KARI
CIMMYT

IRMA Updates
Insect Resistant Maize for Africa

June, 2003 Vol. 4, Issue 1+2

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 Syngenta Foundation for Sustainable Agriculture.

IRMA Gets Positive Marks from External Review Team

An external review team charged with evaluating the IRMA project's progress since its inception gave it high marks, noting that its "achievements have been remarkable and excellent work has been done by a highly motivated team." However, the team also noted that the product had not yet reached farmers, that the timeline for doing so had been "grossly underestimated," and that many factors had contributed to the delay, some beyond the control of project participants.

The external review team was made up of Prof. Walter Alhassan (Ghana), who served as team leader and formerly held the post of Director General, Ghana Council for Scientific and Industrial Research; Prof. Norah Olembo (Kenya), then Director of the Kenya Industrial Property Institute; Mr. Al Imfeld (Switzerland), a free-lance journalist and expert in development with studies and specialization in sociology, tropical agriculture and rural development; and Dr. Jost Frei (Switzerland), team facilitator and consultant for the Syngenta Foundation for Sustainable Agriculture.

The team undertook its exhaustive 12-day review 2-14 February 2003, during which it conducted numerous interviews with CIMMYT and KARI staff, a wide array of stakeholders (ranging from farmers to traditional donors to private companies), and government officials. The team also conducted on-site inspections of project activities and facilities and reviewed projects documents and literature.

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IRMA II Business Plan Developed

More than 30 Representatives from KARI, CIMMYT, the Syngenta Foundation for Sustainable Agriculture, and the Kenya Ministry of Agriculture and Rural Development (MOARD) met from 11 to 23 May in Nairobi to hammer out a business plan for the second phase of the IRMA project.

The business plan stemmed from the IRMA External Review Team's recommendation that KARI and CIMMYT produce a detailed business plan, complete with detailed timelines, target dates for product deployment, and budgets, and present it to the Foundation by May 2003.

IRMA II retains the goal of providing Kenyan farmers with their first insect resistant maize varieties. The plan for phase II is based on a business model that ensures the products are delivered in a timely manner and addresses the needs of the client—the Kenyan farmer. The plan retains 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, including the conversion of local farmer varieties.

To ensure the safe release, adoption, and stewardship of these products, three project themes will run concurrently: product development, product delivery, and product stewardship. Each theme is interdisciplinary and involves a team comprising entomologists, biotechnologists, breeders, economists, communications experts, IP counsels, extension officers, policymakers, regulatory officials, and most importantly, Kenyan farmers.

Research in IRMA II fits within the broader research plans and capabilities of both KARI and CIMMYT. KARI is involved in a number of projects geared toward addressing various constraints to maize production in Kenya, in order to increase overall productivity. The involvement of KARI Research Center directors in all of these projects (and many KARI scientists work on multiple projects), affords a unique opportunity for the integration of breeding efforts to produce products for Kenyan farmers with a host of value added traits. It is noteworthy that many of KARI's stress-targeted projects in maize improvement are carried out in collaboration with CIMMYT, which further enhances the integration of the diverse activities into a cogent overall approach.

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(IRMA Gets positive cont'd...)

The items of inquiry and findings of the team follow:

1. Evaluate the goal, purpose and objectives of the program and its respective sub-programs.

The team observed that the "goal of insect resistant maize production appears simple yet more complex to address. It is multi-dimensional and needs to cover many equally important limiting factors like drought and soil fertility. The project must by necessity be long term to deliver the desired product."

2. Evaluate the specific, organizational, institutional, capacity and infrastructure development, selection and engagement of stakeholders, and regulatory/legal (including handling of biosafety issues) approaches taken.

The team stated that the "scientific work done is very good," progress on infrastructure development has been "satisfactory," and that the project has successfully addressed potential shortcomings in the regulatory framework, as well as environmental concerns. Stakeholders, likewise have been successfully engaged. However it was noted that there was a "need for free information flow between project scientists, extension staff of the MOARD and farmers." They also commented that ongoing training would be required at various levels to meet the staffing requirements of the project. They added that with regard to Material Transfer Agreements, it is important to consider issues related to liability.

3. Evaluate the progress and achievements accomplished so far.

"On the whole the project has been a success," the team report states, but "the target product is yet to be delivered and could take about five more years." Among the reasons given for the delay was the time required for working a new type of application through the Kenyan regulatory process and delays in the construction of the biosafety greenhouse facility. The team recommended the initiation of a second phase of the project to enable delivery of insect resistant maize to farmers. The team also noted a long list of milestones acheived by the project ranging from infrastructure and human capacity development to the identification of genes effective against Kenyan stem borers.

4. Identify the lessons learned from the design, implementation and resource management of the program that will be relevant to other organizations and countries embarking on similar endeavors and to provide input into the design of the next phase of the program.

The main lesson learnt cited by the reviewers was that there are a host of factors that act as constraints in a project involving genetically modified crops that would not come into play in conventional agricultural projects. They stated that "Uncertainties of product development of the nature of the IRMA project are many and include those of the regulatory process and general bureaucracy. Due to these delays the hopes of beneficiary farmers should not be heightened unduly." Communication, public awareness activities, and extension involvement with farmers, they added, should be implemented at the early stages of the project. Also, "product acceptability and marketability should be considered even before product development. This is borne out of the anxiety expressed by farmers on market availability for Bt maize."

The way forward

In putting forth its ideas for the way forward, the team strongly recommended support by the Syngenta Foundation for a Phase II of the project, while stating that other development partners and donors be brought on board. They proposed that a business plan be developed for the next phase, including a realistic timeline for delivery of products and identification of possible constraints to reaching those targets. KARI, they said, should take on a greater role in project management and better integrate IRMA into their overall maize improvement program. Strong emphasis was given to disseminating information about IRMA to other African countries through more widespread distribution of video, brochures, fact sheets, and an updated website.

Bringing it all back to the farmer, the team's report declares "The Syngenta Foundation, KARI and CIMMYT and the whole of Africa [will] have chalked up a historic milestone with the delivery of an insect resistant germplasm to the small-scale farmer borne out of cutting edge technology mastered and applied by African scientists."

– S. Mugo, D . Poland , and D. Hoisington

The IRMA External Review Team at the Kiboko Open Quarantine Site. From left to right: Mr. Al Imfeld, Prof. Norah Olembo, Dr. Jost Frei, and Team Leader Prof. Walter Alhassan.

(IRMA II Business cont'd...)

The first OPVs containing conventional insect resistance will be available to farmers in 2005. Improved hybrids will follow in 2006. Private sector partners will be identified early in the project to handle the commercial production of seed. The first Bt-based products—insect resistant farmer varieties—will be available in 2007. The converted farmer varieties are of particular interest for several reasons: (1) They will serve as "proof of concept" to the farmers and general public. These varieties will grow, look, and taste exactly like the local farmer varieties, the only difference being that they are insect resistant. (2) They will address the criticism that the benefits of biotechnology do not reach resource-poor farmers. And, (3) they will counter criticism that GM techology and "big business" are synonymous. Bt hybrids will be made available in 2008, and Bt OPVs in 2009. Delivery of these products by the deadlines is subject to a number of assumptions and associated risks. In developing the business plan, these key assumptions were considered and contingency measures proposed.

Intellectual property rights (IPR) issues must be addressed. Based on studies carried out by SWIFT-Cornell and CIMMYT's IP counsel, it is expected that full approval will be obtained to allow the IRMA project to deliver Bt maize to Kenyan farmers and partners with no restrictions and at no additional cost. CIMMYT and KARI counsels, however, will maintain a watching brief on the various IP related issues that could affect the IRMA project.

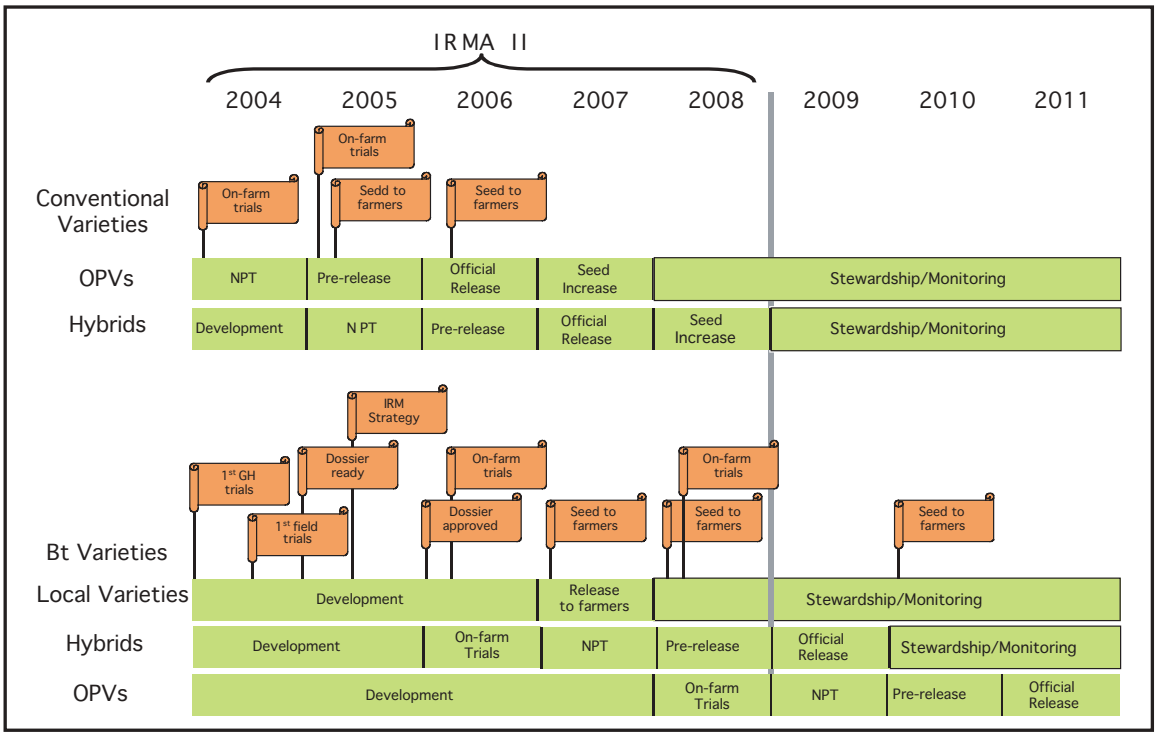
As with any new product, public awareness and education are essential to the acceptance and use of Bt maize. Promotion will be approached from several different angles to ensure that scientifically sound information on the benefits and risks of Bt maize is delivered to key interest groups (policymakers, extension, media, farmers, and consumers). Technical material will be developed and distributed to extension, farmer groups, and NGOs to train farmers how the technology works and on its stewardship.

Product stewardship, the management of the technology to ensure its proper use and extend its functional longevity, will require the implementation of insect resistance management (IRM) strategies, and monitoring of resistance buildup, nontarget organisms, and gene flow. The predominant strategy for minimizing the development of Bt-resistant insect biotypes is the use of refugia, non-Bt plants that maintain a breeding pool of susceptible insects. Geographic information systems (GIS) will be used to map the availability of refugia identified in IRMA I, in different maize-growing districts in Kenya. Collaboration will be sought with advanced research institutes for nontarget insect studies, alternative refugia strategies, and environmental impact studies.

Following the release of Bt and conventional insect resistant maize, continuous ex ante evaluations will be conducted using baseline data collected during IRMA I. Farmers surveyed in those baseline studies will be revisited in the final year of IRMA II to assess adoption of improved maize varieties and economic impacts.

IRMA II's primary emphasis is on delivering products, however, it will also produce a number of "firsts" for Kenya: (1) the first Bt maize field trials; (2) a complete dossier of environmental, food, and feed safety data for the *cry1Ab* and *cry1Ba* gene products; and (3) extensive experience for Kenyan scientists, officials, stakeholders, and farmers in the development, delivery, and stewardship of conventional and Bt-based insect resistant maize varieties. These accomplishments will be in addition to the establishment of the first operating level-2 biosafety greenhouse in East Africa.

– D . Poland, S. Mugo, and D. Hoisington



Timeline for IRMA II.

IRMA News Spots

- It was an outstanding first half of 2003 for **Dr. Benjamin Odhiambo,** who assumed three new positions during this period. The Director KARI appointed Dr. Obdiambo to be the IRMA Co-coordinator, the Center Director, KARI Biotechnology Center, and the Head of the Biotechnology Program in KARI. Congratulations Ben from your IRMA colleagues!

- **Dr. Stephen Mugo** presented the IRMA approaches to biosafety to the workshop on "Developing National Biosafety Systems: Identifying Critical Decision Points and Information Requirements," organized buy ASARECA, ISNAR, CTA, and BIOEARN. The goal of the workshop was to contribute to the design and implementation of functional biosafety systems in East and Central African countries.

- Farmer evaluations of 36 stem borer resistant maize synthetics were conducted at Kiboko, Embu, and Kakamega. These were also grown for agronomic measurements at Mtwapa, Katumani, and Muguga. The best of these will be nominated into the National Performance Trials (NPT) in early 2004.

- Gene flow studies were grown at Kitale, Mtwapa, Kakamega, and Embu using white and yellow endosperm maize cultivars grown in four directions to estimate distances and directions to which the xenia effect will be detected in the white endosperm cultivar, as a measure of distance and direction that pollen moves. A three replication design was adopted.

- The IRMA project was presented at the National Agricultural Biotechnology Council (NABC) Symposium "Biotechnology: Science and Society at Cross Roads (NABC 15)", June 1-3, in Seattle, Washington, USA. **Dr. Christopher Ngichabe** (Former CD KARI Biotechnology Center and currently with ASARECA) presented the African situation. **Dr. David Hoisington** highlighted the unique features of the IRMA project. The IRMA project video, "Smart Seeds: Insect Resistant Maize for Africa" was also screened. The presentation will be published in the NABC Conference proceedings.

- A poster on the IRMA Project entitled "Meeting the Challenges in the Development and Deployment of Insect Resistant Maize using novel technologies: The IRMA project approach" was presented by Charles Mutinda at the **Arnel R. Hallauer International Symposium on Plant Breeding, Mexico City 17-22 August, 2003**.

- The KARI biosafety level II greenhouse was inspected on 22 July 2003 by a team comprising of KEPHIS and NBC members. The team noted that the construction is going well and emphasized that (1) the water in the moats should be managed well, (2) a pit be should be provided within the precincts of the greenhouse for disposal of plant materials after autoclaving, (3) pollen screens should be carefully maintained to prevent clogging of the mesh, (4) used soil should be disposed of properly after sterilization, (5) future expansions need to be catered for in further planning, and (6) maintenance personnel need ongoing training.

- **Dr. Christopher Ngichabe** left KARI and joined ASARECA in Uganda.

- The IRMA Annual Project Meetings will be held 16–20 November 2002, at Hilton Hotel, Nairobi, Kenya as follows:

  - Sunday, Nov. 16 2003 - Arrival at Hilton Hotel, Nairobi
  - Monday, Nov. 17 2003 - Presentations of IRMA I by project teams
  - Tuesday, Nov. 18 2003 - Presentation of IRMA II to partners
  - Wednesday, Nov. 19 2003 - Stakeholders meeting and biosafety greenhouse visit (possible launching)
  - Thursday, Nov. 20 2003 - Steering Committee meetings & departures

– S. Mugo and D . Poland

KARI Staff Train at CIMMYT-Mexico Biotech Facilities

Two KARI staff, Mrs. Catherine Taracha and Mr. Murenga Geoffrey Mwimali, completed training at the Applied Biotechnology Center at CIMMYT-Mexico on 6 June and 6 September 2003, respectively.

The training was a tangible component of the IRMA focus on enhancing human resource capacity hand-in hand with the development of infrastructure. The intensive training undertaken by Taracha and Mwimali provides KARI with a firm foundation for running its level-2 biosafety greenhouse, due for completion in the latter part of 2003. Much of what the two staff learned will be directly applicable to IRMA project activities: tissue culture and plant regeneration, plant genetic transformation / bombardment, molecular techniques and phenotypic screening of transgenic plants, and biosafety greenhouse management.

However, there is need for further training in biosafety and biocontainment aspects, intellectual property rights aspects, molecular markers in screening, diagnostics, and mapping of maize and other related areas for the scientists for capacity building and enhanced output in the same.

Taracha explains that the main purpose of the biosafety procedures is to prevent the unintentional escape of the pollen into the environment and to ensure the integrity of the final products. The proper management of a biosafety greenhouse entails the following: restricted access to authorized personnel only; mandatory use of protective clothing; posting of signs on doors indicating restricted access, experiments in progress, responsible personnel, and special requirements; restricted seed storage and tight inventory of all seeds; termination, decontainment,

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(KARI Staff Train cont'd...)

incineration and disposal of experimental material and soil; a pest control program; and decontamination of all protective clothing and implements before they leave the biosafety greenhouse.

Mwimali commented on the complexity of producing transgenic plants. In addressing the problem of continuous embryo production for the transformation experiments, pollination of the transgenic plants should be adhered to following "step-wise considerations": ear shoot bagging, cutting back the ear, tassel bagging for collecting pollen and pollination, and dating of tassel bags.

Following the training, the two staff made the following recommendations: (1) The training of KARI scientists in the genetic engineering and plant transformation protocols and also biosafety greenhouses should be continuous and for six months at minimum, and should include theory and lectures in addition to rigorous hands-on laboratory work, (2) There is a need for further training through short-term courses on biosafety and biocontainment, intellectual property rights, etc., given locally or regionally, to expose scientists from KARI and other collaborating institutions to these aspects of the work, (3) The production of transgenic plants (primarily maize) is a reality; scientists must extend their knowledge to encompass the economic, social and legal implications of plant transformation.

– C. Taracha, G.M. Mwimali, and D . Poland

KARI staff training at CIMMYT Mexico demonstrate and discuss biosafety greenhouse management procedures with the Director of KARI and visitors from CIMMYT-Kenya. From left to right: Mrs. Catherine Taracha (trainee), Dr. Stephen Mugo (IRMA Co-coordinator), Dr. Alpha Diallo (Head of Office, CIMMYT-Kenya), Dr. Romano Kiome (Director of KARI), and Mr. Murenga Geoffrey Mwimali (trainee).

KARI Committee Approves Application for Introduction of Bt Maize Seeds

An "Application to Introduce Maize Seeds Containing the Bt Genes *Cry1Ab* and *cry1Ba* for Evaluation, Seed Increase and Crossing into Other Maize Lines under Biosafety Greenhouse Containment" was approved 26 June 2003 by the KARI Institutional Biosafety Committee (IBC) and recommended for consideration by the Kenya National Biosafety Committee (NBC).

The application seeks approval and permission to import / introduce seeds of maize genetically modified with *Bacillus thuringiensis* (Bt) genes. These genes confer resistance to the larvae of Lepidopteran insects pests, especially maize stem borers. The seeds will be used to verify, using whole plants, earlier results obtained from cut leaf bioassays carried out in the NARL biosafety laboratory. The specific objectives of the proposed experiments are to

- Evaluate under greenhouse conditions the effectiveness of the *cry1Ab* ad *cry1Ba* genes against target stem borer species and other insects;
- Produce leaf material for use in carrying out laboratory leaf bioassays of all the events against the five borer species used in the first bioassays; and
- Produce seed increases and crosses for future experiments in the biosafety greenhouses.

The biosafety level-2 greenhouse complex where the seeds will be grown and tested for resistance to the Kenya stem borer species is currently under construction at the KARI Biotechnology Center at NARL, Kabete.

The KARI-IBC process started in April 2003 when the application was lodged, and approval followed three subsequent committee sessions. IRMA Coordinators Benjamin Odhiambo and Stephen Mugo appeared before the committee to respond directly to various issues raised by committee members. This is a departure from the past when applicants would only respond in writing, a process that resulted in significant delays.

Another welcome development is the adoption by the IBC of a more structured and systematic method for reviewing and evaluating applications. Through this process, issues of concern are identified, the likelihood of each occurring is estimated and evaluated, the management of suggested risk is considered, and an overall conclusion is reached as to whether the particular risk is acceptable.

The issues of concern raised by the KARI-IBC on the Bt maize seed application were

1. Handling of imported seed in transit,
2. Handling of harvested seed in storage,
3. Pollen control in the greenhouse,
4. Disposal of plant parts, insects, soil, and disposable materials, and
5. Gene components.

After considering the risks associated with these issues, the committee concluded that the risks are acceptable and recommended the NBC consider the application for approval and issuance of import permit subject to completion and approval of the biosafety level-2 greenhouse complex.

– S. Mugo, B. Odhiambo, and D. Hoisington

Surveys of Natural Refugia for Stem Borers

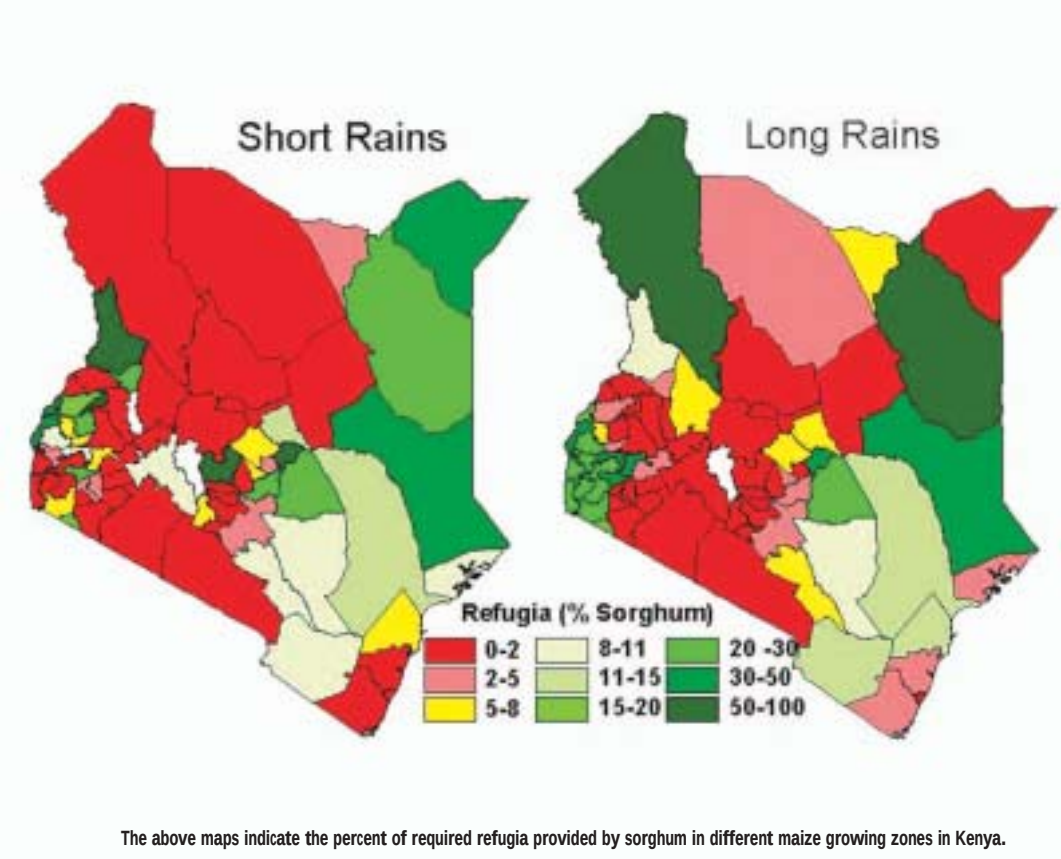
Refugia are a key requirement for maintaining the efficacy of Bt maize. IRMA scientists, in collaboration with the Ministry of Agriculture, are presently quantifying the extent of natural refugia for stem borers in the Kenyan maize growing regions.

The scientists and MOA collaborators are looking for alternate hosts for stemborers, which will likely play a key role in ensuring sufficient numbers of moths are available to inter-mate with moths that have managed to survive on Bt maize. This strategy is designed to reduce the rate of resistance development of stemborer populations to Bt maize. Ideally, an area equal to at least 20% of the area planted to Bt maize should serve as a refugia, consisting of maize, sorghum, or broad stemmed grasses.

Under the IRMA project, a survey questionnaire was developed in 2002 and used to interview farmers in both Trans-Nzoia and Mombasa districts to estimate the area planted to suitable alternate hosts and to characterize the farming systems. For the Trans-Nzoia district, commercial farmers account for most of the land-base and generally plant more than 90% maize. Commercial farmers currently have less than 5% natural refugia, thus requiring structured refugia, which entails planting non-Bt maize in close proximity to Bt maize. Mombasa district, a costal district with a diversity of cropping systems, was very different and appears to have adequate refugia at the district level of 18%. From these surveys, we have learned that the natural refugia will shift between the long- and short-rain cropping seasons and between districts.

The MOA made available the crop production figures at the district level for both maize and sorghum for 2001. By mapping the percent area planted to sorghum relative to maize for the two cropping seasons (see figure), we see that the districts that would likely have enough refugia based on sorghum alone. However, the Mombasa survey indicates that although sorghum alone does not provide sufficient refugia, there was enough refugia when fodder grasses were included. Based on these maps, we have redefined the areas to be surveyed to ensure the changing vegetation patterns are reflected in the diverse agroecologies where Bt maize could be planted. The districts that have now been added to the survey include: Kakamega, Burgoma, Teso, Mt. Elgen, Bureti, Kisii, Migori Kirinyaga, Embu, Marakwet, and Muchacos.

– M. Mulaa, D. Berguinson, and S. Mugo



The above maps indicate the percent of required refugia provided by sorghum in different maize growing zones in Kenya.

Farmers and Biosafety Committee Leaders Participate in Kiboko Mock Trials

The open quarantine site (OQS) facility at Kiboko, developed under the auspices of the IRMA project, was accorded full quarantine status in January 2003. Mock trial have been conducted there since Sept 2002 to train staff in the management of such facilities, demonstrate the efficacy of the quarantine measures related to gene flow, and to calibrate physical parameters for various activities.

IRMA coordinators originally planned for KEPHIS officers to attend the trainings, including the important harvest operations. This was later extended to include a special visit for members of the National Biosafety Committee at harvest time, to directly demonstrate the capacity of the OQS team to follow the set procedures and manage a quarantine site to the highest standards. The visit took place on 21 May 2003 and provided ample opportunity for NBC and KEPHIS representatives to exchange observations and views with scientists and local farmers and community leaders.

Training provided to staff at the Kiboko OQS includes routine management, enforcement of restricted access, disposal of plant and insect tissue, detasseling, irrigation, experimental design and lay out of trials. A formal training was held at the OQS early this year, while a seminar for local KARI support staff, KARI scientists, local community leaders, and farmers was held in December 2002.

In one of the mock trials, 20 yellow endosperm inbred lines of sub-tropical adaptation represent transgenic maize and are grown, half of the rows infested with *Chilo partellus* stem borer while another row is protected. All yellow inbred line plants are detasseled to avoid crossing among themselves and to the perimeter borders planted with a hybrid. The border rows are detasseled as well. Every morning check each plant is checked to ensure that no tassel or part of it remains on the plant long enough to shed pollen. This is the most important training activity in the mock trials.

The visitors witnessed the thoroughness of operations at the OQS. Notably, no yellow endosperm seeds were recovered from the white border rows, thus confirming that the detasseling operation in the test rows was very well executed.

Participants in the May meeting included Mr. Philip Mwongela, farmer-Kiboko; Dr. D.K. Musembi, KARI / Kiboko; Mr. Samuel Maundu, farmer-Kiboko; Mr. James K. Muithya, farmer / Assistant Chief-Kiboko; Mr. Jonathan Mutisya, farmer-Kiboko; Mr. Harrison Kyumu, farmer; Mr. George Nyamai, Chief-Kiboko; Mr. Wilson Muasya, KARI / Kiboko; Mr. D.M. Mutinda, KARI / Kiboko; Mr. Benson Kuria, Plant Inspector / KEPHIS; Mr. Omunyitsi Nassir, Plant Inspector / KEPHIS; Mr. H.K. Macharia, NCST, Member NBC; Mr. J.K. Ng'eno, Deputy Director / MOARD, Member NBC; Mr. H. Karaya, Student, University of Nairobi; Dr. S. Mugo, CIMMYT-Kenya; Mr. Musau MOARD Driver; Mr. Robert Musyoka, KARI / NARC.

– S. Mugo, W. Muasya, and D. Mutinda

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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 (s.mugo@cgiar.org).