KARI
CIMMYT

IRMA Updates
Insect Resistant Maize for Africa

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Contents

The IRMA project was launched in 1999 with the primary goal of increasing maize production and food security for African farmers through the development and deployment of improved maize varieties that provide high resistance to insects, particularly stem borers. To achieve this goal, KARI and CIMMYT scientists will identify conventional and novel sources of stem borer resistance and incorporate them into maize varieties that are well suited to Kenyan growing conditions and to farmer and consumer preferences. Major funding for the project is provided by the Novartis Foundation for Sustainable Development.

IRMA Bioassay Shows Bt Effective Against Kenyan Borers

A small but significant step toward the introduction of insect resistant maize into Kenya and Eastern Africa was taken Feb 2–14, 2001, when an experiment at KARI's National Agricultural Research Laboratories provided scientists with some hard data on how effective genetically modified Bt maize would be against Kenyan stem borers.

The experiment, called a bioassay, was conducted by KARI and CIMMYT scientists under the auspices of the IRMA project.

"Results from the bioassays indicate that Bt genes provided by CIMMYT have been effective against various stem borer species, including the spotted sorghum stem borer, the African pink borer, the African sugarcane borer, and the coastal stem borer," says Dr. John Wafula, Deputy Director, KARI. "More testing, especially in the field, will of course be required, but this is a very encouraging first step."

"Results from the bioassays indicate that Bt genes provided by CIMMYT have been effective against various stem borer species, including the spotted sorghum stem borer, the African pink borer, the African sugarcane borer, and the Coastal stem borer."

In the bioassay, the targeted pests were allowed to feed on leaf tissue containing the Bt toxins. The leaf tissue was brought to Kenya from the CIMMYT Applied Biotechnology Center's Biosafety Greenhouses in Mexico on February 2, 2001. The delivery followed a long and intensive approval process by Kenya authorities led by the National Biosafety Committee (NBC). By using leaf tissue for the experiment, the scientists ensured that no seed or living maize plants could inadvertently "escape" into the environment before the necessary environmental studies have been conducted.

Catherine Taracha (left) records the area of leaf tissue consumed by borer larvae after 96 hours. Irene Ngatia (right) counts the number of surviving larvae.

KARI entomologists Dr. Josephine Songa and Dr. Macharia Gethi performed the bioassays, with the assistance of CatherineTaracha and Irene Ngatia. The results showed that the Bt genes *cry1B*, *cry1Ab*, and *cry1Ab-1B* were lethal to spotted stem borer (*Chilo partellus)* and coastal stem borer (*Chilo orichalcocililiellus)*. African pink borer (*Sesamia calamistis)* and African sugarcane borer (*Eldana saccharina)* were killed by *cry1Ab-1B* and *cry1Ab*. The African maize stem borer (*Busseola fusca)* were not as well controlled by the genes tested indicating the need to look for other genes and/or combinations of genes to target this borer. In short, a prospective control has been identified for the most destructive borer the spotted stem borer, which is also the most widely distributed stem borer in Kenya. Further work will be required to develop an effective control for the African maize stem borer.

"The information obtained from these bioassays will allow us to now transfer the most effective gene combinations into locally adapted maize

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(IRMA Bioassay cont'd...)
germplasm. We will also continue to look for other genes and events to better target *Busseola fusca*," says Dr. David Hoisington, Director of CIMMYT's Applied Biotechnology Center, where the gene constructs and transgenic lines used for the experiment were produced.

"Not all Bt toxins are effective against all lepidopteran (stem borer and moth) pests, and the results obtained here support this fact," explains CIMMYT entomologist David Bergvinson. "So bioassays must be conducted to confirm which toxins are active and which ones should be combined to ensure an effective level of pest control for years to come. These bioassays will be very useful as we initiate our product development to deliver an effective and durable level of insect resistance for African maize."

According to Dr. Stephen Mugo, the CIMMYT IRMA Project Coordinator, the next step would be for KARI scientists to apply for a permit to introduce seeds of these Bt maize lines and then test the effectiveness of the genes under greenhouse and field conditions.

Stem borers are the most destructive insect pests of maize in Kenya. With maize being the nation's major food crop, stem borer damage ultimately affects food security and the agricultural economy.

In March 2000, a meeting of Kenyan Stakeholders brought together maize farmers, researchers, policymakers, commercial firms and religious leaders to discuss development of insect resistant maize for Africa including the use Bt genes. The consensus of the meeting was that such maize would be extremely beneficial to farmers and to the country generally, but that issues related to the environment, the benefits of the technology to different stakeholders, and advantages and constraints to its adoption required further study.

—**Stephen Mugo**, IRMA Project Coordinator, and **David Poland**, CIMMYT Biotechnology Writer/Editor

Mass Rearing of Stem Borers

Given all the stem borers Kenyan farmers encounter in the field, they might find it hard to believe that rearing these insect pests is a considerable challenge. For KARI and CIMMYT entomologists working together on the IRMA project, however, establishing a good supply of stem borers has required patience and persistence, and it now appears that their efforts are beginning to yield. . . well, stem borers.

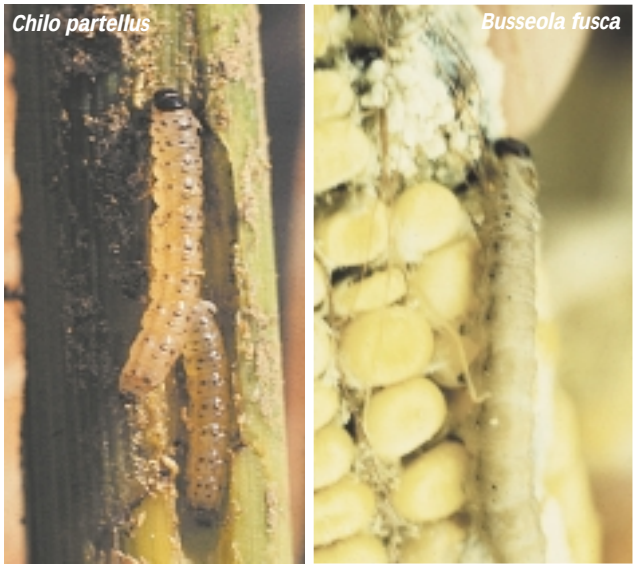
The aim of establishing insectaries capable of mass rearing various stem borer species activity is to supply high quality stem borers at various life stages. The borers will be used for (1) resistance screening studies within the IRMA project and in other KARI projects, (2) insect bioassays involving various Bt-toxins, and (3) baseline studies in the development of a resistance management strategy for the Bt-gene based resistance in maize.

Five stem borer species are currently being reared in the insectaries at Katumani: *Chilo partellus*, *Busseola fusca*, *Sesamia calamistis*, *Chilo orichalcociliellus*, and *Eldana saccharina*, with the bulk of insect production being for the first two species due to relatively higher demand for them. The other three species are maintained in lower numbers while waiting for specific insect orders, after which their numbers will be increased proportionately.

Presently, mass insect production *C. partellus* and *B. fusca* is to provide a supply of stem borers for (1) IRMA sub-projects, including the crop loss studies and the insect resistance management study, and (2) other KARI projects, including the Rockefeller-funded Coordinated Ecosystem Maize Breeding Project, the KARI / NRI Sorghum Pests Project, and the Kenya Government Funded (IDA) Sorghum Breeding Program.

It appears at this time that the insectaries will be able to meet the needs of the upcoming stem borer resistance screening studies. There are sufficient *C. partellus* and *B. fusca* to infest more than 50,000 plants at 20 stem borer eggs per plant. For the resistance management studies, the team is aiming to supply 21,000 larvae and 1,100 pupae of both *C. partellus* and *B. fusca* by mid-June, 2001. The goal of the effort is to sustain an adequate reserve colony size for each of the stem borer species, proportionate to the anticipated requests for next season's work.

—**Josephine Songa,** KARI entomologist



KARI entomologists and technicians working with the IRMA project will harvest hundreds of thousands of eggs of *Chilo partellus* (left) and *Busseola fusca* (right) for upcoming resistance screening studies.

IRMA Researchers Work to Develop Insect Resistance Management Strategies

Scientists from KARI and CIMMYT have concluded their first round of analysis on potential host plants that could serve as refugia to delay the development of Bt resistant stem borers in Kenya.

Resistance to Bt toxins has been observed in more than 11 insect species in the field and laboratory, according to published reports. Given that the development of Bt maize is one avenue of control being explored under the IRMA project, the need to develop management strategies to limit the build-up of Bt-resistant insect populations is clear. Project researchers conducted an extensive literature search on insect resistance management strategies last year, which included refereed journals, libraries, the Internet, and CD-ROMs. Topics that warranted special attention were mode of action and mechanisms of resistance to Bt, wild hosts of cereal and stem borers, and the use of refugia.

Following the literature review and consultations with their peers, IRMA scientists identified potential alternative hosts for stem borers that would provide additional economic value for farmers. A primary candidate was high-yielding livestock feeds that can be incorporated into various Kenyan farming systems. In September, 2000, 10 napier varieties and seven grass species were planted at National Agricultural Research Center (NARC), Kitale. Each variety was planted in its own 10m x 10m plot and observations were later obtained.

Data collected included number of tillers per hill, number of leaves per stem, leaf length, stem diameter, hairiness, disease score, stem borer exit holes, and dry matter. Conclusions based on the preliminary observations and collected data collected were

- Napier varieties Kakamega 1, Kakamega 2, and Columbus grass had the highest dry matter yield from first harvest, probably because they grew more vigorously than the other varieties, had more tillers, longer leaves, and thicker stems.
- Napier varieties Kakamega 1, Kakamega 2, Kakamega 3, Clone 13, Pakistan hybrid, and French Cameroon had the highest number of stem borer exit holes—an indication of borer survivorship and infestation levels.
- Although there were higher incidences of borer damaged plants in Gold Coast, Bana grass, and Uganda Boarder, the exit holes were few, which may be due to low borer-survival rates.
- Some high yielding varieties with more exit holes, such as Kakamega 2 and 3, were susceptible to white fungal disease (*Beniowskia sphaeroides*).

KARI entomologist Margaret Mulaa checks potential refugia host plants for borers.

The bulking plot will be maintained at NARC-Kitale for further observation and for harvesting to acquire actual dry matter yields from each variety on an annual basis. Moreover, the bulking plots will be a source of planting materials for trials to evaluate the alternative hosts in the various maize growing environments of Kenya.

During the long rains season 2001, 16 Napier varieties, six grasses, six sorghum varieties, and two maize varieties will be planted in replicated trials at four sites (Mtwapa, Embu, Kakamega, and Kitale), which represent different agroecological zones. The objective of the trials is to evaluate selected alternative hosts for stem borer preference, survival rates, and development period in various agroecological zones. The results of the trials will be used to identify the species and varieties of alternative hosts that could effectively maintain populations of susceptible insects within refugias, which would mate with potential Bt-resistant insects from the Bt maize plots. In actual practice, it will be important to stress to farmers the importance of suitable management practices such as cutting regimes for the alternative hosts, based on stem borer development. Harvesting the host plant species at the appropriate time ensures that the insect pests complete their life cycle and that the desired inter-mating occurs.

The plants in the trials will be artificially infested with borer species found in the area and data will be collected on the number of egg batches per plant, number of damaged plants, number of larvae, exit holes, number of surviving adults that emerge, and tunnel length. Daily temperatures and rainfall, noteworthy environmental variables, will be recorded. Surveys will be conducted in various agroecological zones to estimate the percent area under alternative hosts and determine which alternative hosts are preferred by farmers.

—**Margaret Mulaa, David Bergvinson, and Stephen Mugo**; KARI entomologist, CIMMYT entomologist, and IRMA project coordinator, respectively.

Do you have a question or comment about the IRMA project or the quarterly newsletter articles? Or perhaps you have an article you would like to contribute. If so, please contact the IRMA Quarterly Newsletter editor at d.poland@cgiar.org or IRMA Coordinator Stephen Mugo (see contact information on this page).

Contacts

CIMMYT-Kenya
Drs. Stephen Mugo and
Hugo De Groote
P.O. Box 25171, Nairobi, Kenya
Tel: (254) 2-522878
Fax: (254) 2-522879
Email: s.mugo@cgiar.org;
h.degroote@cgiar.org

KARI
Dr. John S. Wafula
Kenya Agricultural Research
Institute (KARI)
PO Box 57811 Nairobi, Kenya
Tel: (254) 2-583343 (direct) or
2-583301-20
Fax: (254) 2-583343
Email: jswafula@arcc.or.ke

CIMMYT-Mexico
Dr. David Hoisington
CIMMYT, Apdo. Postal 6-641; 06600
Mexico D.F., Mexico
Tel: (52) 5-804-7575
Fax: (52) 5-804-7567
Email: d.hoisington@cgiar.org

Novartis Foundation for Sustainable Development
WRO.1002.11
CH-4002 Basel, Switzerland
Tel: 0041 61 697 72 00
Fax: 0041 61 697 71 04
Email:
foundation.novartis@group.novartis.com