel the public's misgivings regarding the transgenic technology. The IRMA Project has since its public launch in March 2000, strove to always keep the public informed on its progress. The products include both print and electronics as well as fora such as the annual stakeholders' meetings. Complementary to these have been seminars and training on communication. This paper explores the IRMA Project's public awareness and communication products, target audiences and their judged or perceived effectiveness.

Keywords**:** Transgenic technology, Bt maize technology, communication, public awareness, IRMA project

PARTICIPATORY FARMER EVALUATION OF STEM BORER RESISTANT MAIZE VARIETIES IN THREE MAIZE GROWING ECOLOGIES OF KENYA

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Abstract

To be accepted by farmers, new crop varieties must meet their criteria of preferred traits. The Insect Resistant Maize for Africa (IRMA) Project that aims at developing and deploying insect resistant maize varieties to reduce grain losses due to insect pests, developed new stem borer resistant maize open pollinated varieties (OPVs) and hybrids. As part of incorporating farmer's perceptions and improving the adoption of these varieties, farmer participatory evaluations of these varieties were carried out to analyze farmer's preferences of stem borer resistant maize germplasm developed through conventional breeding. Nine stem borer resistant maize varieties were evaluated alongside six commercial checks in the medium maturity ecology in the KARI Embu mandate region, and in the mid-late moist transitional zones in the KARI-Kakamega mandate region the 2006 April and October rain seasons. Likewise, six new varieties were evaluated together with four commercial checks in the dry mid-altitude KARI-Katumani mandate region. Farmer evaluations were done at the flowering and harvest stages in the medium and mid-late regions and at harvest time only in the dry Mid-altitude area. Each farmer scored each selected trait on all plots on a scale of 1(very poor) to 5 (very good) based on criteria generated in earlier group discussions with farmers. An overall score for the variety was also taken. Data was analyzed using ordinal regression model of Statistical Package for Social Sciences (SPSS). In DT zone, Katumani, 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 moist transitional zone Embu only CKIR06005 was more preferred ($p<0.01$) to the check at harvest stage in April 2006 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 Kakamega area, CKIR06005 and CKIR06005 were more preferred on maturity criteria but CKIR06004 also had good attributes for cob size at the vegetative stage in April rains 2007. We conclude that farmers perceive some varieties to have good tolerance to insect pests in addition to favorable grain yield and maturity attributes, which are critical to the farmers in the adoption of new varieties. These varieties which were being tested in the NPT were released for growing in the respective areas.

Keywords: Farmer participatory evaluation, stem borer resistance, maize varieties, farmer perceptions, ordinal regression

ECONOMICS OF INSECT RESISTANT MANAGEMENT STRATEGIES FOR BT MAIZE PRODUCTION IN KENYA

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Abstract

Given the stagnating economies and food production, decreasing per capita food production and an expected increase in the proportion of poor population in the foreseeable future in Africa, increasing maize production is not debatable. Low maize productivity is associated with an array of biotic and a biotic factors, among which maize stalk borers is of major concern. It has been estimated that the insect pest contributes approximately 15% in grain yield loses in Kenya. Several options of managing the pest exist including use of Bt-maize. This technology has been shown to be innovative and effective management strategy in controlling specific species of the insect pests. Insect Resistant Maize for Africa (IRMA) is in the process of developing and deploying Bt-technology in Kenya. However, it is anticipated that adoption of the technology is likely to result in pest resistance. In response to these concerns, the IRMA project requires to put in place resistance management plans. There are options for resistance management in Bt-maize among them is the use of 'refugia'. Structured 'refugia' refers to planting a portion of each field of Bt maize with non-Bt maize or maize stalk borers s alternative host crops to allow for interbreeding between maize stalk borers migrating from Bt-maize crop which may have developed resistance and insects that are still susceptible to Bt-maize toxins. Some of the 'refugia' in Bt-maize include; Napier grass, Sudan grass, Giant setaria sorghusm and non-Bt-maize. A designated percentage of about 20% is required as 'refugia'. This proportion of 'refugia' has economic tradeoffs to the farmer. The purpose of the study was to assess the economics of using different kinds of 'refugia' as host plants. Both secondary and primary input and output data were used for the study. Partial budgeting technique was utilized in the analysis. The results showed that some of these 'refugia' are cost-effective, flexible, easily adopted and compatible with farmers' common production practices, and they could offer sustainable strategies in Bt management while others were not. In addition, 'refugia' with multiple uses give higher benefits than one with single use. Those 'refugia' crops without any economic value will be uneconomical. However for successful management of these 'refugia', strict stewardship is required from some institutions which may include extension and farmer associations.

Keywords**:** Refugia, insect resistance management, economic analysis

AWARENESS AND ATTITUDES OF MAIZE PROCESSORS, DISTRIBUTORS, AND CONSUMERS TOWARDS GENETICALLY MODIFIED FOOD IN KENYA

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Abstract

This paper presents a synthesis of three studies on awareness, attitudes, opinions and concerns of maize consumers, millers and retailers on genetically modified (GM) crops and products. The introduction and use of transgenic technology has generated varying opinions amongst stakeholders in various parts of the world, Kenya included. To gauge these opinions studies were designed to cover consumers in urban (Nairobi) and rural areas (Western Kenya) and processors and retailers. These classes of primary stakeholders play a crucial role in food marketing and diffusion of any technology resulting from transgenic techniques. Using a set of questionnaires, data were collected on: 1) awareness and knowledge, and, 2) attitudes and concerns of biotechnology and transgenic products at different times. Urban centers where the stakeholders (15 millers and 24 supermarkets) were interviewed included Nairobi, Mombasa, Nakuru, Kericho, Kisumu, Eldoret and Kitale in December 2006 and January 2007. The consumer study covered 604 consumers at the retail points and posho mills in Nairobi in 2003 while 121 rural consumers were covered in Western Kenya in April 2006. Results show that more than half of the respondents in supermarkets and millers have heard and understand what is meant by various transgenic concepts while less than 45% understand specific concepts such as Bt maize and Bt cotton. Slightly over half the respondents were knowledgeable about biotechnology issues with a knowledge score of more than 50%. Most respondents (over 70%), however, had a misconception that GM crops are higher yielding than the conventionally bred. A similar trend is observed on attitudes and concerns towards GM crops and products. Knowledge of GM crops by the urban consumers was more limited, with only 38% aware of GM crops, but they were appreciative of transgenic technology and a large majority (68%) were willing to buy GM maize at the same price as their favorite brand. They were, however, concerned about side effects on the environment and biodiversity. In the rural areas, only few respondents were aware of GM crops. Still, a large majority (89%) would buy it at the same price of conventional maize. Most rural consumers (93%), agree that transgenic technology can offer solutions to food problems, but some expressed concerns on risks of GM crops on local varieties (38%) and the environment (18%).

Keywords: GM food, biotechnology, urban consumer, rural consumer, millers, supermarkets, maize, Kenya

LICENSING BIOTECHNOLOGY FOR HUMANITARIAN USE EXPLORING OPTIONS TO MAKE BT MAIZE ACCESSIBLE TO THE POOR IN KENYA

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Abstract

The higher cost of developing new technologies and their recovery through Intellectual Property Rights (IPR) brings the risk that they become unaffordable to the poor. Companies might be willing to forgo royalties and provide a Humanitarian Use Exemption (HUE). Effective market segmentation approaches need to ensure that the technology reaches the poor and does not spill excessively to people who can afford it. Based on a literature review, different strategies of HUE were identified. Using the IRMA baseline survey of 1800 households, the benefits and the leakage of different strategies were analyzed and compared. In Kenya the Lake Victoria basin, the south-eastern slopes of Mt. Kenya, the dry lands especially around Machakos, and the coastal strip are recognized as regions with high numbers of poor. Options for market segregation analyzed included geographical targeting, self-selection through technology choice (pack size, variety), indirect identification through tiered pricing, and direct identification through a third party. Two types of geographical targeting were analyzed: districts with high proportions of poor people and those that fall in marginal agro-ecological zones. In the first strategy, royalty-free seed is estimated at 1,318 tons, of which about a third would reach the poor and benefiting 113,000 poor households which (43%). Differentiating prices is not a favourbale option since most of the seed is sold in 2 kg package and would lead to spillovers. Selling varieties developed for marginal areas also has a problem in that only a small share of the market is exploited. and only reach 34,000 households. Tiered pricing favors a relatively larger use on improved maize area grown by the poor versus the non-poor (31% -42%). If only the first 2 kg of seed was given royalty-free, benefits in terms of poor maize area reached would be marginal (8%). Increasing the amount of seed given royalty-free to 10 or 15 kg per household would imply that 24% and 31% of all Bt seed would be provided royalty free, reaching 28% and 33% of the maize area grown by the poor to improved seed and benefiting all poor seed purchasers. Finally, direct identification through NGOs or other third parties would assure most of the benefits would go to the poor. However, these organizations reach a very limited number of farmers.

Keywords: Humanitarian use exemption, HUE, technology licencing, tiered pricing, geographical targeting,

THE STATUS OF DEVELOPMENT OF MAIZE RESISTANT TO FIELD AND STORAGE INSECT PESTS IN ETHIOPIA WITH REFERENCE TO MAIZE STEM BORER (*BUSSEOLA FUSCA* FULLER) AND MAIZE WEEVIL (*SITOPHILUS ZEAMAIS* MOTSCH)

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Abstract

Numerous insect pests have been recorded attacking maize in the field and in storage. Among these, only a few are economically important insect pests. In the field the major ones are the maize stem borer *Busseola fusca* (Fuller), , spotted stem borer *Chilo partellus* (Swinhoe) and various termite spp mainly *Macrotermes* spp. and *Microtermes* spp. The maize weevil *Sitophilus zeamais* (Motsch) and Angoumois grain moth *Sitotroga cerealella* (Olivier) in storage. The paper reports work done on the maize stem borer and maize weevil in Ethopia. Host plant resistance offers an economic, stable and ecologically sound approach to minimize the damage caused by these destructive insect pests. Although there have been significant advances in research to improve maize for grain yield, progress in developing varieties resistant/tolerant to these field and storage insect pests has been limited and/or nil. The information on these insect pest constraints in maize production, and strategies being undertaken to address the constraints, including development of resistant/tolerant varieties have been summarized and discussed in this paper.

Keywords: *Busseola fusca, Sitophilus zeamais*, insect pests, post harvest pests

THE IRMA HISTORY: A CRITICAL REVIEW

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Abstract

For six years, from 2000 to 2005, the Swiss journalist Jürg Bürgi accompanied the IRMA project as an independent observer. His book "Mais nach Mass" which was published in German in 2007 (an updated English version being announced for 2009) is more than a critical summary of the project's achievements and setbacks in a chronological order. Considering IRMA as an example of modern development aid the author adds personal comments, introduces farmers, portrays project collaborators and provides in detailed excurses background information on – for example – the controversial discourse on agro biotechnology, on the history of plant breeding and on legal restrictions for public research by the actual system of intellectual property rights. In his short remarks Jürg Bürgi will give an overview of his conclusions.

Keywords: Agro biotechnology, IRMA, intellectual properity right

STATUS AND PROVISIONS OF KENYA'S BIOSAFETY SYSTEM AND BIOSAFETY BILL, 2008

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Abstract

The provisions of Kenya's Biosafety system and Biosafety bill, 2008 has been derived from the decisions made during the Conventional on Biological Diversity (CBD) and Cartagena Protocol on Biosafety meetings. The CBD was finalised in Nairobi in May 1992. It was opened for Signatures in June 1992 and it entered into force on 29th December 1993. The Cartagena Protocol on Biosafety to CBD was finalised and adopted in Montreal on 29th January 2000. It was opened for signatures in May 2000 in Nairobi Kenya and it entered into force in September 2003. So far 147 countries, Kenya included have ratified the Protocol. Parties are supposed to domesticate the Protocol by implementing the 40 articles in it. Kenya started domesticating the protocol before it entered into force. In domesticating the Cartagena protocol, it is a prerequisite for a party to develop National Biosafety Framework (Biotechnology policy, Biosafety law, Guidelines to handle requests/applications, a manual for inspection and monitoring and public awareness strategy). A party is required to have a designated national focal point to Cartagena Protocol on Biosafety and also have a Biosafety Clearing house national focal point.

Twenty Scientists and lawyers developed zero draft copies of the Biotechnology policy and the Biosafety bill in July 2002**.** The two documents were discussed for two days in Nairobi in March 2003 by scientists and lawyers. In September, 2006 they were approved by the Cabinet. Kenya almost got a Biosafety law in 2007 but unfortunately that never happened due to dissolution of the 9th Parliament. Once the Biosafety bill becomes a law, Kenya will have the necessary National Biosafety Framework to embrace modern biotechnology and facilitate responsible research and minimize potential risks; ensure an adequate level of protection in the field of safe transfer, handling and use of genetically modified organisms that may have an adverse effect on human health and environment; and establish a transparent science-based and predictable process to review and make decisions on modern biotechnology activities.

Keywords**:** Kenya Biosafety system, Biosafety bill 2008, Conventional on Biological Diversity, National Biosafety Framework, Biosafety National Focal point, Biosafety Clearing House, Biotechnology Policy, National Council for Science and Technology, NCST, CBD

EXPERIENCES OF THE PRIVATE SECTOR IN DEVELOPMENT AND DISSEMINATION OF BIOTECH CROPS

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Abstract

Recent increases in food prices globally have highlighted the necessity of utilizing all tools, including biotechnology, to increase local food production for the continued benefit of resource-poor farmers. Modern biotechnology provides new opportunities to help farmers in the developing world by improving crops, controlling plant pests and diseases, and addressing the challenges of climate change, such as drought. In 2007, biotech crops were grown by 12 million farmers – 11 million of these small and resource-poor farmers from developing countries - on 114.3 million hectares in 23 countries (12 developing countries and 11 industrial countries). To date, most agricultural biotechnology products have been developed and disseminated by the private sector, primarily in corn, cotton and soybeans. For developing countries, public-private partnerships will play a large role to further extend the benefits of biotechnology to resource-poor farmers. To make drought-tolerant maize for Africa a reality, Monsanto joined the African Agricultural Technology Foundation (AATF), the International Maize and Wheat Improvement Center (CIMMYT), and the national agricultural research systems in Kenya, Uganda, Tanzania, Mozambique and South Africa in a public-private partnership known as Water Efficient Maize for Africa (WEMA) to develop drought-tolerant maize varieties for Africa. The partnership was formed in response to a growing call by African farmers, leaders, and scientists to address the devastating effects of drought. The partners will use conventional breeding, marker-assisted breeding and biotechnology to develop new African drought-tolerant maize varieties, incorporating the best technology available internationally.

Keywords: Maize, public private partnerships, biotechnology

KENYA NATIONAL BIOTECHNOLOGY AWARENESS STRATEGY

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Abstract

Information is the backbone to decision making. Like any other new technology, biotechnology calls for information sharing. There has been a lot of global debate about biotechnology and its applications. The Kenyan government recognizes that availability and access to information is paramount in the development and management of biotechnology. The government therefore plans to ensure that information on modern biotechnology and responsible deployment is accurately and efficiently disseminated to the public for informed decision making regarding adoption and safe application. The majority of stakeholders lack access to accurate and balanced information, a situation that has brought about fear, concerns and myths about biotechnology. The combined effect of these factors can lead to slow rate of adoption or rejection of biotechnology products by the public. National biotechnology awareness creation strategy was initiated to address this gap as a key national priority. The strategy will involve stakeholders from all sectors of the economy. This participatory approach is in line with the current Vision 2030 which aim is to increase the annual GDP growth rate by 10% on average over the period. The Vision embraces science, technology and innovation as important tools in addressing the challenges of food insecurity, environmental degradation and escalating poverty in line with the objectives of the MDGs. In response to Cabinet's approvals of the National Biotechnology Development Policy and The Biosafety Bill, (2008) development and implementation of a comprehensive National Biotechnology Awareness Creation Strategy (BioAWARE-Kenya) was proposed at a series of stakeholder consultative meetings hosted by the Agriculture Secretary in 2006. A subcommittee was constituted to draft the BioAWARE Kenya strategy. After several stakeholders' reviews since March 2007, a final draft was agreed upon in mid 2008, published and launched by the government in September 2008. Successful implementation of BioAWARE will be realized through total involvement of the broad range of biotechnology stakeholders who include agriculture-sector ministries and policy-makers, academic and research community, civil society, extension workers, farmer/community leaders, the private sector and development partners. The key thematic areas in BioAWARE implementation are identified as; policy and resource mobilization, capacity building, communication and outreach, biotechnology education, networking and regional harmonization and participatory monitoring and evaluation. It is hoped that successful implementation of this BioAWARE strategy would lead to better public understanding of biotechnology and its applications. This strategy is an important guideline to the country on biotechnology communication and awareness creation and knowledge-sharing efforts.

Keywords: Biotechnology, biosafety, awareness, BioWARE-Kenya

FARMERS VIEWS ON BIOTECHNOLOGY

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Abstract:

Agricultural growth and development is crucial to Kenya's overall economic and social development. The sector directly contributes to about 26% of the country's Gross Domestic Product (GDP) and a further 27% through linkages with manufacturing, distribution and service related sectors. In Kenya about 80% of the population live in the rural areas and depend on agriculture and fisheries for livelihood. In addition 87% of all poor households live in the rural areas where their main activities are in agriculture. About 50% of Kenyans are food insecure while significant potential for increased production remains largely unexploited. Cereals are very important to Kenya as a means of food security and source of livelihoods for millions of Kenyans. A wide range of cereals are grown in the country for both commercial and subsistence purposes. These include maize, wheat, rice, barley, millet and sorghum among others. Although, most of these staple cereals require mechanization, Kenya has in the recent past experienced sub-divisions of agricultural land hence losing arable land to roads, hedges and homesteads. Maize and wheat are the two major grain (food) staples in Kenya. After liberalization of the grain industry in the early 1990's, it has been observed that production of these commodities is declining due to a number of factors. Among the major reasons for the declining production trend is low development and adoption of new technologies besides the high cost of inputs. A study conducted by Tegemeo Institute benchmarking Kenya's agricultural productivity shows Kenya's maize average production per acre as 9 bags compared to 13 bags for S. Africa and 31 bags for Argentine. The later two are impressing biotechnology. The declining trend in food production in Kenya is an indicator that, farming is becoming unprofitable. Farmers are therefore looking for technologies that can transform their farming into a profitable business. In this regard, farmers have heard about the development of biotechnology, an option that if implemented will increase yield per square unit and make farming profitable. Farmers are therefore enthusiastic to try this technological option. While the farmers are keen to implement biotechnology they are aware of the negative debate about biotechnology especially that of GMO's. In this regard, it is the view of the farmers that as agricultural land diminishes and population increases, it is only through science and technology that productivity and profitability will be enhanced as it is already happening in other countries. However, as farmers forge for biotechnology, they are requesting that the biotechnology issues that are not clear such as those of safety be clarified early enough to avoid any impending negative effects of the products that the technology will bring along.

Keywords. Biotechnology, increased yield, agriculture productivity, maize

APPROACHES AND EXPERIENCES IN CREATING AWARENESS FOR BIOTECHNOLOGY

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Abstract

The potential benefits of today's biotechnology products are largely not evident to the public in Kenya. The public will accept biotechnology only when individuals decide for themselves that biotech products will contribute to their personal well-being. To make such a decision, people will need greater awareness and understanding of how biotechnology will affect the environment, human health, local and national economies, and the well-being of society. Recent surveys indicate a low level of awareness and understanding about biotechnology characteristically for Kenya in particular and Sub Sahara countries in general. In order to improve the understanding of biotechnology and its applications, the African Biotechnology Stakeholders Forum (ABSF) has developed a strategy and approaches to create awareness across the whole spectrum of society. Specific objectives for these approaches include: 1) to make evident to decision makers that modern biotechnology can be an effective tool for increasing agricultural productivity, and thereby economic growth, without imposing unacceptable risk to the environment or human and animal health; 2) to enable the public to make informed decisions about appropriate current and future uses of biotechnology by providing accurate and balanced information about benefits and potential risks; and 3) to incorporate modern biotechnology into science curricula for schools, university and colleges, and agricultural extension officers through biotech field schools. The most common approaches that ABSF uses in biotech awareness include, but are not limited to: Media personnel training; "Seeing – is – believing tours" biotech outreach for farmers in countryside; internship programs for students; exhibitions; conferences; networks through African Biotechnology, Network for Africa (ABNETA); biotechnology field schools; partnerships with stakeholders; subsidizing farmers in tissue culture; newsletters, news papers and publications; curriculum development for academic institutions; sponsorship of biotech events; and capacity building for policy makers.

Keywords: Public awareness, biotechnology, ABSF, ABNETA

MEDIA AND PUBLIC AWARENESS AND TECHNOLOGY DISSEMINATION IN AGRICULTURE

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Abstract

The development and commercialization of genetically modified organisms/products of modern biotechnology has elicited very strong and opposing debate on the advantages and disadvantages. On the two sides of the debate, are two camps. First, proponents of biotechnology (scientists & government policy makers) and the opposing side mainly civil society organizations. Secondly, no where else has this debate been fiercer than in the media for both camps have used the media to try and influence policy makers on decision regarding biotechnology. Initially, it was the civil society organizations that found it necessary to weigh their war on biotechnology using the media, scientists preferring to argue with fellow scientists or proponents of modern biotechnology have also realized the power of the media in changing public attitude and are now using it to argue their case. The question is how effective has been communication of modern biotechnology in media. Has the communication being informative, persuasive and educative? It is quite evident that in most instances reporting on biotechnology has been below par in terms of prominence, accuracy, frequency of coverage, informative and quality of stories in general in virtually all forms of media. There are various reasons advanced or various factors for the inadequate coverage of biotechnology issues in Kenya and other similar countries ranging from lack of comprehension of biotechnology issues by journalists who have working relationships between scientists and journalists, media perception of biotechnology among others. This paper, therefore, explores strength in coverage of biotechnology issues in Kenya, challenges in reporting and what needs to be done to achieve better and more meaningful coverage of biotechnology stories.

Keywords: Biotechnology, public awareness, technology dissemination, civil society, media

NEW INITIATIVES TO SCALING UP CONVENTIONAL BREEDING IN IRMA PROJECT IN EASTERN AND SOUTHERN AFRICA

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Abstract

Maize is important crop for agriculture and livelihoods in Eastern and Southern Africa (ESA), but the regions are net importers of maize annually, largely due to very low grain yields of only 1.3 t/ha compared 4.9 t/ha worldwide. Insect pests in the field and in storage are among the factors that reduce yields and food availability in ESA. Despite the heavy loss caused by stem borers and storage pests in Africa, few maize improvement programs include breeding for resistance. This is attributed to the genetic and logistical challenges posed by screening and selection for insect resistance. CIMMYT and partners have developed germplasm and other technologies to combat stem borers and storage pests. IRMA III plans to share the benefits from IRMA II to the ESA regions, through developing and deploying maize varieties resistant to field and storage insect pests. The project will concentrate on ESA countries (Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Zambia, and Zimbabwe) where insect pests have the greatest impact on maize production, food and income security, and livelihoods thereby reaching more than 190 million people. The best varieties will be moved through the variety release process of target countries and made available to seed companies for scale up, thus ensuring that farmers obtain more productive varieties with strongly improved storability. This project will be executed through established collaborative networks between CIMMYT, national agricultural research systems (NARS), the private seed sector, NGOs and extension. Details of project objectives, activities and expected outputs and project management will be included in this paper.

Keywords: IRMA III, CIMMYT, Eastern and Central Africa, maize

QUANTITATIVE ANALYSIS OF BT δ-ENDOTOXINS IN CROSSES INVOLVING TROPICAL TRANSGENIC BT MAIZE INBRED LINES

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Abstract

Generational studies of transgene expression have been conducted in cereal crops, including maize and rice. The majority of generational studies, however, have focused on the qualitative evaluation of transgene expression levels when assessing the segregation of the transgene phenotype or gene silencing phenomenon. More rarely have transgene expression levels been quantified over generations in plants. Kenya has started to embrace Bt maize technology. It was important to assess transgene behavior in adapted cultivars of the tropical maize germplasm over generations of breeding. This study indicated that accurate measurements of expression levels over generations of breeding is important in identifying transformation events indicating stable transgene behavior for crop improvement. The tests showed that *cry1Ab* gene appeared to be stably transmitted successive sexual generations up to the F2:3 successive generations, and the concentration of the CrylAb protein kept quantitatively stable to the F2:3 generations successive generations of breeding in tropical maize.

Keywords: *Bacillus thuringiensis*, Bt δ-endotoxin; Bt maize; stability of expression, generational studies, Tropical maize, transgene expression levels

CONTROL OF CHILO PARTELLUS STEM BORERS BY BT MAIZE δ-ENDOTOXINS IN GENERATIONS OF TROPICAL MAIZE

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Abstract

In Kenya, stem borers cause losses of maize of 14% of the farmers' total annual harvest of maize. Bt maize, developed using modified genes from the soil bacterium *Bacillus thuringiensis* (Bt), controls stem borers without harming humans, livestock or the environment. Stable integration and expression of transgenes is of great concern in hosts with large genomes like maize. The effectiveness and sustainability of Bt-transgenic technology in the control of major target insect pests will depend on the levels of expression of Bt δ-endotoxins in adequate quantities in appropriate plant parts at the requisite time in successive generations. This study was to determine maintained efficacy of tropical Bt maize formed in successive generations of breeding. The responses to the control of *C. partellus* were done using insect bioassays measuring plant height, number of stem borer exit holes, cumulative stem tunnel length, number of larvae recovered, and number of pupae recovered. Two Bt maize inbred lines; Bt maize Event 216 and Bt maize Event 223 both of CML126 BC_3S_1 (*cry1Ab::ubi*) and two non-Bt inbred lines; CML144 and CML159, CKIR6009 and H513 as resistant and non- resistant hybrid checks respectively, and MBR and CML216 were grown in an RCBD design with four replications and with checks, parent inbred lines, F_1s and $F_{2:3}$s. Results showed that there were differences in resistance to *C. partellus* due to differences in the expression levels of Bt δ-endotoxins among Bt and non-Bt maize inbred lines, their F_1s and $F_{2:3}$s and additionally. It indicated that the expression of Bt δ-endotoxins appeared to be stable in the three successive generations of breeding.

Keywords: Bacillus thuringiensis, Bt δ-endotoxin; transgenic maize; stability of expression, generations

COMPARATIVE STUDIES ON DIFFERENT STEM BORER POPULATIONS FOR RESISTANCE DEVELOPMENT

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Abstract

Stem borers are a key pest complex and most prevalent insect pests of maize globally. They are most serious in the tropics and sub- tropical environments than in the temperate regions. In Kenya, *Busseola fusca* and *Chilo partellus,* are of greater economic importance and larvae are the longest and most destructive stage in the life cycle of stem borers, which attack maize from seedling to maturity. *C. partellus,* a native of Asia, is found in low altitude warmer zones below 1200 meters above sea level, while *B. fusca,* an indigenous pest of Africa is not known to occur outside Africa. Using genetic engineering tools, modified genes from the soil bacterium *Bacillus thuringiensis* (Bt) have been introduced into maize. They encode δ-endotoxin proteins, which, when ingested by the susceptible stem borer, are activated by favorable environments in the insect guts, resulting in larval mortality. Resistance studies were carried out in a biosafety level 2 greenhouse to compare the reaction of different stem borer populations to Bt-maize delta endotoxins. Three *C. partellus* and one *B. fusca* populations were fed with Bt-maize leaves containing two gene constructs event *223:cry1Ab::Ubiquitin* and event *10:cry1Ba:: Ubiquitin*. Similar populations were fed with the non-transgenic CML216 as control. Maize leaves were harvested at 6-8-leaf stage and fed to 300 neonates of each *C. partellus* population for 3-4 hours. *B. fusca* neonates were allowed to feed for 48 hours because it is inherently tolerant to cry proteins in the Bt-maize events that were used. The larvae were removed and reared in artificial diet to adult stage. Eight generations of *C. partellus* and five generations of *B. fusca* were assessed for changes in susceptibility to the Bt-maize cry proteins. Weight reduction was high compared in *C. partellus* populations compared to *B. fusca*. Pupal weights were lower for the populations that were exposed compared to the control. Each subsequent generation exposed to the cry proteins exhibited reduced pupae weights. Development of the larvae went on well to adult stage. There were no notable differences on the *C. partellus* populations from different agro-ecological zones.

Keywords: Stem borer, resistance development, *Chilo partellus, Busseola fusca*

PHENOTYPIC DIVERSITY FOR MORPHOLOGICAL TRAITS IN KENYAN LOCAL COASTAL MAIZE LANDRACES

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Abstract

Farmers in coastal region of Kenya grow local coastal maize landraces (LCML) despite the improved varieties that have been released for the region. High crop phenotypic diversity is, therefore, seen as a way for resource poor farmers to spread risk and support their own food security. Crop genetic diversity is thus the basis of our food supply and survival. A total of 30 genotypes, which included 25 LCML and five improved checks were evaluated for morphological traits in a replicated randomized complete block design. Data collected include among others days to anthesis (AD), days to silking (SD), anthesis – silking interval (ASI), number of leaves (LN), ear height (EH) and plant height (PH). Agglomerical herrachical cluster analysis was done and group 2 - 1 had 9 entries, which include entries 7 (034660) from Taita Taveta, 18 (047635) – Kienyeji from Kwale, 9 (044454), 10 (044458) and 17 (047632) – Ngonjora from Lamu, 3 (032379) - Mdzihana, 11 (046360) - Kanjerenjere, 12 – (047624) - Mengawa, and 14 (047628) – Chinga cha mosi all from Kilifi. This group is dominated by Kilifi and Lamu entries. Group 2 – 2 had 19 entries, which include entries from Kilifi and Kwale districts. Entries from Taita Taveta and Lamu appeared only appeared only in G 2 - 1. The other checks like PH 4, CLS-3 and KDV-3 were also in Group 2 – 2. This may indicate that these checks were developed from the local landraces from Kilifi and Kwale districts. The pattern of forming clusters may have some geographical implication since some clusters were formed with entries form neighboring districts. This study confirmed that local coastal maize landraces display large amounts of variation for morphological traits. The broad trait diversity evident among the LCMLs suggests ample opportunity for genetic improvement of the crop through selection directly from the accession and/or the development of inbred lines for future hybrid programs. Grouping accessions into morphologically similar and most likely genetically similar groups is helpful for selecting parents for crossing. Harnessing of this biodiversity in future cultivation practices may aid in stabilizing maize yield in the region.

Keywords: Phenotypic traits, diversity, cluster analysis, local coastal maize, landraces.

PHENOTYPIC CHARACTERIZATION OF KENYA LOCAL COASTAL MAIZE LANDRACES

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Abstract

Maize (*Zea Mays* L.) is the most important food crop in the Coast province of Kenya, particularly in Kilifi and Kwale Districts, which together accounts for half of all maize production in the province. Coast Province however produces only 50,279 tones of maize per year, while the demand is 22.5 m tones. Farmers grow local coastal maize landraces (LCML) despite the improved varieties that have been released for the region. Genotype morphology and agronomic characteristics are often responsible for its favorable performance. This study sought to develop morphological characteristics of LCML at KARI-Mtwapa Center. A randomized complete block design (RCBD) design used, with three replication set up for 30 genotypes. Data was collected on anthocyanin coloration of various plant parts, leaf angle, degree of stem zig zag, width of leaf blade, anthesis to silking interval, grain color as recommended by the International Union of Protection of New Varieties of plants (UPOV). Strong anthocyanin coloration was observed on brace roots of entries 11 (046360) - Kanjerenjere from Kilifi, and 23 (0447642) from Kwale; on glumes excluding the base and anthers of entry 12 (047624) - Mengawa from Kilifi, and on silks of entry 30 (KDV-3), the drought check. Entry 11 (47624) – Kanjerenjere from Kilifi had a very wide (>13 cm) width of leaf blade. The entry 13 (047625) - Mdzihana from Kilifi and the drought tolerant 30 (KDV-3), were the only genotypes categorized as "early" for both days to anthesis and days to silking. While entries 9 (044454) from Lamu, and 12 (047624) - Mengawa from Kilifi were the only genotypes categorized as "late" for both days to anthesis and silking. For grain color entry 15 (047629) – Mwangongo was categorized as "red", while entry 11 (047624) – Kanjerenjere was categorized as dark red and are both from Kilifi. The genotypes that were categorized as "yellow" were entries 5 (032423) – Tela from Kilifi, 17 (047632) – Gonjora from Lamu, 20 (047638), 21 (047639) and 22 (047641) all from Kwale. Entry 8 (034661) from Taita Taveta was categorized as "yellowish white". Three genotypes 3 (032379) – Mdzihana, 13 (047625) – Mdzihana from Kilifi and 23 (047642) from Kwale were categorized as "blue black". Farmers and breeders can now use this information.

Keywords: Phenotypic traits, characterization, local coastal maize, landraces

EFFECTS OF *BACILLUS THURINGIENSIS* CRY1A(C) δ - ENDOTOXINS ON NITROGEN FIXING BACTERIA IN CLAY SOIL IN KENYA

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Abstract

It is important that new technologies do not result in unfavorable effects on non-target organisms. Kenya is exploring the possibilities of using maize transformed using *Bacillus thuringiensis* genes for control of stem borer pests in maize production. The study aimed at assessing the effects of Bt Cry1A(c) δ-endotoxins s on nitrogen fixing bacteria in clay soil in Kenya with particular concerns on its effects on rhizobial diversity, and nitrogen fixation in the studied soil type. Clay soil was obtained from KARI-NARL farm in Kabete, Kenya. Cry1A(c) δ-endotoxins s from a local *Bacillus thuringiensis* (Bt) isolate (ICIPE L1-2) active against *Chilo partellus* was used. Beans, *Phaseolus vulgaris* and siratro, *Macroptilium atropurpureum* (DC.) seedlings were grown in pots that were treated with Bt Cry1A(c) δ-endotoxins solution (100µg/ml) and water as control. The plants were maintained in the greenhouse till nodulation and maturity stages when sampling was done for analysis. The Bt δ-endotoxins was applied to the soil at a concentration of 100 µg/ml. A culture-dependent technique was used to analyze the isolates obtained from the root nodules of the leguminous plants. The diversity and species composition of DNA extracted from the pure isolates was done using DNA fingerprinting (RFLP). The effects of Bt Cry1A(c) δ-endotoxins on nitrogen fixation were investigated in vitro. The extracted Bt δ-endotoxins solution (from culturing of ICIPE L1-2 isolate) was applied to the soils at a concentration of 100 µg/ml and subsequently acetylene reduction assays at times 0hr, 22hr, 36hr, 42hr and 60hr were measured using Gas Chromatograph (GC) fitted with a Flame Ionization Detector (FID) to evaluate its effect on nitrogen fixation in the soil. The results indicated that there was conversion of acetylene to ethylene in both the test and control soil samples by nitrogen fixing bacteria. Though the rate of the acetylene reduction was comparable slow in both cases, the difference was insignificant. In conclusion, our experimental data indicated that Bt Cry1A(c) δ-endotoxins at a concentration of 100 µg/ml neither interfere with the plant growth nor the nitrogen fixing activity of the rhizobia. However, RFLP analyses data showed that Bt Cry1A(c) δ-endotoxins present at a concentration of 100 µg/ml in the soil clearly influenced the rhizobial diversity.

Keywords: Transgenic crops, *Bacillus thuringiensis*, Cry1A(c) δ-endotoxins, *Macroptilium atropurpureum*, RFLP.

AGRONOMIC TRAITS OF INSECT RESISTANT LINES AND YIELD RESPONSE OF F1 HYBRIDS UNDER ARTIFICIAL STEM BORER INFESTATION

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Abstract

A study was carried out using partial diallel mating design using insect resistant maize inbred lines to determine their combining ability and identify lines and F1 hybrids with good agronomic traits. Twenty inbred lines known to be resistant to *Chilo partellus* and *Busseola fusca* were crossed without their reciprocals to generate 110 F1 hybrids. The hybrids and the parents were evaluated in Kiboko and Embu for two seasons under artificial stem borer infestation in short and the long seasons of 2003. The results showed significant differences among the entries for all measured traits. The progeny performance showed that the hybrids were better than their parent inbred lines for insect resistance and other agronomic traits.

Keywords: Agronomic traits stem borers, inbred lines, partial diallel

THE STATUS OF DEVELOPMENT OF MAIZE RESISTANT TO FIELD AND STORAGE PESTS IN ZAMBIA

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Abstract

Zambia is divided into three agro-ecological regions primarily based on rainfall. Region I has rainfall below 800 mm, Region II: 800-1000 mm and Region III: above 1000 mm. Major pest problems in maize are storage pests such as grain weevils and the larger gran borer in all regions, field pests such as stalk borers in all regions, leaf hoppers causing maize streak virus in Region II and III and termites in some parts of Region I and II. Damage caused by pests ranging from less than 10 % for field pests to 100 % for storage pests in the case of the larger gran borer. There are three species of stalk borers that occur, *Busseola fusca, Chilo partellus* and *Sesamia calamistis* and their proportions vary from season to season and place to place. Pest control measures have included the development of resistant varieties (leaf hoppers, weevils, stalk borers), use of chemicals (all pests), use of cultural practices (larger gran borer, termites) and biological control (stem borers, and termites, larger gran borer).

Keywords: Pest control measures, stem borers, storage pests, Zambia

STATUS OF INSECTS IN MAIZE RESEARCH IN KENYA

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Abstract

Maize is the major and staple food in Kenya and contributing over 40% of calorie requirements of Kenya. The total per capita consumption is estimated at 125 kg per person per year. Of the total 1.5m hectares under maize, small scale farmers constitute 70-80% of the total area under maize. Abiotic and biotic constraints are among the major causes of reduced maize production. Stem borer is the most damaging field pest of maize causing 13-45% loss in yield, a loss estimated at US $ 90 million annually and storage losses estimated at 30% valued at US$ 108 million annually. The most important species of stem borers in Kenya include *Chilo partellus* (Swinhoe), *Chilo orichalcociliellus* (Strand), *Busseola fusca* (Fuller), *Eldana saccharina* (Walker), and *Sesamia calamistis* (Hampton). Other field pests include African bollworm *Helicoverpa armigera* and cutworms. Occasionally the army worms *Spodoptera exempta* which are notifiable pests in Africa also attack maize and pasture grasses, storage pests such as common weevils (*Sitophilus zeamais*), larger gran borer (*Prostephanus truncatus* Horn) and Angoumois grain moth (*Sitotroga cerealela* Olivia). The major management options include use of cultural practices such as smoking, synthetic pesticides, and use of host plant resistance. Synthetic pesticides have been associated with poisoning and development of resistance to the pesticide due to continuous use and misuse. In the past, research work on insect pests has been carried out under the auspices of KARI (Crop Protection Program, RF supported Program, Alliance for Green Revolution for Africa and DfID, CIMMYT (IRMA), and ICIPE. Kenya has developed facilities to undertake insect science research, the major ones located at KARI-Biotechnology Centre, KARI-Katumani-Kiboko (Open Quarantine Facility) and ICIPE facilities. Under IRMA program, several maize varieties with stem borer resistance have been developed and released for commercial production. Varieties tolerant to storage pest LGB and common weevils are at advanced stages of variety release process. The main lesson learnt is that it is possible to manage insect pests using both cultural, conventional and biotechnology approaches, with the latter being the most effective, at least for the stemborer species, however, some events transformed using *Bacillus thuringiensis* L. (Bt) genes were more effective than others on some stem borer pests. The introduction, augmentation and conservation of natural enemies especially the parasitoids against all the life stages of the cereal stem borers also offer prospects for control. The introduction of *Cotesia flavipes* against the spotted stem borer achieved about 21% control in Coastal Kenya.

Keywords; Insect pests, maize breeding, stem borer resistance, prospects for control

DISTRIBUTION AND IMPACT OF STEM BORERS IN MALAWI – A REVIEW

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Abstract
Maize is a major staple food for Malawi's majority of the population and the most widely grown cereal in the country. Three major maize stemborers occur in Malawi, namely, *Chilo partellus* Swinhoe (Crambidae), *Busseola fusca* Fuller (Noctuidae) and *Sesamia calamistis* Hampson (Noctuidae). They are the most important insect pests of maize in the country. The distribution of the borers is country wide. The impact of the stemborers on maize is seen in the yield losses it causes. Spatial and temporal distribution of the maize stemborers and their impact are discussed. Some methods of controlling stemborers are mentioned.

Keywords: *Chilo partellus, Buseola fusca, Sesamia calamisitis*, yield loss, impact, distribution, stem borers

THE STATUS OF DEVELOPMENT OF MAIZE RESISTANT TO FIELD AND STORAGE PESTS IN MOZAMBIQUE

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Abstract

Stem borers (*Chilo partellus, Busseola fusca and Sesamia calamistis*) and the larger grain borer (*Prostephanus truncatus*) are the most important field and storage pests affecting maize in the smallholder farmers across Mozambique. Maize yield losses under small-scale farmer's fields due to stem borers account for 40 – 100%, while weevils are responsible for more than 80% of grain damage and more than 60% weight loss under small scale storage system. Chemical control was extensively promoted by extension service, but was not adopted by the resource poor farmers, who are the majority in the Mozambican agricultural Sector, where only 4.5% of them use pesticides to protect their crops. Studies on biological control of stem borer infestation were carried out by Eduardo Mondlane University, but these studies were not complemented by genetic breeding. Research on pest has been limited on introduction and testing exotic germplasm reported as resistant to stem borer, but no one genotype has been confirmed as such under Mozambican environments. The use of integrated pest management, including the use of genetic resistant varieties, should be adopted to increase crop productivity and ensure food availability and food security in Mozambique.

Keywords: Maize, pest, resistant varieties, improvement

THE EFFECT OF STEM BORERS ON MAIZE PRODUCTION IN TANZANIA

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Abstract

Like other East African countries, maize production in Tanzania has not reached its optimum due to obstacles that include drought, low soil fertility, weeds, pest and diseases. Realization of optimum maize production will need technologies that will effectively overcome these obstacles without destroying the environment. Maize stem borers are among the field pest which can reduce maize production to >40% under severe condition and if not controlled. Maize stem borers are common pests in Tanzania, stressing in all maize growing ecologies with elevation of 600 - 2700m above seas level, but with distribution and pest status varying from one region to another. The larvae of this pest at advanced stage of growth make extensive tunnels inside the stem. This disrupts the flow of water and nutrients in the plant. Tunneling also weakens the stem resulting in plant lodging. In older plants the first generation caterpillars bore in the main stem but later some of the second generation bore into the maize cobs. Grains damaged by stem borers become susceptible to infection by mould fungi such as *Aspergillus spp*, which produce aflatoxin, a toxic substance which is extremely poisonous to human being and can be fatal. In Tanzania cultural and chemical methods are being applied. These include crop rotation, field sanitation and intercropping. The use of botanicals such as pyrethrum powder left after industrial pyrethrin extraction process, hot pepper extracts, and neem seed and leaves extracts. Other local practices include the use of ashes and cow urine. Industrial chemicals in use are endosulfan, Actelic dust and other insecticides. The control level of the current practices reach to about 50%, but integrated pest management practices that will include host plant resistance from varieties resistant to stem borers will have greater impact in the control of stem borer.

Keywords: Maize stem borers, Tanzania

APPROACHES TO CONTROL OF INSECT PESTS OF MAIZE IN UGANDA

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Abstract
The maize storage weevils and Lepidopterous stem borers constitute the major insect pests of maize production in Uganda. Four major species of stem borers; *Busseola fusca*, *Chilo partellus*, *Sesamia calamistis* and *Eldana saccharina* and two storage weevil species; *Sitophilus zeamais* and *Sitophilus oryzae* occur in the country with varying pest status depending on climate, ecology and altitude. While stem borers are the most important field pests causing estimated yield losses of 20 -30%, storage weevils are the greatest post harvest constraint causing up to 30 -40 % of grain weight loss. Although pesticides are effective against these pests, a majority of the low resource farmers cannot afford them. Attempts have, therefore, been made to control these pests using various methods with varying degree of success. This paper discusses the efforts and successes that have been made on stem borers and storage weevils in the elucidation of their economic importance, distribution and control. Control strategies involving chemical, host-plant resistance, biological control and habitat management and prospects for their integration are discussed.

Keywords: Stem borers, storage weevils, biological control, habitat management, integrated pest management

Field Visits

Field Trips: Summary of Proposed Visiting Locations on Thursday 30th Oct 2008

Location	**KARI-Biotechnology Centre**	**KARI-Katumani**	**KARI-Kiboko**
Guide	Dr. S. Gichuki / Mr. M. Mwimali	Mr. V. Kega	Dr. S. Mugo / Mr. P. Likhayo/Dr. J. Gethi
Areas of interest	1. Biosafety Level 2 Laboratory 2. Biosafety Level 2 Greenhouse 3. Other KARI Biotech. Projects: ▪ Molecular Markers Studies ▪ Transformation Studies ▪ Tissue Culture Studies	1. Insect rearing facilities 2. Biotechnology laboratory 3. Food utilization 4. KARI Seed Unit (KSU)	1. Open Quarantine Site (OQS) 2. Demo of stem borer resistance 3. Screening of drought tolerance - regional 4. Screening of drought tolerance – National 5. Screening facilities for postharvest 6. Others
Tentative program	Depart Nairobi Hotel: 09.00 am Visits Start: 09.30 am Tea Break: 1.00 am Depart Biotech Centre: 12.30 pm Lunch at the NBI Hotel: 01.00 pm Arrival at Nairobi Hotel: 01.00pm	Depart Nairobi Hotel: 07.00 am Visits Start: 09.00 am Tea Break: 10.00 am Lunch at Katumani Center : 01.00 pm Depart KARI Centre: 02.00 pm Arrival at Nairobi Hotel: 04.00pm	Depart Nairobi Hotel: 07.00 am Tea Break: 10.00 am Visits Start: 10.30 am Lunch at HLH: 02.00 pm Depart KARI Centre: 03.00 pm Arrival at Nairobi Hotel: 06.00pm
Action points	1. Provision of tea to invitees by the Centre (Mr. P. Likhayo) 2. Prepare updated centre brochures (Dr. S. Gichuki). 3. Repairs of the Biosafety greenhouse (Mr. M. Mwimali).	1. Provision of tea to invitees by the Centre (Mr. V. Kega). 2. Prepare updated centre brochures (Mr. V. Kega/ Ms. C.I Mukundi).	1. Provision of tea to invitees by the Centre and packed lunch (Ms. C. Mukundi / Mr. Mbithi).

Participants

List of Invited Participants for the End-of-Project Conference - October 28-29, 2008

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