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CGIAR

RESEARCH PROGRAM ON
Maize

Contents

Message from the CRP MAIZE Director

During 2016, the CGIAR Research Program on Maize (MAIZE) made strong progress on both of its research strategies, stress resilient and nutritious maize, and sustainable intensification of maize-based systems. In total, 111 improved maize varieties based on germplasm from MAIZE lead centers, the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute of Tropical Agriculture (IITA), were released through MAIZE partners in 2016. These include 76 in sub-Saharan Africa, 27 in Latin America and 8 in Asia. Besides high and stable yield potential, some of the special traits stacked in these varieties include drought tolerance, nitrogen use efficiency (NUE), tar spot complex (TSC) resistance, Quality Protein Maize (QPM), increased provitamin A content (through the CGIAR Research Program on Agriculture for Nutrition and Health - A4NH), ear rot or mycotoxin resistance and Turcicum leaf blight resistance, among others.

-To view an interactive version of this map, click here.

Over 5.5 million hectares were under improved MAIZE-derived technologies or management practices in 2016 as a result of CRP research; directly reaching more than 11 million smallholder farmers. As we transition into Phase II (2017-2022), MAIZE remains committed to finding sustainable solutions to the challenges faced by smallholder farmers around the world.

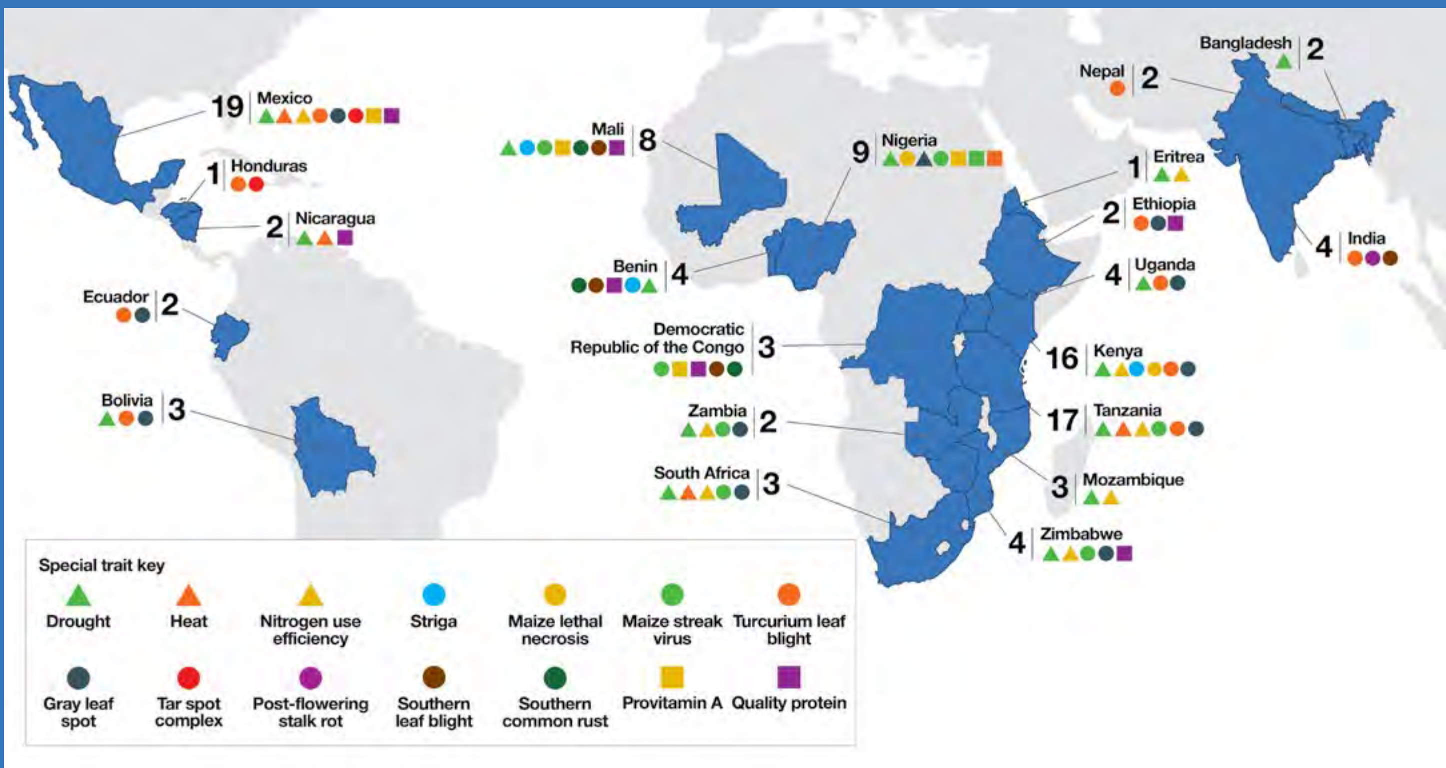
From emerging pests and diseases such as fall armyworm and maize lethal necrosis, to drought and heat stress that threaten livelihoods and food security, MAIZE and partners are working together to help farmers feed our growing population under a changing climate. We would like to extend our deepest thanks to our donors, without whom none of this work would be possible.

Thank you to all who have supported and followed our work throughout Phase I (2012-2016), we look forward to sharing our updates and achievements with you in the years to come.

BM Prasanna

B.M. Prasanna,

Director, CGIAR Research Program MAIZE



Improved maize varieties released by MAIZE partners in 2016, with depiction of some special traits. The map includes eight provitamin-A enriched varieties based on MAIZE germplasm that were released under A4NH CRP in Latin America and sub-Saharan Africa (1 in Mexico, 7 Mali,3 in DRC, and 1 in Nigeria) in 2016.

Drought- and heat-tolerant maize for Asian tropics

In May 2016, India recorded its highest temperature ever when a town in the western state of Rajasthan reached 51 degrees Celsius. The searing heat across South Asia critically damaged crops and destabilized food security in the region. In continuous drought hit years of 2014 and 2015, 330 million people in India across 10 states were affected. To address such repeated catastrophes, CGIAR Research Program on Maize (MAIZE) scientists have been hard at work to develop and deploy heat- and drought-tolerant maize varieties specific to the region for the vulnerable smallholder farmers that need them most.

Across South Asia, MAIZE scientists with the Heat Stress Tolerant Maize for Asia (HTMA) project made great progress on variety development and deployment in 2016. The project licensed 18 new heat- and drought-tolerant hybrids to partners for deployment and scale-out, including both public and private sector institutions.

HTMA seed partners at commercial seed production field at Kaveri seeds, Jiyanpur, India.

"Temperature increases associated with climate change and high vapor pressure deficit, or less water content in air, pose huge pressure on irrigation water. During periods of heat and drought stress, farmers are forced to increase the frequency of irrigation to save the crop from drying out and to prevent yield loss," said P.H. Zaidi, maize physiologist and breeder working with the HTMA project.

"Water use efficient drought- and heat-tolerant maize hybrids have significant potential to reduce irrigation frequency, which in turn will help reduce high-energy consumption and other detrimental effects on the environment and increase available water for agricultural purposes".

Twelve new seed companies, including five each from Pakistan and Bangladesh and two from Nepal, signed research collaboration agreements and formally joined the project. In addition, a joint hybrid initiative by CIMMYT and DuPont Pioneer under HTMA helped in identifying promising combinations, and DuPont Pioneer selected two hybrids for further large-scale testing.

As women now make up over 50 percent of the agricultural labor force in Bangladesh and more than 60 percent in Nepal, HTMA is working to ensure that female farmers get equal opportunities as their male counterparts in training and capacity building. Under the HTMA project, special emphasis was given on participation of both male and female farmers, especially in on-farm demonstrations, and during various capacity development activities such as trainings, workshops and refresher courses organized under the project.

A total of 16 students, including 7 M.Sc. and 9 Ph.D., received long-term training under the project. Over 400 scientists, including 304 male and 98 female participants, received short-term trainings through 12 training courses organized on various topics of importance to developing heat- and drought-tolerant varieties, including precision phenotyping, genomic selection, digital data management and seed production.

The Affordable, Accessible, Asian (AAA) Drought-Tolerant Maize Project – a public-private partnership involving CIMMYT, Syngenta, and national partners from Vietnam and Indonesia – has identified 3 drought-tolerant hybrids for deployment in the targeted west central zone of India. This region includes drought prone and tribal areas, a high risk environment where farmers require improved low-cost seed.

This target area covers more than 1.5 million hectares in India, which translates to a seed market potential of about 34,000 metric tons and offers the opportunity to address the needs of over two million households. The region's climate and other dynamics make seed marketing risky, unpredictable and unattractive, meaning that it is often overlooked by the private seed sector – exactly the kind of underserved area MAIZE seeks to target. The project plans to market a limited quantity of hybrid seed in 2017 followed by a full market launch in 2018.

A 2016 assessment study on the impact of current and future heat stress on maize and benefits of heat-tolerant varieties in South Asia found that, if current trends persist, much of the region is likely to experience an average yield reduction of up to 15 percent in 2030 and 25 percent in 2050. However, regional simulations conducted by the study indicated that by improving heat tolerance alone, it is possible to reduce maize yield loss by up to 36 and 33 percent under rainfed conditions and by 93 and 86 percent under irrigated conditions in 2030 and 2050, respectively. This suggests that heat-tolerant maize varieties have the potential to shield farmers from severe yield loss due to heat stress and help them adapt to climate change impacts.

Delivering stress-tolerant maize for climate resilience

Evidence from climate simulation studies presents an alarming picture of developing country maize production in the decades to come. Higher temperatures, as well as more severe and frequent droughts, are predicted to seriously undermine national food security and rural livelihoods. For example, the results of a study using big data in refining the geospatial targeting of new drought-tolerant (DT) maize varieties in Malawi, Mozambique, Zambia, and Zimbabwe indicated that more than 1.0 million hectares (Mha) of maize in the study countries is exposed to a seasonal drought frequency exceeding 20 percent. To enhance the climate resilience of smallholder farming requires a mix of interventions, including new technologies as well as institutional innovations. Stress-tolerant maize varieties must form a central part of the mix, providing farmers with tangible insurance against crop losses.

Spatial modeling further shows that DT varieties give a yield advantage of up to 40% over the commercial check varieties across drought-prone environments. There is thus huge potential for marketing the new varieties in these countries and also wide scope for using big data analytical tools to enhance the targeting and uptake of this and other new technologies. CGIAR Research Program on Maize (MAIZE) researchers have put GIS tools to various other uses as well, such as mapping innovation and maize nursery sites (for integration into a unique digital maize atlas being developed by MAIZE) and updating climate change impact data for Mexico.

A key study estimating the impact of DT maize varieties in 13 target countries in sub-Saharan Africa, found that DT maize varieties outperformed popular commercial maize varieties grown in SSA in terms of main yields – DT maize varieties have more stable yields, which translates in a more stable income. The study comprised countries in eastern, southern and West Africa and focused on the period 2007-2016, a decade that shows the substantial investments and advances in DT maize development and uptake in target countries. Benefits were estimated to be US$395 million for producers and consumers in the aggregate target countries during the study period. The increased availability of data – including near-real-time remotely sensed drought measures and geo-referenced on-farm trial data – provides opportunities to select varieties which perform better under certain conditions leading to more robust and efficient technology adoption recommendations and targeting.

CIMMYT senior maize breeder Cosmos Magorokosho demonstrates the difference between new heat- and drought-tolerant hybrid maize and a susceptible hybrid at Chiredzi Research Station, Zimbabwe. Photo: Johnson Siamachira/CIMMYT

MAIZE researchers are gathering crucial evidence from adoption and ex post impact studies, which will help guide and muster support for continued development and dissemination of DT maize. Using new plot-level data from surveys of 3,700 farm households in Ethiopia, Malawi, Tanzania, Uganda, Zambia, and Zimbabwe, the researchers measured DT maize adoption rates and examined key factors that influence adoption. They found considerable variation in adoption between countries – from 9 percent in Zimbabwe to 61 percent in Malawi. In 2016, 6,705,000 farmers have benefited from MAIZE-derived varieties and 2,700,000 hectares were sown with these varieties. Boosting the uptake of DT maize will require that seed companies and agro-dealers redouble their efforts to expand seed supplies in local markets, with emphasis on selling seed in affordable 1 or 2 kilogram micro-packs. Major promotional efforts are also needed to raise awareness and understanding of the benefits of the new varieties, as the new varieties have great potential to reduce food insecurity and boost incomes at the household and national levels.

Farmer Appolonia Marutsvaka shows off her drought-tolerant maize cobs. Photo: Johnson Siamachira/CIMMYT

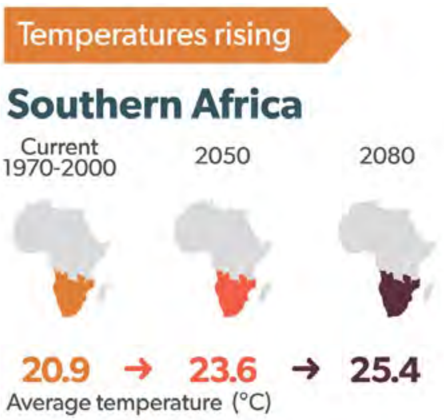
MAIZE is fast-tracking the development and dissemination of stress-tolerant varieties. New maize lines and varieties are constantly being developed and are connected to farmers through public and private sector seed system investments. A strong network has been created for rapid deployment of hybrids through public-private partnerships. These partners are commercializing MAIZE-derived varieties. Building on the successes of the International Maize Improvement Consortium for Latin America (IMIC-LATAM) and the International Maize Improvement Consortium for Asia (IMIC-Asia), a Consortium for sub-Saharan Africa (IMIC-SSA) is now being initiated.

As population growth, climate change impacts, and other challenges put increasing strain on the global food system, the development of advanced tools to guide decisions about food security at all levels is becoming ever more urgent. In collaboration with the International Food Policy Research Institute (IFPRI), University of Minnesota in the USA, Wageningen University in The Netherlands, and others, MAIZE researchers are contributing importantly to this end through new approaches to foresight, ex-ante impact assessment, and targeting of improved agricultural technologies.

In response to growing interest in the use of micro-level bio-economic models, researchers moved ahead with the construction of a prototype model for ex-ante impact assessment and presented this work to the international modeling community. The tool has great potential for helping target new technologies with greater precision, taking into account conditions such as the climate, soil, market access, and others. The challenge is to make the tool sufficiently generic and modular (using open-source software) that it can be applied widely by a growing community of modellers.

Combining stress breeding and conservation agriculture to mitigate climate change

Climate change and land degradation affect countries across the world, reducing crop yields and destabilizing food security. Extreme weather events such as El Niño further exacerbate this problem. According to the U.S. Agency for International Development (USAID), countries in sub-Saharan Africa (SSA) such as Malawi are particularly susceptible to these challenges due to high population growth, deforestation and soil erosion. Scientists with the CGIAR Research Program on Maize (MAIZE) are working to use climate smart technologies such as conservation agriculture (CA) and drought-tolerant (DT) maize varieties in conjunction to mitigate climate change and increase yields for vulnerable smallholder farmers.



To respond to the increasing threats of climate variability and declining soil fertility, MAIZE tested improved DT maize varieties in combination with CA in seven districts of Malawi. These efforts were conducted in collaboration with lead center CIMMYT and partners including Malawi's Ministry of Agriculture and Total LandCare, an NGO working in Malawi, with support from USAID's Feed the Future program. The trials were set up in a mother and baby trial design including 60 mothers (researcher-managed trials) and 360 babies (farmer-managed trials) across a range of agro-ecologies, farm types and environments.

Benefits of CA under drought (left) compared to conventional planting (right) in Hoya, Lundazi District, eastern Zambia.

Despite a strong El Niño in 2016 that left more than half of Malawi's population in need of food relief, farmers experienced a great response from CA systems and DT maize varieties. The best DT variety (Peacock 10) planted under CA demonstrated 66 percent higher yields in comparison with the best non-DT commercial variety (DKC80-53). This shows that a joint promotion of both of these climate-smart technologies, CA and DT maize varieties, can reap the benefit of both approaches as they are mutually re-enforcing.

Farmers were able to harvest comparably more maize than their peers in the 2016 cropping season while also spending 35-45 less labor days in the CA systems, where direct seeding was practiced, as compared to preparing conventional ridging and applying traditional weed control strategies. These multiple benefits preferentially benefit women and children who are usually tasked for this backbreaking work. Nepiyala Thope, a farmer from Chinguluwe, a small village in Central Malawi, appreciated the time she saved with CA. "We spend less time on the CA fields and use this time to expand our land area, relax at home, look after our children and make doughnuts to sell in the market and earn extra income. All of this benefits our households," Thope said.

MAIZE's work on GxExM, the genotype by environment by management interaction, spans from southern Zimbabwe to southern and central Malawi and eastern Zambia to support farmers with options they need to adapt to climate change. A study by MAIZE scientists published in 2016 on the benefits of CA and DT maize in Mozambique found that direct seeded manual CA treatments out yielded conventional tillage treatments in up to 89 percent of cases on maize. The study also found that improved DT maize varieties out yielded the traditional control variety by 26 to 46 percent (695–1422 kg ha–1) on different tillage treatments, across sites and seasons. In the future, as farmers will have to produce more food on less land in an uncertain climate, sustainable cropping systems and CA must be examined as viable options to improve food security and livelihoods.

In the second study, "Adoption and Impacts of Sustainable Agricultural Practices on Maize Yields and Incomes: Evidence from Rural Zambia," Manda et al. (2016) report that SAPs such as CA are essential in mitigating risks from climate change. For example, it was found that when practicing crop rotation and crop diversification (components of CA), farmers are sowing a diverse range of crops that can perform well under a range of environmental conditions and, due to different sowing dates and maturity periods of these crops, harvest produce at different times of year. This reduces the risk of total crop loss if drought strikes. Indeed, the retention of crop residue, another SAP, was found to be a vital factor in "improving the soil and retaining moisture especially in drought prone areas". The results of the Zambia study clearly suggest that "farmers are adopting these SAPs to reduce the effects of droughts" (Manda et al., 2016). The study goes on to recommend the need for policy interventions that promote the combined adoption of improved maize varieties and SAPs, such as a maize–legume rotation and residue retention, which can boost yields and farm incomes especially among resource poor farmers who cannot afford inorganic fertilizers.

Taking the science to the people: Real results

MAIZE researchers published 19 impact assessment studies in 2016. Two groundbreaking studies in Malawi and Zambia highlight win-win scenarios associated with the adoption of improved maize varieties and sustainable agricultural practices (SAPs):

In "Development of Conservation Agriculture (CA) Systems in Malawi: Lessons Learned from 2005 to 2014," Thierfelder et al. (2016) examine the impact of Conservation agriculture (CA), a combination of SAPs, on maize yields and small farmer incomes over the period 2005 to 2014. The study determined that the adoption of CA out yielded conventional ridge tilled control plots in Mwansambo and Zidyana Districts between 22 and 31 percent, respectively, and increased income by 50 and 83 percent, respectively. This was in part due to the fact that crops were produced with 28-39 less labor days ha-1 compared with the conventional practice. Successful extension of CA systems by Total LandCare, using innovation systems approaches, has led to significant out-scaling of this technology to more than 30,000 farmers on more than 14,000 hectares in Malawi in the last decade and this is expected to increase.

Value added makeover for traditional maize varieties

Mexico, known as the "cradle of maize", is home to much of the crop's genetic diversity. Across the country, smallholder farmers are the guardians of much of this diversity, planting "heirloom" maize varieties known as landraces. However, limited access to markets threaten farmers' ability to continue growing their traditional maize. The CGIAR Research Program on Maize (MAIZE) and partners are working to help smallholder farmers market their maize to national and international buyers at a fair price, improving lives and livelihoods while giving farmers stronger incentives to conserve valuable genetic resources in their fields.

Landraces are descendants of ancient maize varieties that have been handed down through generations and have adapted to different climates and regions of Mexico, developing special traits such as resistance to local stresses like drought, heat or disease, in addition to unique qualities and flavor that local communities prize for use in traditional foods. Not only is this genetic diversity crucial in the development of improved stress-tolerant maize varieties, the unique taste and colors of this ancient maize are now coveted by consumers around the world. However, many of the farmers that grow these landrace varieties live in marginalized rural communities with little access to larger markets. MAIZE and partners, such as the National Institute of Research on Forestry, Agriculture, and Livestock (INIFAP), are working to help change this.

As part of efforts to help organize smallholder farmers, researchers began training farmers to provide excess grain at a reasonable price negotiated on a group basis. In the past, many of these rural smallholder farmers have been forced to accept extremely low, unfair prices for their maize in order to have money for farming inputs such as labor and fertilizer, due to lack of access to formal markets. With funding from MAIZE, these farmers are learning how to access markets, based on knowledge of quality requirements, grain moisture and aflatoxin testing, and the use of hermetic bags to prevent insect damage during storage and transportation. Researchers also advise farmers on demand of specific maize color variants from culinary markets so that they can plant accordingly. One of the farmer groups sent its first container of nearly 20 tons of a local landrace to a company in the USA, which sells to more than 60 high-end restaurants. A major restaurant chain in Mexico has also approached the group of farmers.

"As rural smallholder farmers, we haven't been able to take advantage of the market on a larger scale," said Jaime Ariza Franco, one of the local farmers. "In the past we have only been able to sell in to local intermediaries, and sometimes have had to accept extremely low, unfair prices in order to feed our families. We know that our maize has incredible flavor and quality, and are excited that it will now be enjoyed and appreciated by an international audience."

Daniel Sanchez, the son of one of the farmers in the group, is hopeful about the prospects this partnership has for his family. He hopes to go to college to become an agricultural engineer, and now that his family has received the training necessary to sell to an international market, this dream could become a reality. "Before we could only sell our maize in Mexico at very low prices that didn't even cover our basic expenses. Now that we have access to better national and international markets, things will get better for my family."

A farmer in the farmer group helps load his traditional maize onto a truck that will be sent to high-end restaurants in the United States. Photo: Jennifer Johnson.

The culinary communities' interest in authenticity and traceability of product that supports small farm families has provided an opportunity to enhance smallholder farmers' profitability, while expanding knowledge and opportunities for conservation of Mexico's treasured maize germplasm diversity. The key has been the involvement of scientists with a depth of knowledge of the country's maize diversity and long-term links to smallholder farmers in communities that conserve this diversity of native maize.

It is very important that farmers can continue to plant and sell their native maize. "Maize is the base of our lives—it's not just our main income, it's our main food," said Sanchez.

More and better maize improves female farmers' livelihoods in India

Improved maize varieties and agricultural practices are changing the lives of female farmers and their families in the village of Badbil in the Mayurbhanj district of Odisha, India. Farmers in Badbil, a remote and deeply impoverished tribal village with high poverty and low literacy rates, have traditionally planted a local rice variety called Sathia. However, rice production is declining due to regularly occurring droughts and declining rainfall, leaving much of Badbil's agricultural land fallow. Scientists with the CGIAR Research Program on Maize (MAIZE) are working to help farmers use suitable maize hybrids and agricultural technologies to increase agricultural productivity in drought-prone Odisha.

Maize yields in Badbil have traditionally been low due to the use of unimproved varieties, traditional sowing methods and lack of information about good agronomic practices, especially weed and nutrient management. This particularly affects children, as maize cake is a common breakfast and snack for children in the area, and low maize production often means they receive less food. To address this issue, the Cereal Systems Initiative for South Asia (CSISA) has been working with women's self-help groups in Badbil since 2013 to promote the uptake of better agronomic practices, such as sowing with a seed drill and applying site-specific nutrients, and identify the best performing maize hybrids.

Women farmers in the plateau region of Odisha play an integral role in increasing maize productivity. Photo: Srikanth Kolari/CIMMYT

In 2016, ten self-help groups composed of 105 women members cultivated hybrid maize in a total of 80 acres at Badbil village up from 30 acres in 2015, increasing the area under hybrid maize cultivation by more than 150 percent.

Children enjoy fresh maize cobs grown by their mothers. Photo: Wasim Iftikar/CSISA.

Around 100 tons of dry grain were purchased from the women's self-help groups by a poultry feed mill at a price of Rs. 15,000 (USD $233) per ton, giving the groups a net profit of Rs. 18,000 to Rs. 20,000 (USD $280-$310) per acre, an excellent return on investments.

These improved maize yields are helping female farmers not only increase their income, but also their family's food security. "In addition to selling dry grain, we fed roasted maize and maize cake to our family members during the rainy season, besides distributing green cobs to neighbors and relatives for consumption," said Jobha Murmu, a member of the Johar Jaher Ayo self-help group.

CSISA-led interventions, jointly with Odisha's Department of Agriculture, have supported the groups in adopting improved practices such as mechanized line sowing using seed drills, application of pre-emergence herbicide, controlling weeds using power weeders and nutrient application management, as well as in the marketing and selling of dry grain.

The work of self-help groups in Badbil on converting unused fallow land into productive cultivable land through maize farming has become a successful example for many farmers in neighboring areas. Their success story was published on the front page of a leading local newspaper, 'The Samaja,' on September 15, 2016, entitled "Women farmers produced gold in plateau." Because of this work, this remote village is now known for turning fallow lands into golden maize.

In 2016, CSISA directly supported maize cultivation with the use of best management practices in more than 4500 acres in the Mayurbhanj district, a nearly 200 percent increase over 2015. Because of this work, maize farming in the region has changed from labor intensive and less profitable traditional practices to modern, efficient agricultural techniques with higher yields, and has asserted women's fundamental role in the agricultural sector.

Members of the self-help groups apply potash fertilizer to maize fields after sowing. Photo: Wasim Iftikar/CSISA

Increasing resistance to maize lethal necrosis

As deadly maize lethal necrosis (MLN) disease continues to decimate crops across eastern Africa, it is crucial to develop new maize varieties with tolerance to the disease. According to a community survey held in 2016, annual maize losses due to MLN are estimated at 0.5 million tons in Kenya alone, 22 percent of the average annual production before MLN, with a value estimated at $180 million. CGIAR Research Program on Maize (MAIZE) scientists have made exciting progress against MLN in 2016 on many fronts, from developing and deploying MLN tolerant varieties to the development of innovative technologies, such as standardized MLN survey and sampling protocols and digital surveillance tools. Information management was enhanced with the launch of the MLN information portal and establishment of a MLN Phytosanitary Community of Practice. Strategic capacity building took place via training of personnel from National Plant Protection Organizations (NPPOs) in eight countries in eastern and southern Africa in 2016.

When MLN first struck in Kenya in 2011, MAIZE and its partners immediately launched intensive efforts to identify and develop MLN-tolerant maize hybrids, while developing the capacity of partners to identify sources of MLN resistance.

Since then, MAIZE researchers and their partners have screened nearly 100,000 germplasm entries from all over the world at the specially constructed MLN screening facility in Naivasha, Kenya in search of maize varieties with natural resistance to the disease. The first phase of these evaluations focused on

Maize leaf infected with MLN.
Photo: CIMMYT

existing released varieties and materials in the elite breeding pipelines, however, over 95 percent of these materials have proven susceptible to MLN.

MLN leaf testing. Photo: CIMMYT

A strong pipeline of new MLN-tolerant/resistant MAIZE hybrids has been established, as shown by trials conducted in 2016 that compared 18 first-generation MLN-tolerant hybrids and 19 second-generation MLN-tolerant/resistant hybrids to the 9 most popular commercial hybrid checks in the region. Scientists found that the commercial check hybrids were highly susceptible to MLN under artificial inoculation, giving a mean yield of 0.69 tons per hectare (t/ha), while the mean grain yield of the first-generation and second-generation hybrids under MLN artificial inoculation were 3.41 and 4.49 t/ha. This significant yield increase can help improve the food security and livelihoods of farmers that have suffered crop losses from this disease. While the percentage of tolerant material discovered was low, since 2015 the MAIZE team has succeeded in releasing a number of MLN-tolerant maize hybrids in eastern Africa, including five released through partners in 2016 and 22 currently under development. For example, in 2016, the NASECO seed company commercialized nearly 20 tons of certified seed of "Bazooka" in Uganda, a variety developed by researchers with MAIZE, and harvested around 300 tons of certified seed to be commercialized in 2017. In addition, the MAIZE team produced and distributed 100 kg of seed of MLN-tolerant pre-commercial hybrids to nine partners in East Africa for national performance trials and on-farm demonstrations.

Due to the low percentage of materials with tolerance to MLN, there is a need to further expand the genetic sources of resistance to this complex disease. To this end, MAIZE scientists decided to focus their efforts on maize chlorotic mottle virus (MCMV), the virus that is the major factor in MLN disease and to which most of the material screened was susceptible. Starting in 2015, MAIZE scientists focused on evaluating heirloom maize varieties known as landraces from areas of Latin America and the Caribbean that are known to have high incidences of MCMV and other viruses as well as high levels of maize genetic diversity.

To date, over 1,000 landrace accessions and populations have been evaluated and the 20 most promising landraces for MCMV tolerance have been crossed to high-performing elite lines from the International Maize and Wheat Improvement Center (CIMMYT) and then selfed, or self-pollinated, to create new advanced progenies for advanced evaluation.

MLN trial performance 60 days after first post-inoculation, with distinct resistance performance of CIMMYT MLN resistant hybrids along with susceptible commercial check at MLN screening facility at Naivasha under artificial condition. Photo: CIMMYT

To date, over 900 F3, or third generation, maize lines have been evaluated in the greenhouse for MCMV tolerance. These lines have additionally been genotyped in order to evaluate if the genetic source of any observed tolerance is from novel alleles, or gene forms that have not been used before, or is from alleles that already exist in elite breeding materials. The F4 lines derived from the F3 lines with observed MCMV tolerance have been produced and are being sent to the MLN screening facility in Naivasha, Kenya for more in depth evaluation in 2017. Breeders hope to begin releasing semi-inbred lines with novel alleles for MCMV/MLN tolerance to the maize breeding community in late 2017 and in 2018.

Maize germplasm artificially inoculated with MLN-causing viruses, at the Naivasha screening site, Kenya.

Hunting the witch (weed): Striga Mitigation

The root parasitic weed Striga, also known as 'witch weed' or 'violet vampire' due to its deceptively beautiful purple flowers, is a pervasive and recalcitrant problem of cereal-based systems in many parts of Africa. As a root parasite, Striga causes significant damage by attaching itself to a maize root, where it extracts the water and nutrients it needs, stunting or killing its host. Indeed, Striga does most of its damage underground before emerging above the surface. As such, farmers cannot do much to save their crop when they see the weed and its flowers appear.

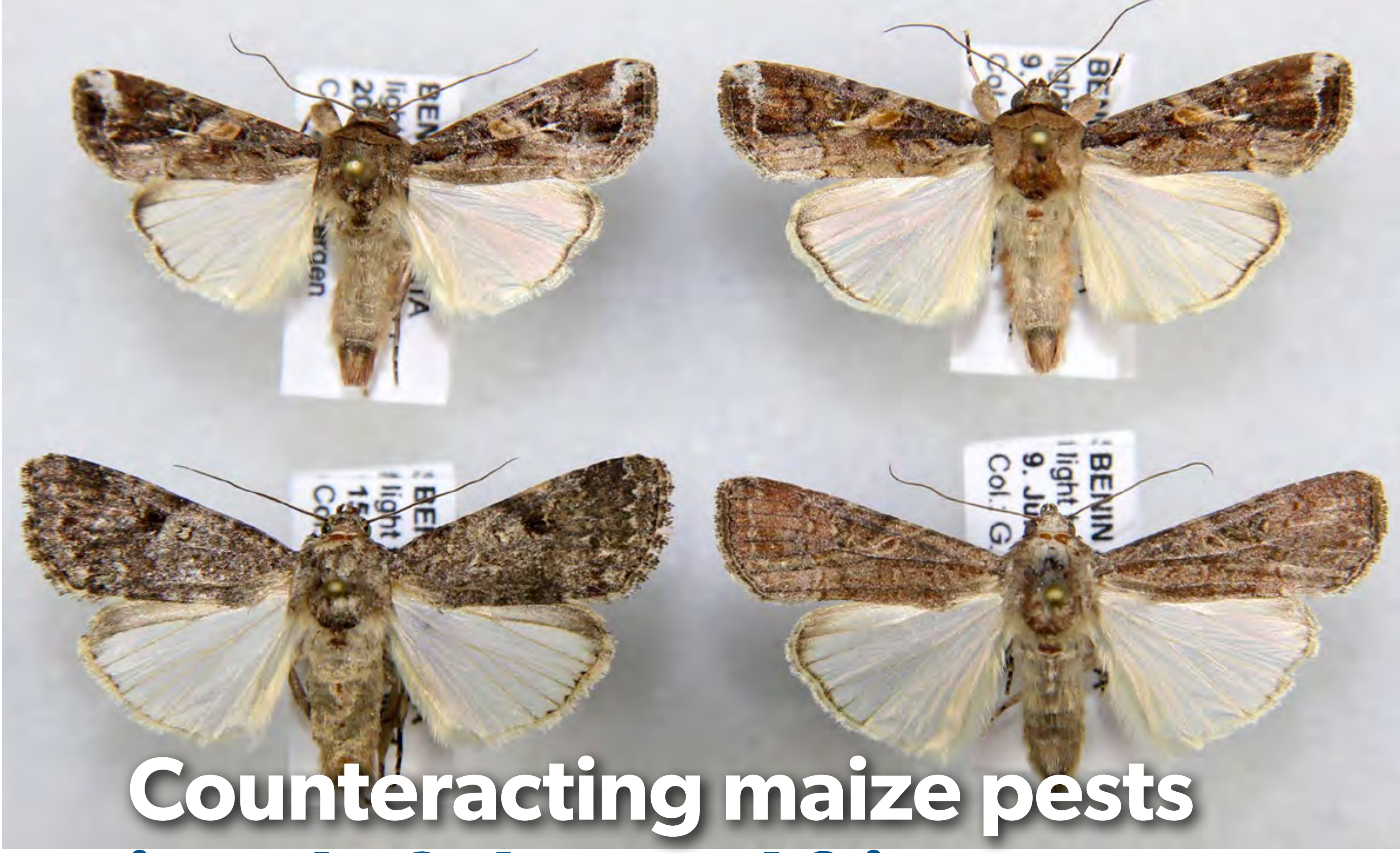
Developed by the CGIAR Research Program on Maize (MAIZE), Striga-resistant maize varieties (SRMVs), such as SAMMAZ 11 or Across 97, SAMMAZ 15 and SAMMAZ 16, are easy for farmers to adopt and have already been released and widely disseminated in Nigeria. Adoption rate of these cultivars in the Federal Capital Territory area of Nigeria stands at about 41 percent. Adoption of SRMVs has led to both higher maize yields and increased household income of adopters by about US$ 110 per capita. Adoption also reduced the incidence of poverty among adopters by 9 percentage points (Hassan et al., 2016). There is

Farmers stand by their Striga-infested maize field. Photo: IITA also significant adoption of Integrated Striga Management (ISMA) practices in the northern part of Nigeria. The study by Hassan et al. (2016) highlighted the need for policies and programs aimed at enhancing adoption of SRMVs in Nigeria and beyond.


Deceptively beautiful Striga flowers. Photo: IITA

Although ISMA practices work well, there are reports of variability in the extent of control achieved by Striga control options, particularly host plant resistance, in different agro-ecological zones. For example, maize varieties that show tolerance in a specific geographical location, when taken to another test location do not perform as well as the landraces in these locations. Therefore, there is a need to further understand the basis of Striga diversity and host-parasite relationships in order to deploy suitable control methods that will remain effective over time and across different locations.

As a first step towards understanding the interaction between the host plant and the parasitic weed, MAIZE researchers performed genetic diversity and population structure tests on Striga populations. Approximately 1500 high quality genotyping by sequencing (GBS)-derived single nucleotide polymorphism (SNP) markers were used to characterize over 1000 Striga populations collected from several locations and different host crops in Kenya and Nigeria. In both populations, high levels of genetic diversity were observed. The populations from northern Nigeria formed three distinct subpopulations based on their collection location, while those collected from western Kenya were largely undifferentiated. Striga populations parasitizing rice in Kenya showed some genetic distinctness, but clear evidence of host specificity was not observed. In summary, the findings highlight the importance of developing and testing Striga control technologies in diverse locations as the existence of potential Striga ecotypes (a genetically distinct geographic population within the species, adapted to specific environmental conditions) has been brought to light. These findings pave the way for breeding maize varieties with broad spectrum or ecotype specific resistance to Striga. MAIZE is also working with the University of Sheffield in the United Kingdom to study the genetic basis of Striga resistance.



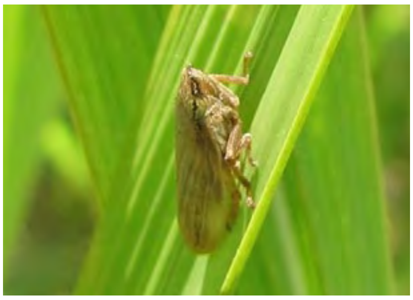
Counteracting maize pests in sub-Saharan Africa

Food security in sub-Saharan Africa is increasingly at risk due to the rapid spread of maize pests in the region, which are destroying crops and causing significant losses to farmers. Each year, between 20 and 40 percent of global crop yields are reduced due to plant pests and diseases.

"Up to very recently, maize growers have been at peace with insect problems in their crop, apart from sporadic attacks by stem borers. Then, spittlebugs started to emerge, possibly due to climate change," said Manuele Tamò, insect ecologist at the International Institute for Tropical Agriculture (IITA) in Benin.

"Just last year, a new brutal invader landed in Africa, the fall armyworm, destroying thousands of hectares of maize crops. There is hence an urgent need to develop and deploy ecologically sustainable, economically profitable, and socially acceptable control measures against these new bio risks attacking maize in Africa."

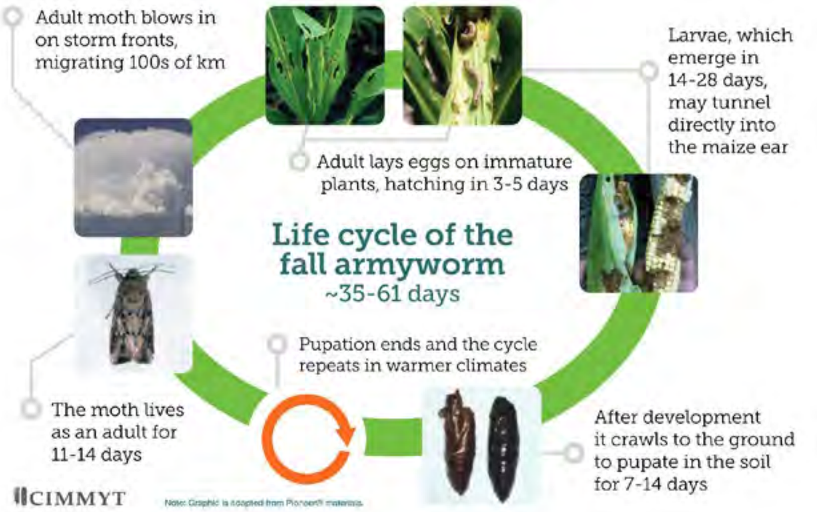
Spittlebug



Spittlebug (*Poophilus costalis*) is the most widespread and damaging species observed on maize in Togo and Ghana. Although maize farmers are aware of the damage made by the spittlebug, most of them do not apply any control measures. Infestation rates vary from one season and from one region to another, but are generally higher in the coastal and moist savannas; with peak densities of over three adult spittlebugs per maize plant. With up to 40 percent yield loss, economic damage can be substantial. Diverse host plants assure the survival of the spittlebug during the off-season, with preference for shady and moist environments.

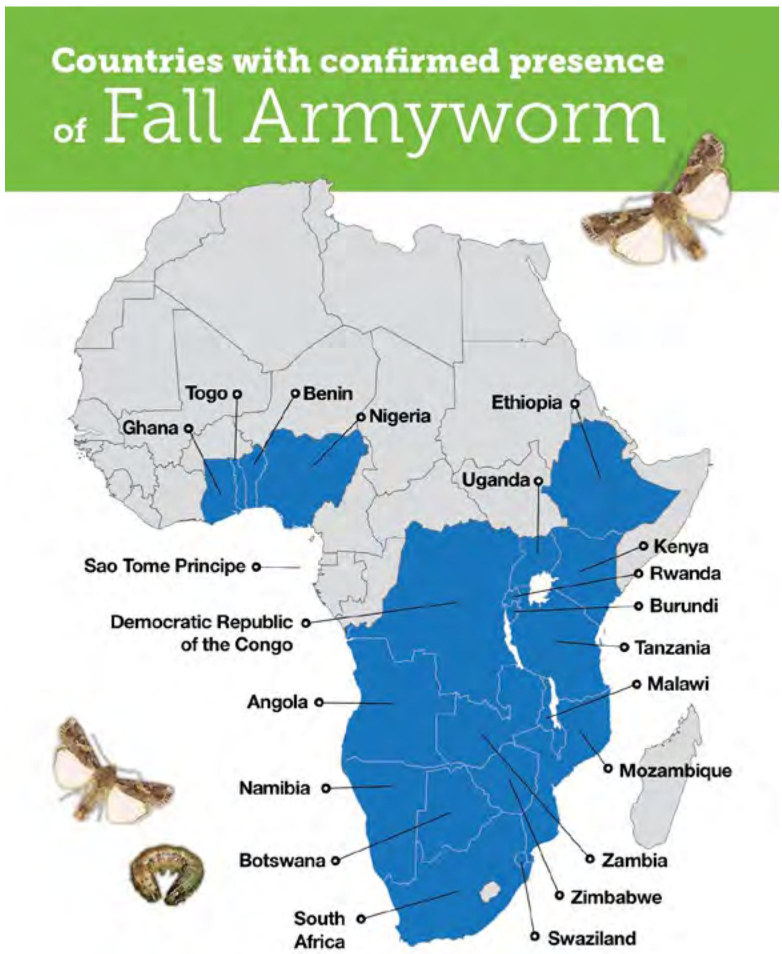
Some natural enemies are found to be associated with the pest, but their impact is presently still unknown. Eight isolates of the entomopathogenic fungus Beauveria bassiana – which can act as a parasite of insects – have shown promising results as biocontrol agent against the spittlebug. Studies to assess their endophytic competence in the maize plants – the degree to which these isolates increase the resistance of the maize plants to the spittlebug – are underway. The CGIAR Research Program on Maize (MAIZE) is also funding a project to develop bio pesticides for the control of spittlebugs on maize crops in Togo together with the Laboratoire de Biosécurité et de Biotechnologie at the Institut Togolais de Recherche Agronomique (ITRA).

Fall Armyworm



A new, highly destructive, maize pest, the invasive fall armyworm (Spodoptera frugiperda), has suddenly appeared in West, Central and southern Africa, causing panic among maize farmers. It was first reported in West Africa in January 2016 and had assumed epidemic proportions by the first quarter of 2017 in several southern African countries, including Mozambique, Namibia, South Africa, Zambia and Zimbabwe. To date, Zambia has confirmed reports that almost 90,000 hectares of maize have been affected, Malawi reports some 17,000 hectares have been hit, Zimbabwe reports a potential 130,000 hectares affected, while in Namibia, approximately 50,000 hectares of maize and millet have been damaged, according to the FAO.

Scientists are in intensive discussions with various research and development institutions based in Africa, as well as integrated pest management (IPM) experts to identify the best possible short-, medium- and long-term solution to this major menace. Control of the fall armyworm will require a multi-pronged approach, following the principles of IPM, including chemical control, biological control, host-plant resistance, agronomic management at different scales (field, farm and landscape), and a community- and GIS-based tracking and early warning system. Scientists will undertake experiments to screen elite maize germplasm to identify potential sources of even partial resistance to the insect pest. MAIZE agronomists will also be experimenting on suitable agronomic management practices to minimize the damage from the fall armyworm in maize-based cropping systems. (video)



CIMMYT
International Maize and Wheat Improvement Center
www.cimmyt.org

This map reflects countries with comfirmed reports of Fall Armyworm as of April 28, 2017. Other countries might not have conducted systematic surveillance; therefore, lack of reporting in some cases could be due to lack of surveillance (and might not be because of lack of incidence).

African Stem Borer

Nearly all of sub-Saharan Africa is affected by Busseola fusca (Fuller), an indigenous stem borer that occurs at higher altitudes. Various control strategies have been tried, but all have limitations and none has provided a complete solution. The four general approaches to stem borer control are chemical, biological, cultural, and host plant resistance. Chemical control is costly and risky to humans and the environment and using systemic insecticides provide only protection at early attacks but not against the borers feeding in the cob. Biological control requires trained personnel, and the disruption of natural enemies due to extensive pesticide use has often led to resurgence and pest population explosion besides the concern of pesticide residue on the marketable produce. Cultural methods are only good when combined with other methods and involve the manipulation of aspects of crop agronomy to make the habitat less favourable for the pests or more favourable for their natural enemies. Farmers often do nothing but to bear the losses.

MAIZE and partners have emphasized on host plant resistance, whereby resistance developed through conventional breeding or through transgenic technology is availed to farmers encapsulated in the seed, a fact that ensures the technology is affordable, safe, easy to use, and that farmers need not purchase more than the seed. Use of stem borer resistant maize increases efficiency of farming through reduction or elimination of the cost of insecticides and reduction of yield losses from stem borer damage.

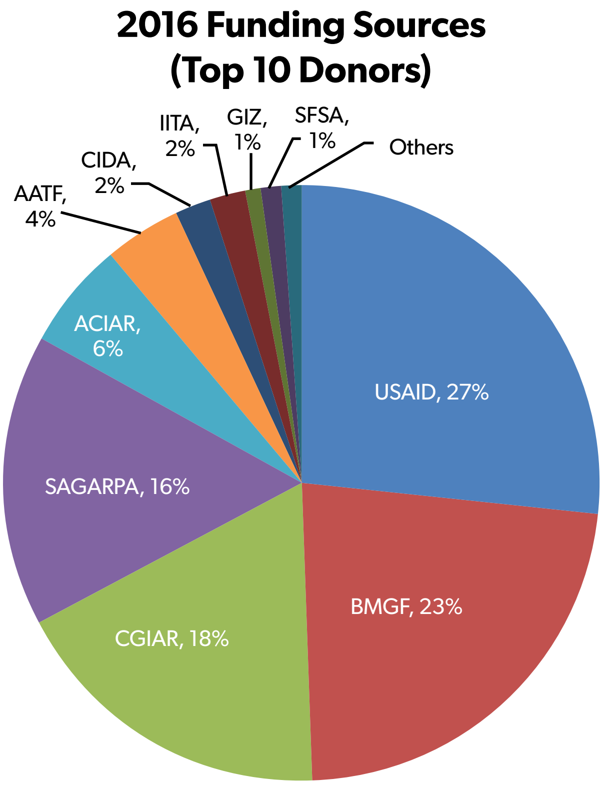
Bt maize provides a new management tool for small scale farmers and has the potential to increase yields where stem borers are a major constraint. Bt maize represents genetically modified maize that is capable of producing an insecticide – Bt protein – that can kill certain chewing insects. MON810 is a genetically-engineered, stem borer insect-pest resistant maize event that carries the Cry1Ba Bt gene from a common soil-dwelling bacterium, Bacillus thuringiensis. The gene helps Bt maize to resist damage by major stem borers in Africa.

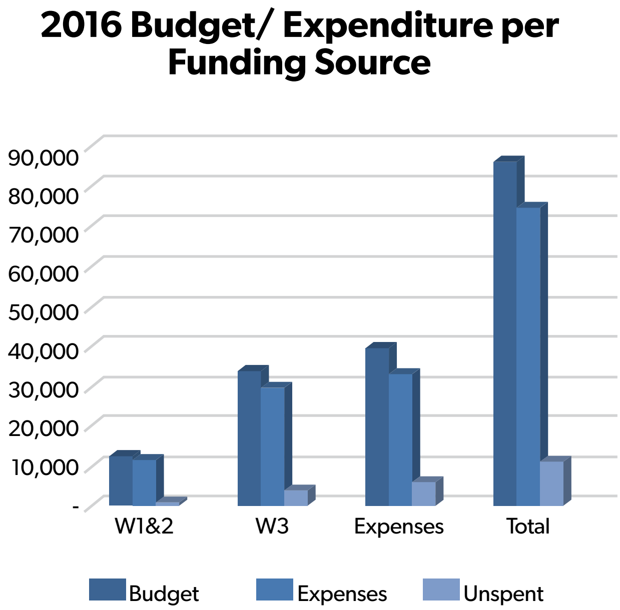
As demonstrated in several countries globally, Bt maize can reduce significantly losses of maize yield due to stem borers without unfavorable effects on non-target insects, mammals, livestock humans and the environment.

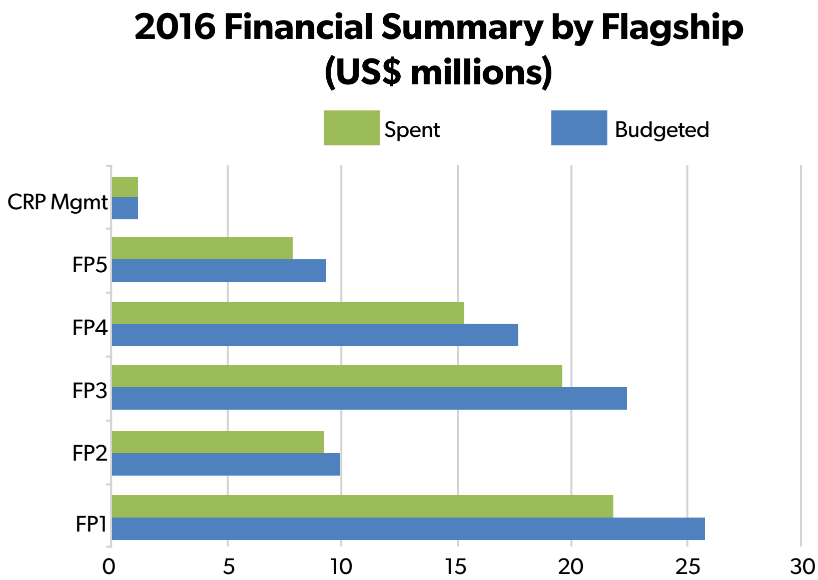
The Bt maize event MON810 was first tested against stem borers in laboratories and greenhouses. Recently, confined field trials of MON810 took place in 2011 in Kitale in the Kenyan highlands. Maize plants with and without MON810 were artificially infested with larvae of the respective stem borer species and data was taken on leaf damage score, number of exit holes, tunnel length and grain yield. Preliminary results of leaf damage scores indicate complete control of the species. Similar trials were conducted in Uganda and more are planned in Tanzania and Mozambique in 2017.

Most maize subsistence farming in Africa has been carried out without the use of pesticides, as insect pest damage before the emergence of spittlebugs and the invasion of the fall armyworm remained low and would not have justified the expense of buying and applying pesticides. The situation is different now, where farmers are desperate to save their crops and resort to any insecticide they can find on the market. However, from a technical standpoint, applying pesticides to these types of insect pests is challenging, as one needs to apply the right product, usually in a very short window of time where the pest is exposed before boring into the plant. But also from an economic standpoint, the cost of buying and applying the appropriate insecticides will not be profitable for most of the average maize farmers in Africa with less than 2 hectares of maize fields. MAIZE and partners are committed to working to find appropriate and sustainable solutions to these new threats.

Financial Highlights







Flagship project 1 – Enhancing MAIZE's R4D strategy for impact.
Flagship project 2 – Novel diversity and tools for increasing genetics gains.
Flagship project 3 – Stress tolerant and nutritious maize.
Flagship project 4 – Sustainable intensification of maize-based systems for improved smallholder livelihoods.
Flagship project 5 – Adding value for maize producers, processors and consumers.

Visit the MAIZE website for more information

The CGIAR Research Program on MAIZE (MAIZE) is an international collaboration between more than 300 partners that seeks to mobilize global resources in maize research and development to achieve a greater strategic impact on maize-based farming systems in Africa, South Asia and Latin America.

Led by the International Maize and Wheat Improvement Center (CIMMYT), with the International Institute of Tropical Agriculture (IITA) as its main CGIAR partner, MAIZE focuses on increasing maize production for the 900 million poor consumers for whom maize is a staple food in Africa, South Asia and Latin America. MAIZE's overarching goal is to double maize productivity and increase incomes and livelihood opportunities from sustainable maize-based farming systems.

Writers/Editors: Bianca Beks, Jennifer Johnson, Dave Watson

Contributors: Tahirou Abdoulaye, Bruce Anani, Anuradha Dhar, Olaf Erenstein, Melaku Gedil, Kostandini Genti, Bruno Gerard, Wasim Iftikar, Cynthia Mathys, Abebe Menkir, Terence Molnar, Stephen Mugo, B.M. Prasanna, Manuele Tamò, Christian Thierfelder, B.S. Vivek, Brenda Wawa, Martha Willcox, P.H. Zaidi

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The CGIAR Research Program on Maize (MAIZE)
Email: maizecrp@cgiar.org • Web: http://maize.org

International Maize and Wheat Improvement Center (CIMMYT)
Apdo. Postal 041, C.A.P. Plaza Galerías
Col. Verónica Anzures 11305
CDMX, Mexico
Tel: +52 (55) 5804 2004
Email: cimmyt@cgiar.org
www.cimmyt.org

International Institute of Tropical Agriculture (IITA)
IITA-Nigeria Ibadan,
PMB 5320, Ibadan
Oyo State, Nigeria
Tel: +234 2 7517472
Email: iita@cgiar.org
www.iita.org

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