



Annual Report **2018**

Harnessing the power of partnerships and innovation



On September 24, 2013, the newly-formed United Nations (UN) High-level Political Forum on Sustainable Development held its first meeting. At the Rio+20 Conference, Member States also agreed to launch a process to develop a set of Sustainable Development Goals (SDGs), which were to build upon the Millennium Development Goals (MDGs) that were established in 2000 and expired in 2015.

Of the 17 individual goals, 10 relate directly to CGIAR activities and to CIMMYT's mandate. The SDGs have set the pathway for the next 15 years of agricultural, social and economic development. Likewise, CGIAR has transformed its approach to ensure that its work aligns with the ambitious goals.

CIMMYT, through its research for development activities, is working toward a world free of poverty, hunger and environmental degradation. CIMMYT and CGIAR efforts help bring the world closer to reaching the goals, such as the empowerment of women, the reduction of greenhouse gas emissions and the improvement of health and nutrition for the world's poorest people.

In this issue, icons attached to each story signal how CIMMYT's work ties to the SDGs.



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CIMMYT – the International Maize and Wheat Improvement Center – is the global leader in publicly-funded maize and wheat research and related farming systems. Headquartered near Mexico City, CIMMYT works with hundreds of partners throughout the developing world to sustainably increase the productivity of maize and wheat cropping systems, thus improving global food security and reducing poverty. CIMMYT is a member of the CGIAR System and leads the CGIAR Research Programs on Maize and Wheat and the Excellence in Breeding Platform. The Center receives support from national governments, foundations, development banks and other public and private agencies.

Message from the Chair of the

Board of Trustees

As CIMMYT entered the second year of its 2017-22 Strategic Plan, its research and partnerships continued to bear results across the globe and to improve the livelihoods of the world's poorest.

The Board of Trustees saw an example of that impact during a day-long visit to the Mexican State of Guanajuato, in meetings with local partners and at demonstrations of locally-adapted experiments.

CIMMYT continues to respond to a changing environment. The research-for-development dialogue is gravitating towards improved food systems supporting healthy diets that are sustainably produced and climate-resilient. Policymakers and leaders in the countries where CIMMYT works are prioritizing the diversified

production of climate change-resilient crops on less land and with fewer inputs. The Center's solutions are geared to meeting these priorities.

One constant is the threat of new pests and diseases. The Board is proud of CIMMYT's role in the coordinated fight against Maize Lethal Necrosis, fall armyworm, and wheat blast disease.

CIMMYT was also an active contributor in the shaping of the 2019-21 CGIAR Business Plan and looks forward to participating in its execution.

In the face of funding partners' changing priorities, CIMMYT is redoubling its efforts in

coordinated resource mobilization, as well as enhanced proposal development and project management practices.

The Board was pleased to note significant strengthening of business processes both at headquarters and in the regional offices. This included capacity building, an enhanced governance framework, and improved systems including a reinforced Center-wide Risk Management Framework.

Prudent stewardship of the Center's financial resources has preserved CIMMYT's strong financial position despite funding uncertainties.

CIMMYT's Board of Trustees acknowledges another year of sterling effort and strong achievements on the part of the Center's staff, management, and worldwide partners.

Nicole L. Birrell
Chair, Board of Trustees

Message from the

Director General

In response to shifting priorities of funding partners in 2018, the Center has pursued stability, organizational unity, efficiency, and strong science to make maize and wheat cropping systems more productive and durable.

Building on the release of a new wheat genome reference map, our researchers more precisely tagged genes for valuable traits, including disease resistance, heat tolerance, and grain quality, in more than 40,000 CIMMYT wheat lines.

While the maize-hungry fall armyworm spreads from Africa to Southeast Asia, CIMMYT joined with more than 40 partners in an international

consortium advancing the fight against the devastating insect pest.

In Mexico, a local initiative is connecting leading food-processing companies with farmers who, guided by CIMMYT and partners, are growing their maize, wheat, and other crops in resource-conserving, climate-resilient ways.

A CIMMYT-led study on gender has explored the lives and viewpoints of 7,500 men and women from farming communities in 26 countries, providing invaluable information that will lead to better productivity and food security.

Advances in those areas are also coming from the use of appropriate

machinery and implements for efficient and climate-smart agriculture on small farms, as one result of CIMMYT-led initiatives in Mexico, Pakistan, and Zimbabwe. A manual developed with the Food and Agriculture Organization (FAO) of the United Nations offers technical and business advice for local entrepreneurs of mechanized services, such as sowing or threshing, for smallholder farmers.

In a positive signal for seed companies and nutrition specialists, as part of taste tests in Ethiopia, Kenya, and Tanzania, consumers indicated their willingness to pay a premium for quality protein maize (QPM), which contains enhanced levels of the amino acids needed to synthesize protein.

2018 showed us that the only constants are the passion and values of our staff and partners, which help CIMMYT to have major impact on the livelihoods of smallholders and the poor. This Annual Report pays tribute to them.

Martin Kropff
Director General



CIMMYT Board of Trustees in 2018 (l to r): Neal Gutterson, José Ernesto Cacho Ribeiro, Bongwiwe Njobe, William (Bill) Angus, Martin Kropff (Director General), Ramesh Chand, Nicole Birrell, Bob Semple, Feng Feng, Harry de Roo, Rita Mumm. Not pictured: Rafael Ambríz Cervantes, Raúl Obando Rodríguez.



EXAMPLES OF

CIMMYT's Impact

AROUND THE WORLD

CIMMYT and ICARDA released



48 wheat varieties

throughout the world in 2018

CIMMYT generates benefits of **\$3.5-4.0 BILLION** annually



CIMMYT and IITA released



81 maize varieties

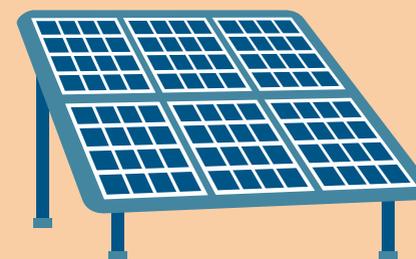
throughout the world in 2018

CIMMYT annually distributes more than **1,500** maize and wheat seed shipments to as many as **800** recipients in over **100** countries. These shipments contain over **500,000** individual seed packets.



1,675 staff of **51** nationalities work at CIMMYT

Solar panels on CIMMYT HQ rooftops have produced **1.41 GWh** to date and reduced CO₂ emissions by more than **551,000 kg**



3.5 million farmers are planting stress-tolerant maize varieties in sub-Saharan Africa



More than **81,800** followers on 7 social media platforms in 2018 (**31% increase from 2017**) and **234,200** views on YouTube



Nearly **43,800** farmers, scientists and technical workers took part in more than **1,500** training and capacity development activities in over 30 countries in 2018



Over **50,000** farmers take part in innovation networks in Mexico

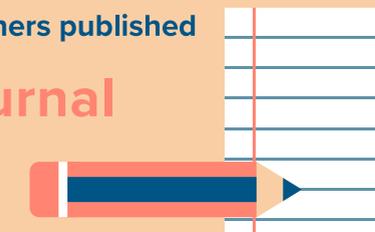


CIMMYT appeared in **481** media mentions in 2018



More than **102,000** farmers are growing wheat using **innovative farm machinery, zero tillage, or advanced seeding dates** in Bangladesh, India and Nepal as part of the CSISA project

CIMMYT researchers published **338** journal articles in 2018



CGIAR Research Programs and Platforms



New hybrids and varieties offer better productivity and nutrition

The CGIAR Research Program on Maize (MAIZE) continues to achieve significant development outcomes and impacts through varietal release, scale-up, delivery and adoption of CIMMYT-derived climate-resilient and nutritionally-enriched maize varieties. In 2018, national partners released 81 unique CGIAR-derived maize varieties across Africa, Asia and Latin America. Of these varieties 14 were hybrid combinations, showing that regional/multinational seed companies use MAIZE improved germplasm to develop and release improved maize hybrids. 20 of the released varieties are nutritionally enriched – Provitamin A, Quality Protein Maize, high-zinc – the result of the MAIZE partnership with Agriculture for Nutrition and Health (A4NH; HarvestPlus).

With both public and private sector partners, MAIZE made great strides in combating Maize Lethal Necrosis (MLN), from providing capacity building to partners

on preventing the spread of the disease to contributing to four new MAIZE-derived MLN tolerant maize hybrids released in Kenya. The battle continues against the fall armyworm, which has been marching across Africa since 2016 and is now spreading throughout Asia. MAIZE has worked alongside regional and international partners to launch the Fall Armyworm R4D International Consortium, an integrated pest management guide, and trainings and videos to support smallholder farmers in fighting against this devastating insect pest.



International collaboration boosts breeding for climate- and disease-resilient wheat

Drought-tolerant wheat varieties developed through international wheat breeding research with the CGIAR Research Program on Wheat (WHEAT) are helping mitigate the effects of climate change on farmers' fields. A recent impact study found that trials in a variety of growing environments around the world have improved yields by 1.6 percent each year over the past 12 years, surpassing previously reported annual yield gains.



Likewise, international exchanges and breeding research partnerships have more than doubled wheat yields in China over the last 30 years. The newly-mapped wheat genome promises to drive even faster development of high-yielding, climate- and disease-resilient wheat varieties.

WHEAT brings together advanced science with field-level research and extension to raise the productivity and affordable availability of wheat for 2.5 billion resource-poor producers and consumers. In 2018, national partners released 48 new CGIAR-derived wheat varieties to farmers, and WHEAT researchers developed 11 farm management or social science innovations.

In South Asia, estimated annual wheat losses due to wheat blast could reach 1.8 million tons on 7 million hectares in Bangladesh, India, and Pakistan. WHEAT scientists have identified genetic sources of

blast resistance to complement the current CGIAR-derived BARI Gom 33 variety.

In Ethiopia, rust-resistant wheat varieties and rapid diagnostics through field-based genetic and participatory tools such as [MARPLE](#) and [RustTracker](#) are playing an important role in the country's quest to become wheat self-sufficient by 2022.



Evidence-based approaches for gender in agricultural research

MAIZE and WHEAT have contributed to and drawn lessons from GENNOVATE, a CIMMYT-led study involving more than 7,500 rural men and women in 26 countries, as well as 11 CGIAR Research Programs

(CRPs) and nearly a dozen crops and other agricultural outputs. In 2017, the initiative delivered reports on study outcomes to MAIZE, WHEAT, and other CRPs, and made available a suite of tools and resources for scientists applying gender-aware approaches. See the story "Opening space for innovation through gender-smart approaches" in this report, for details on 2018 activities and achievements.



Innovations in excellence in breeding

In 2018, the Excellence in Breeding Platform (EiB) developed a major role supporting CGIAR centers to respond to the [Crops to End Hunger Initiative](#) (CtEH). Drawing from feedback at the second Contributor's Meeting that took place in 2018, EiB has

standardized planning for breeding program improvements across CGIAR and secured new funding worth US \$7.4 million from GIZ to deliver on the CtEH goals.

New product management tools and trainings were developed to focus breeding efforts toward farmer and market needs and a new breeding scheme assessment tool was applied to NARO, Uganda, and KALRO, Kenya, breeding programs. Demand for low-cost genotyping services grew by a factor of 4 to US \$800,000, phenotyping and operations were assessed at 8 research stations, and significant advances were made to integrate data management systems and improve CGIAR capacities. EiB-supported innovations are part of an online [toolbox](#) that was launched at the end of 2018.

Broad CGIAR research engagements

CIMMYT is a leading implementation partner in the CGIAR Research Program on Climate Change, Agriculture and Food Security, as well as participating in the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), the CGIAR Research Program on Policies, Institutions and Markets (PIM), the Big Data for Agriculture Platform, the CGIAR Genebanks Platform and the GENNOVATE research initiative.

Highlights

from around the world



1 In October, at its headquarters in Mexico, CIMMYT hosted government officials from Sichuan Province, China, for the signing of a Memorandum of Understanding, which will increase collaboration with the province. “CIMMYT’s support and collaboration is very important for us,” explained vice governor Yao Sidan. Collaboration with the Sichuan Academy of Agricultural Sciences has contributed to a significant improvement in standards of living within the province over the last 30 years, but there is scope for widening the partnership to continue improving maize and wheat production in the region.

2 Barley shortages from extreme weather events could unleash significant beer price spikes, according to a 2018

study, which coupled leading crop production and economic models. “Barley, the primary cereal grain from which beer is brewed, is very heat-sensitive, so even short periods of high temperatures can affect grain quality and yields,” said Wei Xiong, a CIMMYT scientist and key contributor to the research.

3 The inaugural Maize-Asia Youth Innovators Awards recognized the contributions of young women and men who can inspire other young people to get involved with maize-based research, change agency and farming. The awards celebrate youth participation in maize-based agri-food systems. Four winners were given an opportunity to present their work at the 13th Asian Maize Conference and will join a platform for young innovators from around the world to network and share their experiences.

4 In March, 14 young researchers from South Asia attended a screening and surveillance course to address wheat blast at the Regional Agricultural Research Station (RARS), in Bangladesh. As part of the facility’s precision phenotyping platform to develop resistant wheat varieties, the course emphasized hands-on practice for crucial and challenging aspects of disease control and resistance breeding, including scoring infections on plants and achieving optimal development of the disease on experimental wheat plots.

5 CIMMYT researchers called for closer consideration of how soils and forests

contribute to improved nutrition. A study in Ethiopia by CIMMYT scientist Frederic Baudron and Stephen Wood with the Nature Conservancy found that wheat grown in areas closer to the forest had more nutrients, like zinc and protein. Soils in these areas are rich in organic matter – about 1 percent higher – due to decomposing trees and plants, as well as manure of livestock that graze in the forest.

6 In response to the spread of the fall armyworm across Africa, CIMMYT and its partners published a technical guide for integrated pest management. Produced by international experts, it offers details on the best

management practices to help smallholder farmers control the pest while protecting people, animals and the environment. CIMMYT and IITA are co-leading the new Fall Armyworm R4D International Consortium composed of 40 partners.

7 CIMMYT’s genebank coolant system was retrofitted to use a more climate-friendly, recommended refrigerant, R-404A. The new system will reduce annual electrical energy consumption by about 25 percent and will complement the GIZ-funded solar voltaic system installed in 2014. “The lifespan of this equipment is expected to exceed 20 years,” said Tom Payne, head of wheat genetic resources at CIMMYT.

8 In March, more than 200 wheat science and food specialists from 34 countries gathered in northwestern Mexico to address threats to global nutrition and food security. Among them were the winners of the Jeanie Borlaug Laube Women in Triticum (WIT) Early Career Award, who also participated in an ongoing wheat training course organized by CIMMYT. Established in 2010, the WIT program has provided professional development opportunities for 44 young women researchers in wheat from more than 20 countries.

Climate-smart maize-legume farms power resilience in Africa



Kenyan farmer Purity Gachanga shows how farming smarter can yield better results.

Climate-smart farming in Africa is building resilience and productivity in the face of extreme climate variability.

Family farmers, researchers, and other value chain actors have together amassed eight years of evidence on how maize and legume conservation agriculture-based sustainable intensification practices can thrive in diverse socioeconomic and agroecological environments.

Purity Gachanga, a 65-year-old farmer living 200 kilometers northeast of Nairobi, shows how farming smarter – not harder – can build resilience and increase food production, despite mounting challenges from climate change.

Gachanga’s household is one of more than 300,000 across eastern and southern Africa that have put aside the plow and abandoned mono-cropping to pursue the

principles of conservation agriculture, including reduced tillage, crop residue retention, and crop rotation or intercropping.

“I get a profit from each patch, so it makes sense to plan how to use it,” she said, noting that she rotates maize and legume crops to add nutrients to the soil, while keeping residues on the surface to protect it from harsh weather.

Those innovations and complementary practices such as drought tolerant maize and labor-saving machinery are spreading as part of efforts by the Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) project. They allow Gachanga and peers to care for soil and boost harvests on rain-fed farms, despite longer and more frequent dry spells and erratic rainfall.



Farmer Rukaya Hasani Mtambo weeds a plot of maize/beans grown using climate-smart practices.

“Before, I would lose topsoil when it rained heavily,” Gachanga said. “I learned that planting certain varieties of fodder plants with deep roots holds the soil together, as well as improving soil fertility and giving good feed for my goats. I make money, keep my soil and animals in good health, and we have a varied diet ourselves.”

Research by SIMLESA shows that farmers who run their homesteads as a system and adopt complementary, climate-smart practices can reduce labor up to 60 percent, saving time and money while raising crop yields as much as 37 percent, according to Paswel Marenya, CIMMYT scientist and SIMLESA leader.

“That represents an immense addition to household food and income security,” Marenya said. “We’ve also seen that farmers who network are better able to exchange information about conservation practices and can negotiate collectively to get better prices for inputs such as fertilizer, improved seed, or mechanization, all of which facilitate climate-smart farming.”

As part of the above, SIMLESA has helped set up 58 agricultural innovation platforms across Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, and Uganda, connecting farmer groups, agribusiness, government extension, policymakers and researchers who

work to enhance farm-level food security, productivity and incomes through maize-legume intercropping and crop rotations.

“Having a network of stakeholders allows farmers to test and adopt conservation agriculture-based techniques without the risks of going it alone,” said Michael Misiko, a CIMMYT agricultural innovation scientist who studies the role of social networks. “Researchers and governments learn and can use results to recommend best practices to other farmers in similar conditions.”

SIMLESA has also pursued competitive grant schemes to support 19 private and public

partners, including seed companies, in those countries.

More than 51 policy briefs and dozens of reports, factsheets, videos, and other outreach materials are reaching regional decision makers regarding the benefits of conservation agriculture-based farming.

“We are delighted with SIMLESA’s unique strategy of involving multiple partners to implement conservation agriculture for sustainable intensification,” said Albertina Alage, the Technical Director for Technology Transfer, Mozambique. “This has accelerated dissemination of practices and technologies in more locations and to more farmers.”

Funded by the Australian Centre for International Agricultural Research (ACIAR), the SIMLESA program is led by CIMMYT in collaboration with CGIAR centers and national agricultural research institutes in Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania and Uganda. Other regional and international partners include the Queensland Alliance for Agriculture and Food Innovation (QAAFI) at the University of Queensland, Australia, and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA).



40
New climate-smart maize varieties released



58
Agricultural Innovation Platforms established



19
Partners selected to scale out climate-smart practices



64
Climate-smart legume varieties released



More than **51**
policy briefs and **120** journal articles published



65
postgraduate students trained (24 Ph.D. graduates)



Regional, national and local policy forums to **promote the inclusion** of climate-smart farming systems in agricultural policy

Top left: Farmer Anjeline Odera checks maize in her conservation agriculture plot in Siaya County, Kenya.

Center: A quality check at a soya collection point in Kasungu District, Malawi.

Bottom left: George Ayaga discusses conservation agriculture practices with students at Alupe Food Crops Research Centre in Busia County, Kenya.



Orange is the new white:

biofortified maize combats hidden hunger



Through a program of the Food and Agriculture Organization (FAO) of the United Nations, 130,000 households are growing and eating provitamin A-enhanced orange maize in Zimbabwe, a country where thousands of children suffer acute malnutrition.

The new maize, whose grain is bright orange in contrast to the region's traditional white maize, was developed through cross-breeding

by scientists of the International Maize and Wheat Improvement Center (CIMMYT) and is being spread and promoted through the FAO Livelihood and Food Security Program (LFSP), along with marketing by national seed companies.

Research in Zambia has shown that regular consumption of provitamin A-rich orange maize is as effective to address deficiencies as taking vitamin A supplements.

“Our family now prefers the orange maize over the white maize, as it has great health benefits for my children and granddaughter and the taste is delicious,” says Zimbabwean farmer Musonza Musiwa. “I was also pleased the variety is drought tolerant. Despite a dry spell in January my maize was able to yield a good harvest.”

A prolonged drought in 2018 reduced harvests and made nutritious food

scarce in many rural areas. Added to this, people's maize-heavy diets often lack essential micronutrients such as zinc, iron, and vitamin A, according to Thokozile Ndhlela, a maize breeder who leads CIMMYT's biofortification efforts in Zimbabwe.

"White maize is limited in minerals and vitamins and doesn't contain carotenoids, the orange-colored nutrients that are the building blocks of vitamin A," Ndhlela said. "Biofortification increases the density of vitamins and minerals in staple crops like maize through conventional plant breeding, while conserving farmer-valued traits such as yield, drought tolerance, or disease resistance."

CIMMYT breeding lines and scientific expertise are behind continued efforts to develop nutritious maize, said Prince Matova, a maize breeder with the Zimbabwe Ministry of



Agriculture. "In the next few years we expect to release two more varieties."

As elsewhere in the region, challenges include achieving widespread consumer acceptance of food products made from non-white maize.

The work is supported by the UK's Department for International Development (DFID) and the CGIAR program HarvestPlus.

Thinking zinc in Latin America

Leveraging CIMMYT breeding and the support of HarvestPlus, in 2018 Colombia, Guatemala, and Nicaragua released new maize varieties whose grain features enhanced levels of zinc, an essential micronutrient that plays a crucial role in pre-natal and infant development and in healthy immune systems, and a zinc-enhanced wheat variety was released in Mexico.

More than 40 percent of Guatemala's rural population does not obtain enough zinc from traditional foods and in Colombia around 22 percent of inhabitants suffer zinc deficiencies.

Traditional foods such as tortillas or arepas made from the new varieties can offer over 60 percent more zinc than the same foods from non-biofortified maize.

"The greatest advantage of working with CIMMYT is their quality research and extensive knowledge of maize and wheat," said Marilia Nuti, Regional Director for Latin America and the Caribbean of HarvestPlus. "Meanwhile, partnerships on the ground with HarvestPlus and the International Center for Tropical Agriculture (CIAT) in Colombia have helped ensure that this zinc-biofortified maize reaches farmers and consumers."

The varieties were developed in collaboration with the CGIAR Research Program on Maize (MAIZE) and the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH) and will be marketed by partners in the region including seed companies Semilla Nueva and Maxi Semillas S.A.S.

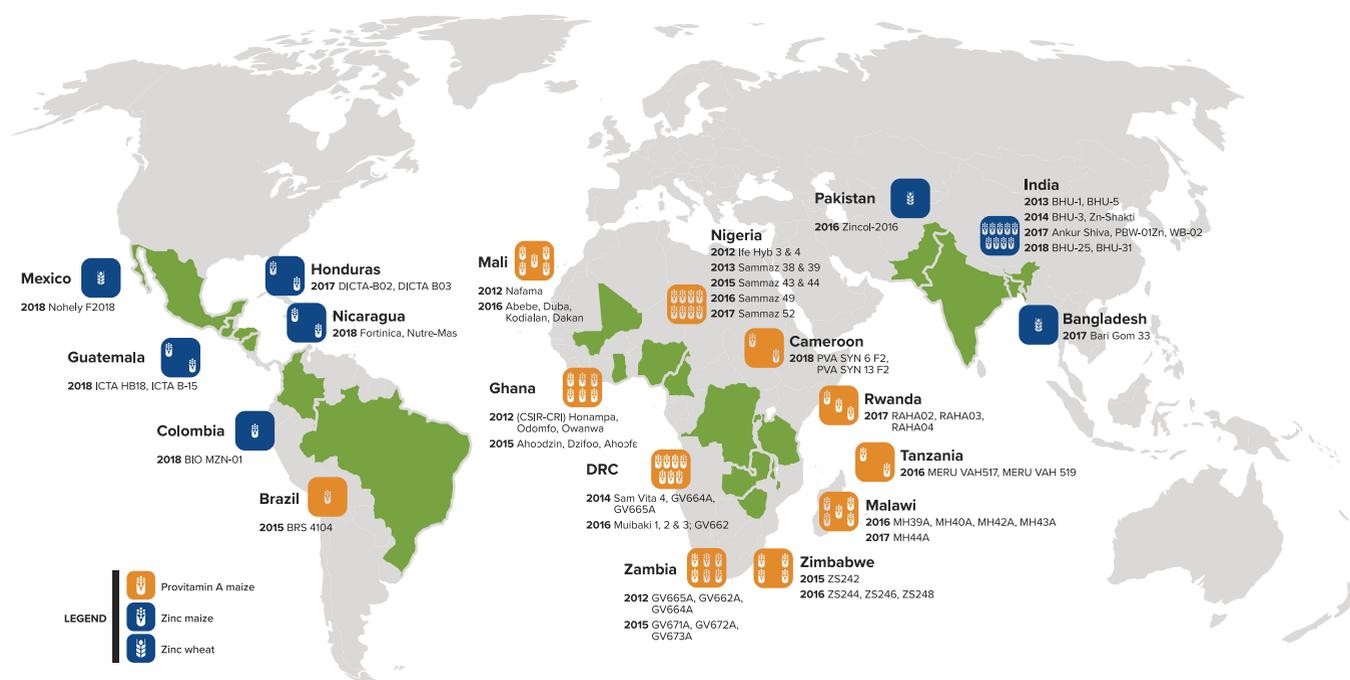
Quality protein maize improves nutrition in children

In addition to promoting provitamin A-enhanced maize in Ethiopia, where child malnutrition is widespread with large health and economic consequences, CIMMYT and partners are multiplying seed and publicizing the benefits of quality protein maize (QPM), a white maize variety that offers higher levels of lysine and tryptophan, essential amino acids for protein synthesis in humans.

A study in southern Ethiopia has shown that QPM can improve child nutrition in areas heavily dependent on maize-based foods.

Additionally, consumer acceptance testing of QPM in Ethiopia, Kenya and Tanzania confirmed that African consumers can distinguish QPM varieties from their conventional ones in double-blind evaluations and that they are willing to pay a premium for QPM.

Farmer and consumer interest has grown for some 60 maize and wheat varieties whose grain features enhanced levels of the essential micronutrients zinc and provitamin A, developed and promoted through collaborations of CIMMYT, HarvestPlus, and partners in 18 countries.



"Through dozens of public-private partnerships and farmer participatory trials, CIMMYT is testing and promoting high-zinc wheat varieties in Afghanistan, Ethiopia, Nepal, Rwanda, and Zimbabwe. CIMMYT is also seeking funding to make high-zinc grain a core trait in all its wheat breeding lines."

Velu Govindan
CIMMYT wheat breeder



Opening space for innovation through gender-smart approaches

Women and men from maize- and wheat-growing villages in 13 countries consider improved varieties to be among the most valuable agricultural innovations in their communities in recent years.

This was a finding from **GENNOVATE**, a CIMMYT-led research initiative involving gender researchers from 11 CGIAR Research Programs (CRPs), and drawing on the experience of more than 7,500 rural men and women from 137 communities in 26 countries. The initiative ended in 2018, having delivered a range of research outputs to MAIZE, WHEAT and other CRPs, including a series of peer-reviewed journal articles and a suite of resources for scientists

interested in applying gender-aware approaches.

GENNOVATE focuses on how gender norms and “agency” – the capacity and space for self-determination – shape who is able to learn about, try out, and benefit from new agricultural technologies and practices.

“Across geographies and diverse agri-food systems, the findings consistently highlight the importance and the urgency of addressing gender equality and social inclusion as part and parcel of agricultural research for development,” said Lone Badstue, CIMMYT Research Theme Leader for Gender and Social Inclusion, and GENNOVATE



project leader. “This is of strategic interest for agricultural research for development and a means to catalyze positive change and enhance impact.”

Opportunities include broadening the scope of research to invest in institutional improvements that help women and men to innovate in agriculture and improve their families' wellbeing. “This takes multi-pronged approaches,” said Badstue, “including engaging men and boys as allies for gender equality.”

In 2018, GENNOVATE specialists conducted workshops, communication initiatives, and dissemination events. The initiative was also featured in a [special issue](#) of the *Journal of Gender, Agriculture*

and Food Security, profiling it as an empirically and methodologically innovative initiative.

Gender-based approaches cross borders

CIMMYT-led initiatives in Ethiopia are helping gender awareness and gender-sensitive approaches to spread in agricultural research, extension, and policy, based on [statements from a cross section of professionals and practitioners](#) in the country.

“By broadening their understanding of social contexts and factors that constrain adoption of improved technologies, researchers can both boost gender equality and reach

project goals more quickly,” said Kristie Druzca, CIMMYT gender and social inclusion researcher based in Ethiopia.

The CIMMYT-led Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa (SIMLESA) project is integrating gender sensitivity into all its activities so that outcomes reach all individuals in target communities.

Agricultural innovation platforms under SIMLESA connect farmer groups with extension workers, researchers, agribusiness, and policymakers, providing improved access to markets, credit, farming innovations, and capacity development for men, women, and young farmers.

Meanwhile, in South Asia, CIMMYT is working through such projects as the Cereal Systems Initiative for South Asia (CSISA) to promote inclusive and sustainable farming, reflecting the increased decision-making responsibility of women in farm households.

GENNOVATE received funding from CGIAR Trust Fund Donors, the CRPs, the CGIAR Gender and Agricultural Research Network, the World Bank, the Bill & Melinda Gates Foundation, and the governments of Germany and Mexico. The study involved 27 research partner institutions. SIMLESA is funded by the Australian Centre for International Agricultural Research (ACIAR). Partners include the Rwanda Agricultural Board (RAB), CGIAR centers and national agricultural research institutes in Ethiopia, Kenya,

Malawi, Mozambique, Tanzania and Uganda. Other regional and international partners include the Queensland Alliance for Agriculture and Food Innovation (QAAFI) at the University of Queensland, Australia, and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). CSISA is implemented jointly by CIMMYT, the International Food Policy Research Institute (IFPRI), and the International Rice Research Institute (IRRI) and receives funding from the Bill & Melinda Gates Foundation and the United States Agency for International Development (USAID).

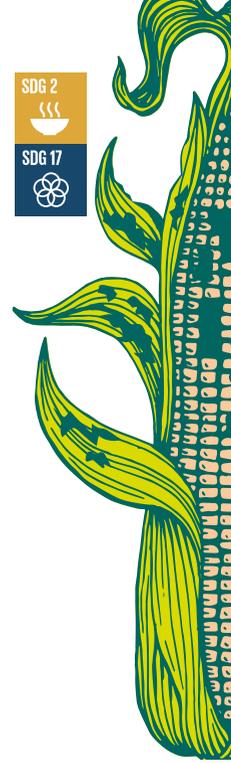
The GENNOVATE reports found that farmers from maize- and wheat-growing villages in 13 countries consider improved varieties to be among the most valuable agricultural innovations.

Photos (l to r): Women farmers use a mini tiller for direct seeding maize during a field day in Surkhet, Nepal.

Kemeriya Mohamed and her brother Hasan Gurari preparing a load of harvested wheat for transport in Dodola district, Ethiopia.

A farmer adjusts a maize shelling machine with the assistance of CSISA agricultural mechanization engineer Subash Adhikari in Kanchanpur, Nepal.





Rapid responses to emerging

THREATS

Rapid and coordinated action among public and private institutions across sub-Saharan Africa has helped contain the spread of the deadly maize lethal necrosis (MLN) disease, averting a potential food security disaster in the region.

Maize is the primary staple food for more than 300 million consumers in sub-Saharan Africa, each of whom eats more than 50 kilograms of the grain on average per year.

MLN is a viral disease that appeared in Kenya in 2011. It causes extensive necrosis and affects seed in maize ears, leading to as much as 100 percent grain yield loss or, in extreme cases, simply killing the plants. By 2014, the disease had been extensively reported in eastern Africa,

including the Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, South Sudan, Tanzania and Uganda.

Timely and targeted interventions led by the International Maize and Wheat Improvement Center (CIMMYT) in partnership with national agricultural research institutions, governments, commercial seed companies, and global R4D partners have largely controlled the disease, according to Anne Wangai, senior scientist at the Kenya Agricultural and Livestock Research Organization (KALRO).

“As an independent international organization, CIMMYT had the unique ability to coordinate and link key players, as well as resources to identify the disease and bring to bear global knowledge and resistant maize germplasm,” Wangai said.

The battle against such a devastating disease had to be coordinated on multiple fronts, with a multi-pronged approach, explained B.M. Prasanna, director of CIMMYT's Global Maize Program and the CGIAR Research Program on Maize (MAIZE), who led the large-scale, intensive international response to the MLN outbreak in eastern Africa.

resistant breeding lines and hybrids," Prasanna said.

"CIMMYT has also set up an MLN Quarantine Facility in Mazowe, near Harare, Zimbabwe, in 2017, in partnership with the Plant Quarantine Institute of Zimbabwe, for safe introduction of CIMMYT maize germplasm from Kenya to Zimbabwe.

farmers, improving their yields, food security and livelihoods."

CIMMYT also provided capacity development for public and private partners on MLN virus diagnostics and production of MLN virus-free seed, besides disease surveys. These efforts have helped significantly to keep the disease from spreading on commercial seed.

MLN experience paves the way to limit a deadly insect pest

The fight against MLN is not over, but Prasanna said successful efforts to address it are guiding responses to a more recent threat: the fall armyworm. Originally from the Americas, fall armyworm has caused major damage to maize crops in Africa since 2016 and is extensively reported in Asia since 2018.

A Fall Armyworm R4D International Consortium launched jointly by CIMMYT and the International Institute of Tropical Agriculture (IITA) in 2018 involves over 45

organizations and is implementing strategic plans for short-, medium- and long-term research and development steps against the pest.

CIMMYT, the U.S. Agency for International Development (USAID), and other partners jointly released a [comprehensive manual](#) describing integrated management of fall armyworm and organized regional training workshops in Africa. A video in multiple languages by Scientific Animations Without Borders (SAWBO) is being used to train smallholder farmers to identify and respond to fall armyworm.

"The coordinated and rapid response to major diseases and insect pests affecting maize-based agri-food systems in Africa shows the power of cross-sector and cross-regional partnerships," Prasanna added.

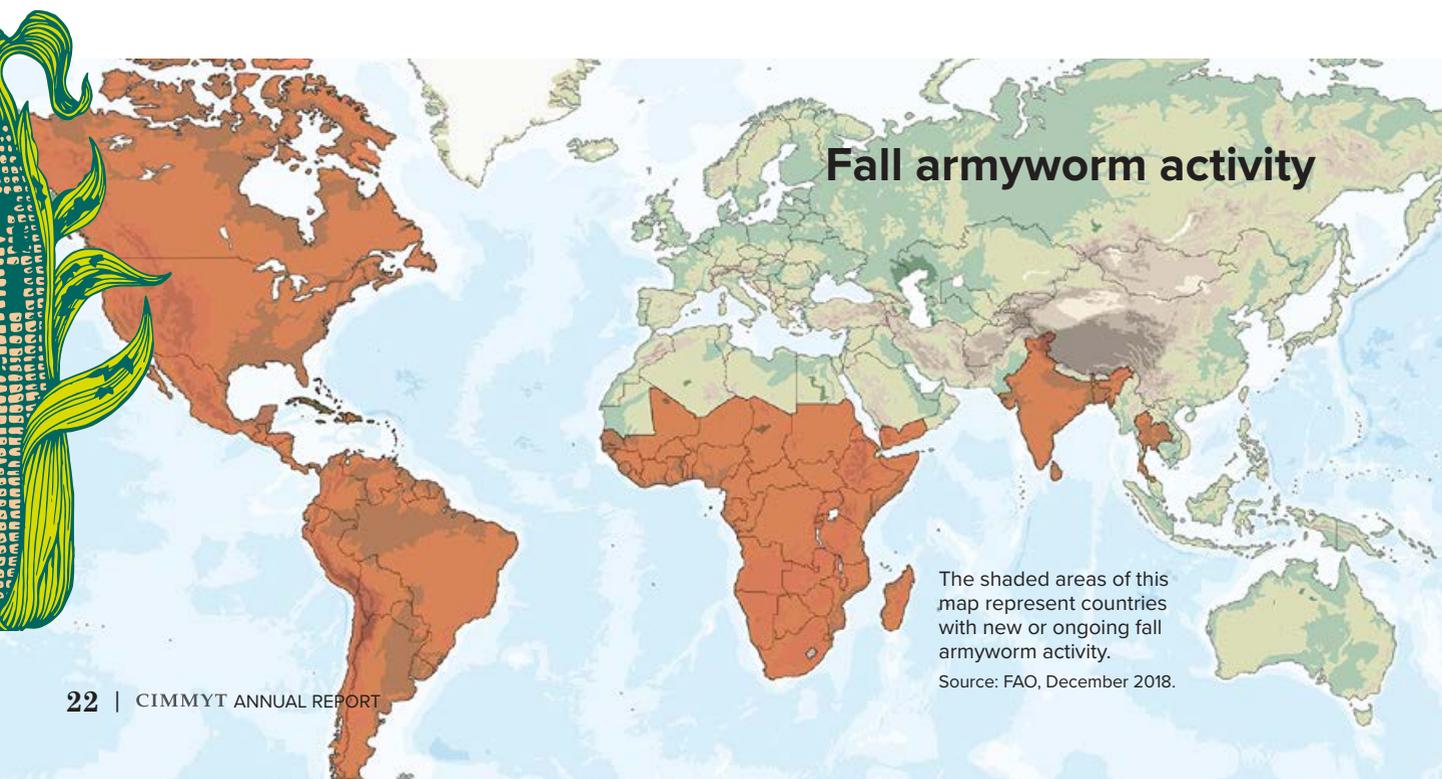
Funding for research to control Maize Lethal Necrosis has come from the Bill & Melinda Gates Foundation, the U.S. Agency for International Development (USAID), the Syngenta Foundation for Sustainable Agriculture, and the CGIAR Research Program on Maize (MAIZE). USAID, the U.S. Department of Agriculture, and MAIZE have provided generous support for research to monitor and control fall armyworm.



The photos above show the progressive plant destruction caused by maize lethal necrosis.

"Among other actions, CIMMYT established a dedicated MLN screening facility in partnership with KALRO at Naivasha in 2013. This has enabled screening of more than 175,000 germplasm entries over the last 6 years and helped identify MLN-

An MLN information portal and related community of practice have helped partners across Africa to unite effectively against the disease. As many as 18 MLN-tolerant or resistant maize hybrids from the screening efforts are giving hope to smallholder



CIMMYT scientists in Kenya observe the transmission of MLN at a secure testing site.

Field gene sequencing to control wheat rust disease

A revolutionary method using palm-sized gene sequencers is improving the ability of Ethiopia's researchers, policymakers and farmers to curtail virulent fungal pathogen outbreaks on wheat.

Rapidly identifying the exact pathogen strain, especially new ones, is crucial to swiftly stopping potential rust outbreaks, which have been compared to wildfires in how they destroy crops and spread. Until now, field researchers have had to send samples to specialized laboratories to identify the exact strain, which is costly and can take months, making preventive action impossible.

Known as Mobile and Real-time Plant Disease Diagnostics (MARPLE) and being tested for wheat yellow rust disease in Ethiopia, the new tool can diagnose pathogen strains in a few days. It builds upon initial development work at the John Innes Centre (JIC) in the UK and represents a collaboration between the International Maize and Wheat Improvement Center (CIMMYT), JIC, and the Ethiopian Institute of Agricultural Research (EIAR).

A major threat to global wheat production since the early 2000s, yellow rust – also called stripe rust – results in wheat grain losses

estimated at over 5 million tons annually and worth US \$1 billion. The causal pathogen, *Puccinia striiformis* f.sp. *tritici*, evolves quickly and its spores easily cross continents on wind currents.

“We were the first to identify yellow rust strains accurately in less than three days,” said Dave Hodson, CIMMYT principal scientist. “We can also find out quickly if the strain is a new one. This is critical for stopping epidemics.”

“MARPLE’s piloting in Ethiopia will help us set up a national wheat rust early warning system. This is aligned with national efforts to attain self-sufficiency for wheat,” added Tadesa Daba, director of Agricultural Biotechnological Research at EIAR.

Ethiopia’s farmers produce more than 4.5 million tons of wheat each year but the country imports over 1 million tons of wheat grain annually to satisfy domestic demand. Rapidly emerging and evolving races of wheat stem rust and stripe rust

disease – the crop’s deadliest scourges worldwide – have driven large-scale wheat seed replacement by Ethiopia’s farmers in recent years.

Developed by a John Innes Centre team led by Diane Saunders,

MARPLE uses a small, nanopore-technology gene sequencer from Oxford Nanopore Technologies that plugs into a laptop and is easy to use in field conditions. This scientific innovation won 2017 and 2018 prizes from the CGIAR Big Data Platform

and matching funds were recently obtained from the Delivering Genetic Gain in Wheat (DGGW) project led by Cornell University.

Further success in 2019

The research team behind the MARPLE diagnostic kit won the International Impact category of the Innovator of the Year 2019 Awards, sponsored by the United Kingdom’s Biotechnology and Biological Sciences Research Council (BBSRC).

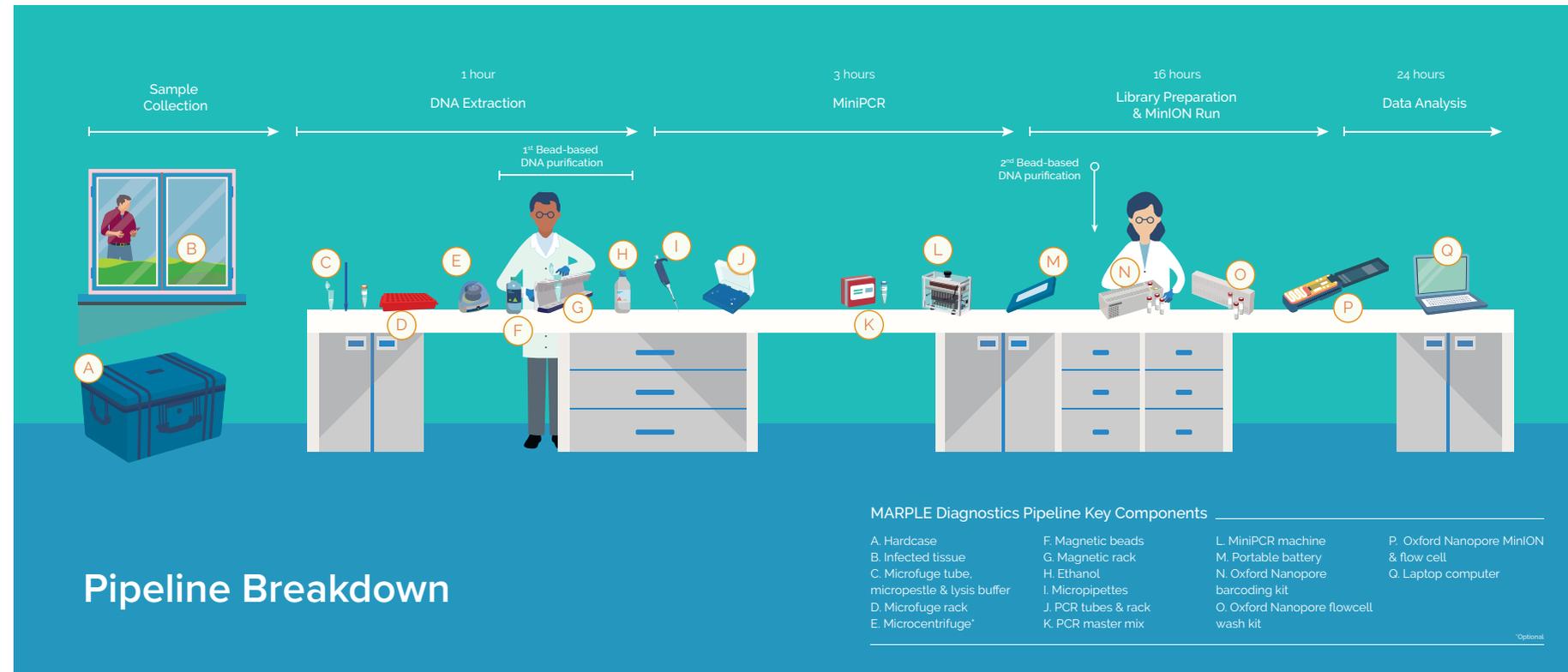
The team of Saunders (John Innes Centre), Hodson (CIMMYT) and Daba (EIAR) was presented with the award at an event at the London Science Museum in May 2019.

The BBSRC Innovator of the Year awards, now in their 11th year, recognize and support individuals or teams who have taken discoveries in bioscience and translated them to deliver impact. Reflecting the breadth of research that BBSRC supports, they are awarded in four categories of impact: commercial, societal, international and early career.



Daba, Hodson and Saunders were among a select group of 12 finalists competing for the 4 prestigious awards.

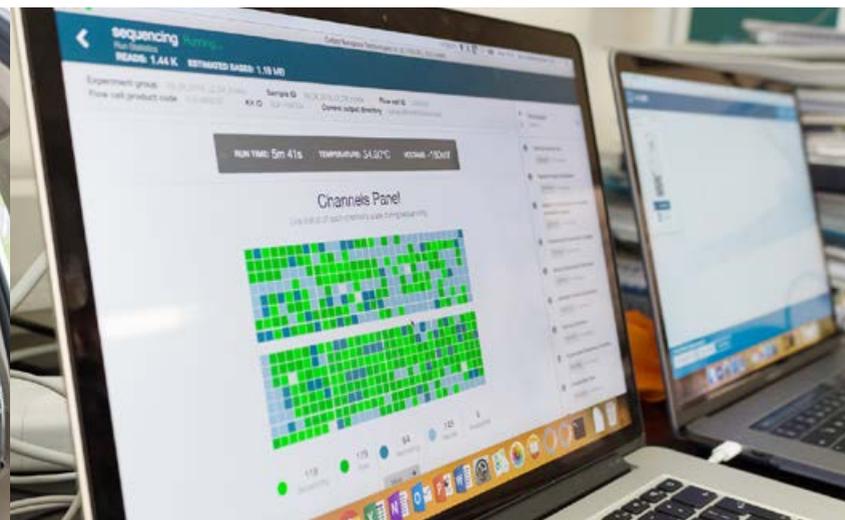
“I am delighted that this work has been recognized,” Hodson said. “Wheat rusts are a global threat to agriculture and to the livelihoods of farmers in developing countries such as Ethiopia. MARPLE diagnostics puts state-of-the-art, rapid diagnostic results in the hands of those best placed to respond: researchers on the ground, local governments and farmers.”



Leaf samples are taken in the field.



Samples are tested in the field using mobile equipment.



Laptop computers in the lab display sequencing results.

New wheat reference sequence

Blueprint for effective breeding

Using the new reference map for wheat published by the International Wheat Genome Sequencing Consortium (IWGSC) in 2018, researchers from the International Maize and Wheat Improvement Center (CIMMYT) have shown that breeding by the Center and partners since 2003 has accumulated many favorable, yield-related genes in most wheat lines distributed through its International Wheat Improvement Network (IWIN), benefiting wheat farmers worldwide.

“These favorable alleles appear increasingly in wheat varieties released by national partners over the last decade,” said Philomin Juliana, associate scientist at CIMMYT who is facilitating the center’s efforts to use the new map. “This points to CIMMYT’s effectiveness in delivering high-

quality wheat lines and serving countries unable to run their own full-fledged wheat breeding program.”

Wheat is the world’s most widely cultivated crop and contributes roughly one-fifth of the calories in human diets. Expert sources including the Food and Agriculture Organization (FAO) of the United Nations have projected a rise in the demand for wheat as high as 60 percent by mid-century, as the world population rapidly increases and moves to cities. Together with more resource-efficient cropping systems, high-yielding and climate-resilient wheat varieties will constitute a key component of the sustainable intensification of food production described in Strategy 3 of the recent [EAT-Lancet Commission recommendations](#) to transform the global food system.

THE WHEAT GENOME: A complex genetic treasure trove

The August 2018 edition of *Science* magazine published the newly completed and fully annotated reference genome for bread wheat by the IWGSC. The new wheat genome map includes a detailed analysis of genes among subgenomes as well as the organization of the chromosomes, the thread-like structures that carry the genes. A genome is the complete set of an organism's DNA.

The bread wheat genome is a hybrid that comes from the natural crosses of genetically simpler Emmer wheat with a wild grass around 10,000 years ago and incorporates both genomes. The bread wheat genome is more than five times larger than the human genome. Its size and complexity made it hard for scientists to produce a high-quality reference sequence. The IWGSC has involved 2,400 members in 68 countries working together since 2005.

A BBC report on the new wheat genome map mentioned CIMMYT as a leader in the work to help meet the food demand of the 9.6 billion global population expected in 2050.

Philomin and her colleagues have located key genomic regions associated with grain yield, tolerance to heat and drought stresses, disease resistance, and grain quality in CIMMYT wheat lines, along with cross-referencing those to matching regions in the new wheat genome map.

"This sheds light on the relative positions of our markers, with respect to the genes, and on whether we have a novel ones or just the known ones, ultimately informing us how better to select for these traits," explained Philomin.

She said that CIMMYT has pioneered global research to leverage the new reference sequence. "And because our results are freely available, they represent a valuable resource for the global wheat research community and can accelerate genomics-assisted breeding for this crucial food crop."

To enable this research using the new wheat genome, CIMMYT researchers fingerprinted more than 40,000 CIMMYT wheat breeding lines and dozens of wheat varieties

worldwide, providing what Philomin calls "a quantum leap" in datasets for understanding the genetic bases of key traits in superior varieties.

Genomic assisted breeding: Wave of the future

The new genome map and related CIMMYT research will help the center's scientists to apply genomic information in choosing better parental combinations and selecting superior progenies through "genomic selection" that integrates the new wheat genome knowledge and constitutes a novel approach for wheat.

"The new map and CIMMYT studies provide insights into the genomic bases of trait 'predictabilities' and pinpoint chromosomal segments that contribute to the best lines," Philomin said. "This can improve selection efficiency and get high-yielding, climate- and disease-resilient wheat varieties to farmers much faster."

As documented in a [2017 article](#) in the science journal *Global Food*



"The new map and CIMMYT studies provide insights into the genomic bases of trait 'predictabilities' and pinpoint chromosomal segments that contribute to the best lines."

Philomin Juliana
CIMMYT Wheat Breeder

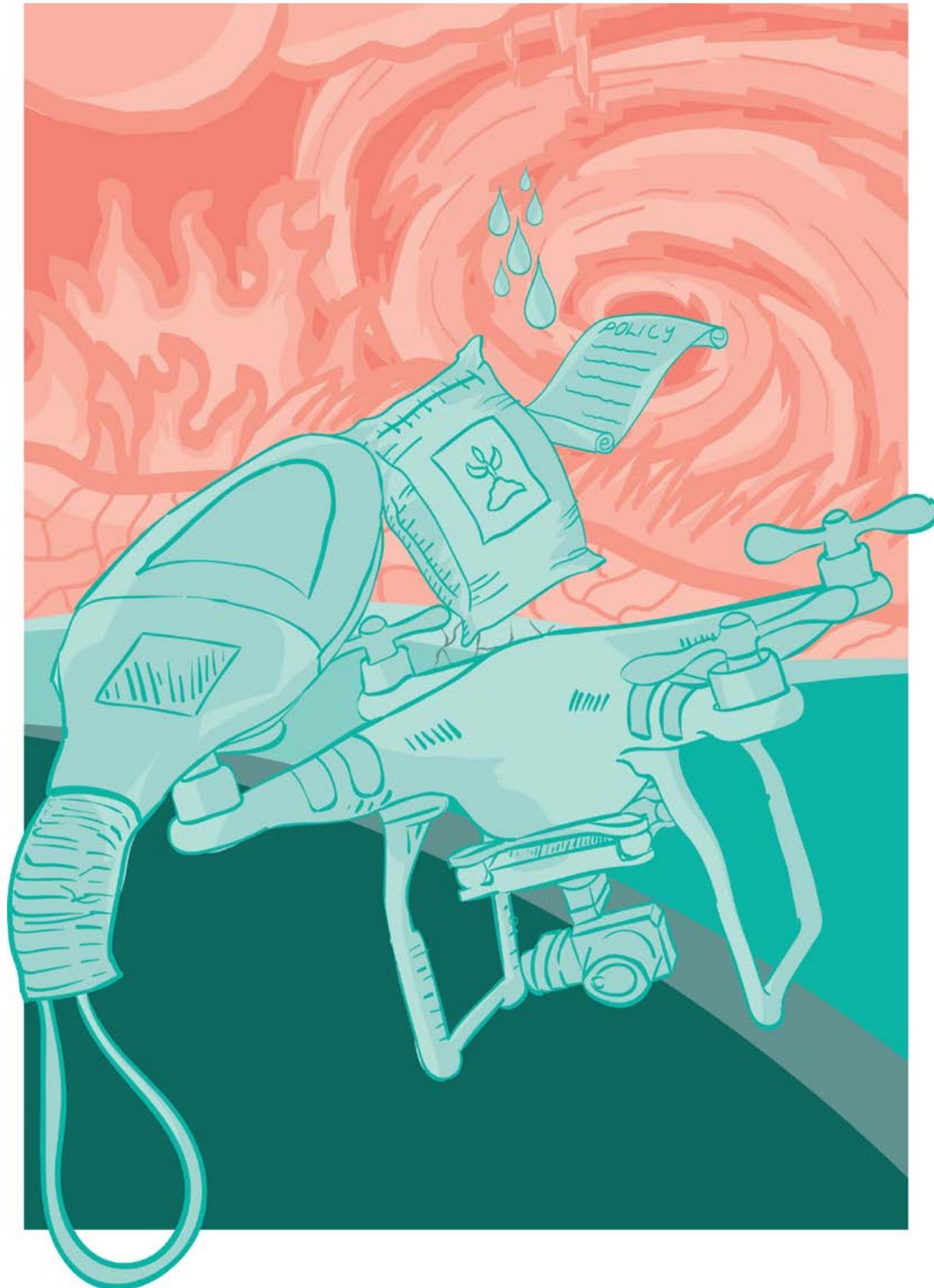
Security, rapid breeding and varietal replacement are critical for adapting the developing world's wheat and other cropping systems to the effects of climate change.

Philomin was a recipient of Monsanto's Beachell-Borlaug International Scholars Program Award (2013) and the Jeanie Borlaug Laube Women in Triticum award (2015).

Funders of this work include the Cornell University-led Delivering Genetic Gain in Wheat (DGGW) project and USAID's Feed the Future (FTF) Innovation Lab for Applied Wheat Genomics. Contributing to the research described are research teams engaged in wheat improvement at CIMMYT, and Jesse Poland, Associate Professor at Kansas State University and Director of the USAID Applied Wheat Genomics Innovation Lab.

Left: Carolina Sansaloni, head of CIMMYT's sequencing and genotyping lab, has supported research to understand the genetic bases of key traits for wheat breeding.





Targeted tools and practices to tackle **CLIMATE CHANGE**

Decades of research and application by scientists, extension workers, machinery specialists, and farmers have perfected practices that conserve soil and water resources, improve yields under hotter and dryer conditions, and reduce the greenhouse gas emissions and pollution associated with maize and wheat farming in Africa, Asia, and Latin America.

All are being studied and promoted with farmers and partners by the International Maize and Wheat Improvement Center (CIMMYT), as the following examples illustrate.

Strict dosing of wheat fertilizer in Mexico

In the Yaqui Valley, an irrigated desert in northwest Mexico dedicated to intensive durum wheat cropping, scientists are working urgently with farmers to help them apply nitrogen fertilizer more precisely.

“If you under-apply nitrogen fertilizer, your yield goes down, so farmers typically over-fertilize,” said Iván Ortíz-Monasterio, CIMMYT sustainable intensification and wheat crop management expert.

Wheat plants will use only about a third of the nitrogen applied; the remainder is partly emitted as nitrous oxide, a powerful greenhouse gas, or seeps into waterways, causing harmful algae blooms in the Sea of Cortés off Mexico’s northwest coast.

Ortíz-Monasterio has worked with developers of inexpensive hand-held sensors that let farmers know exactly when to apply fertilizer and how much for optimal crop yield and nitrogen use. Last year, a local company began flying drone-mounted sensors over wheat fields, converting the readings to fertilizer



Sergio Sivamea Cepeda grows wheat and sorghum in Tetabiate, state of Sonora, northwestern Mexico, using zero tillage, crop residues, biofertilizers, and irrigation with waste water.

dosage recommendations and selling the information to farmers.

“Farmers growing wheat on approximately 1,000 hectares paid for the service last year,” said Ortíz-Monasterio. “Now four such companies are operating in the Valley. This represents a win-win for local businesses, farmers, and climate change mitigation, not only for Yaqui Valley but potentially for other regions worldwide that share similar growing conditions and challenges.”

Endorsing climate-smart farm policies in South Asia

To increase farmer adoption of resource-conserving and climate-resilient methods in South Asia, where more than 13 million hectares are under rice-wheat cropping rotations, the CIMMYT-led Cereal Systems Initiative for South Asia

(CSISA) has helped foster small businesses that sell zero-tillage and other services to farmers or rent specialized equipment to them. CIMMYT scientists worked with local experts in South Asia and other partners to develop and spread a powerful implement that can sow wheat seed directly into unplowed soils and thick rice residues. In Bihar and eastern Uttar Pradesh, India,

the number of service providers using this “Happy Seeder” grew from just over 200 in 2012 to more than 4,000 – covering nearly 260,000 hectares – in 2018.

“India could reduce its greenhouse gas emissions from agriculture by almost 18 percent through efficient use of fertilizer, zero tillage, and better water management in rice farming,” said Tek Sapkota, agricultural systems and climate change mitigation specialist for CIMMYT, referring to a 2018 study he led.

Paralleling the work by Ortíz-Monasterio in Mexico, Sapkota and colleagues found that precision management using the Nutrient Expert and photosynthesis sensors to fine tune fertilizer dosages raised yields as much as 25 percent, with up to 20 percent less greenhouse gas emissions.



GreenSeeker is a compact sensor that quickly assesses crop vigor to calculate optimal fertilizer dosages.

“Adopting those practices for rice and wheat throughout India would result in 13.9 million tons more grain, 1.4 million tons less fertilizer applied, and 5.3 million tons less carbon-dioxide-equivalent emissions per year, over current farming practices,” Sapkota said.

Conservation agriculture boosts resilience in small-scale maize farming in Africa

Climate-smart practices are helping smallholder farmers maintain maize yields under increasingly hot and dry conditions in sub-Saharan Africa. The region’s number-one food crop, maize is grown using rainfall and with little or no mineral fertilizer, according to CIMMYT scientist Christian Thierfelder.

“Soil quality is improved by reduced tillage and by rotating or intercropping maize with ‘green manures,’ legumes that add nitrogen and organic matter to the system,” said Thierfelder. “Together with

keeping crop residues on the field, these practices build healthier soils, conserve moisture, and allow crops to stand up to erratic weather.”

The residue cover also suppresses weeds and the legume intercrop provides more fodder for livestock, a critical source of income for many farmers. Thierfelder said farmers are requesting more information on climate-smart practices, fertilizer access, improved varieties, and labor-saving techniques.

Funders and partners include the Agriculture and Rural Development Department (SADER) of Mexico, the Australian Centre for International Agricultural Research (ACIAR), the Bill & Melinda Gates Foundation, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and its funders, the Indian Council of Agricultural Research (ICAR), the International Food Policy Research Program (IFPRI), the International Rice Research Institute (IRRI), and the U.S. Agency for International Development (USAID).



Zambian farmer Gertrude Banda has benefited from CA practices, including zero tillage, improved weed control, and intercropping maize with cowpeas.



Drought-tolerant hybrid seed offers farmers reprieve from hunger

Gitau Gichuru, a smallholder farmer in Vyulya, Machakos, Kenya, is not worried about his maize crop, despite the hot sun and dry weather.

For years, prolonged dry spells have undermined the food security and livelihoods of rural families in the region, who depend on rain-fed farming. But Gitau is growing a drought tolerant hybrid developed by CIMMYT and promoted to Kenyan farmers by Dryland Seed company. Under the right management practices, the hybrid can yield up to 20 percent more than other popular drought-tolerant hybrids in the region, according to Dryland Seed’s managing director, Ngila Kimotho.

When Gichuru sowed the hybrid maize for the first-time last season, he didn’t expect the crop to amount to anything. “We only had some little rain at the time of planting and during the vegetative state,” he explained, “but, I’m looking forward to a good harvest.”



Left: Appropriate mechanization can support smallholder farmers' adoption of diverse innovations and move to more efficient, profitable agriculture.

Systems, scaling, and suitable mechanization for smallholder farmers

A new approach is helping to extend the benefits of international maize and wheat research to more farmers and consumers in developing countries in transformative and lasting ways.

Known among development experts as “scaling,” the approach has enabled a mechanization and irrigation project by the Cereal Systems Initiative for South Asia (CSISA-MI) to foster and promote more than 3,300 local operators of small-scale agricultural machinery who serve approximately 213,000 farmers on more than 100,000 hectares in southern Bangladesh.

With more than 1,250 inhabitants per square kilometer, Bangladesh is among the world’s most densely populated countries and depends on intensive agriculture for its food security and nearly one-sixth of its economy.

“Scaling” is about expanding appropriate technologies and practices to benefit many farmers and consumers with lasting improvements – for example, the permanent adoption of more profitable and climate-smart methods such as conservation agriculture to grow crops, according to Jack McHugh, a senior scientist at the International Maize and Wheat Improvement Center (CIMMYT), who leads CSISA and the mechanization and irrigation project.

“To support local agriculture machinery services, CSISA-MI assists more than 76 mechanics and workshops, 80 spare parts shops, and over 120 machinery dealers, many of which did not exist a year ago and may not have come into being, had we not focused on certain scaling elements,” said McHugh, explaining that CSISA-MI aims to boost dry-season agriculture



in southern Bangladesh through adoption of surface water irrigation and right-sized agricultural machinery services.

McHugh and colleagues decided to examine project successes and constraints employing CIMMYT's Scaling Scan tool in 2018, as CSISA-MI was facing its final year. Using around 40 tactical questions, the Scaling Scan walks users through diagnostic steps to assess and score a project's ambitions, business plan, value chain and collaborative linkages, and other real-world factors that impinge on its lasting impact and possible external consequences.

"The clinical analysis we conducted following the scaling scan helped us to re-focus our efforts, leading among other things to dramatically



"Scaling" is about expanding appropriate technologies and practices to benefit many farmers and consumers with lasting improvements.

reducing the number of target sub-districts and concentrating on those with the highest market potential," McHugh explained. "The success of CSISA-MI's final year can be directly attributed to the scaling scan."

Mechanization for smallholders across regions

Similar projects led by CIMMYT and partners in Africa, Latin America, and South Asia are providing technical support and business advice to promote appropriate mechanization among smallholder farmers, according to Jelle Van Loon, a CIMMYT mechanization specialist.

"Around half of the world's food is grown by smallholder farmers in low- or middle-income countries, largely using hand labor," said Van Loon. "They are being forced to intensify



and become more competitive, as the costs of labor and farm inputs rise, while many youths and working-age men migrate to cities to find work."

Van Loon and colleagues are testing and promoting technology such as two-wheel tractors and related implements that are suited to small fields, sloped lands, and rural households unable to afford expensive equipment and often headed by women.

"Many farmers cannot afford or obtain credit to purchase even small-scale equipment," Van Loon said. "So our projects are helping to establish low-cost rental centers or local entrepreneurs able to purchase equipment and sow, harvest, or thresh grain for farmers willing to pay for such services."

To better address the constraints for such operations, Van Loon and his colleagues applied the Scaling Scan to CIMMYT-led mechanization initiatives in Ethiopia, Kenya, Mexico, and Zimbabwe, in addition to CSISA-MI project countries.

"Preliminary results suggest that, rather than subsidizing equipment, we should incentivize potential clients to access machine services while linking potential service providers with machinery dealers and mechanics," Van Loon explained. "The demand for services actually appears to outstrip the supply in all three regions. Poor distribution networks for machines and spare parts are a problem, especially in Ethiopia and Zimbabwe, where there is little awareness about the potential financial benefits for farmers to hire machine services."

Van Loon noted that more extensive adoption of appropriate machinery is held back by smallholders' lack of financing and a long-term need for technical and business training for service providers.



Finding system "sweet spots" for change

"Scaling draws on the notion that technology adoption relies largely on parallel and supporting innovations in other sectors such as finance, public governance, and capacities," said Lennart Woltering, CIMMYT scaling advisor who is working with CGIAR and other partners to explain and apply scaling in agricultural research for development. "This helps bring our projects face-to-face with the complex realities they must address for success, as well as fostering a more demand-driven,

systemic approach so that whatever we change with our intervention continues beyond the project."

The idea, explained Woltering, is that systems of people, relationships, and norms perpetuate the problems that development efforts seek to address. "Accordingly, systems thinking and tools like the scaling scan can help find leverage points for the same system to perpetuate a solution," he said. "Successful scaling requires a mindset that critically distinguishes between artificial changes due to a project and changes in the system."

Key partners for scaling include the PPP lab (a consortium of SNV, Erasmus University, Aqua4All and CDI Wageningen) and MasAgro (a partnership between the Mexican government and CIMMYT). Essential funding is provided by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Germany, and the CGIAR Research Programs on Maize and Wheat.

Opposite page, from top: A local service provider uses a bed planter on farms near Barisal, Bangladesh; visitors test tractors during a field day in Zimbabwe; new manufacturers are trained in Harare; a youth group provides mechanization services in Ethiopia. Above: Two-wheel tractor engines are ready for final assembly.



Scaling out sustainable farming in Mexico



More than 0.5 million Mexican farmers have adopted research products for maize and wheat conservation, improvement, sustainable production, and commercialization over the past 8 years. They are at the forefront of sustainable farming in Mexico thanks to MasAgro, a successful partnership between the Mexican government and the International Maize and Wheat Improvement Center (CIMMYT).

To help increase farmers' yields sustainably, CIMMYT has bred 64 maize hybrids adapted to the tropical, subtropical and temperate regions of Mexico. Together with the Mexican agricultural research system (INIFAP), CIMMYT has also developed 15 high-yielding wheat varieties adapted to the main growing areas located in central and northwestern Mexico.

In 2018, 62 small and medium-sized local companies receiving training from CIMMYT sold 1 million bags of improved maize seed. Since

2011, their combined sales have increased by 55 percent. The new MasAgro maize hybrids and wheat varieties grown under sustainable intensification have helped farmers increase their productivity and income above the national average.

The latest data show that maize farmers who participated in the project achieved average yields and income that were 54 and 61 percent higher, respectively, than those obtained by other farmers in Mexico. Similarly, the productivity and income of participant wheat farmers were above the national average by 10 and 14 percent, respectively. In sum, the farmers who took part in MasAgro grew maize, wheat and related crops on more than 1.2 million hectares across Mexico in 2018.

CIMMYT also coordinated training for field technicians of one of Mexico's Agriculture Department primary programs, which further expanded MasAgro's outreach and impact. Over 34,000 farmers from 16 states

of Mexico participated in 2,074 workshops and 1,941 field events in 2018. CIMMYT estimates that these activities had beneficial spillovers in adjacent farms covering a total area of 390,000 hectares.

CIMMYT is also working with the private sector to promote sustainable farming in Mexico with local, responsible-sourcing projects. More than 3,300 farmers growing maize and wheat on more than 32,000 hectares in 5 states have been identified as project beneficiaries. Together, these farmers will supply more than 400,000 tons of grain produced locally and sustainably to leading food processing companies over the next three-to-five years.

Opposite page, top: Farmers harvest maize in the state of Chiapas, Mexico.

Opposite page, left: Collaborators from field research platforms and demonstration modules inspect the new MasAgro maize hybrids at Villa de Corzo, Chiapas.

Opposite page, right: Technicians from Tabasco state participate in a workshop on geographic information systems in Cárdenas, Tabasco.

CIMMYT financial overview

Top funders, 2018 (in thousands of U.S. dollars)

Donor	2018	2017
CGIAR Research Programs/Platforms (Note 1)	27,659	
Bill & Melinda Gates Foundation	22,149	
Secretaría de Agricultura y Desarrollo Rural	21,912	
United States Agency for International Development	16,926	
Australian Centre for International Agricultural Research	5,634	
Cornell University (Note 2)	5,065	
HarvestPlus (Note 3)	2,040	
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GbmH	2,030	
Agricultural Research, Education and Extension Organization	1,606	
Biotechnology and Biological Sciences Research Council	1,012	

Amounts exclude deferred depreciation.

Note 1: Australia, Belgium, Canada, France, Global Crop Diversity Trust, India, Korea Republic, Netherlands, New Zealand, Norway, Sweden, Switzerland, UK (DFID), United States Agency for International Development and World Bank.

Note 2: Bill & Melinda Gates Foundation and DFID as back funder.

Note 3: UK Government, Bill & Melinda Gates Foundation, US Government's Feed the Future initiative, European Commission, CGIAR Research Program on Agriculture for Nutrition and Health, and supported by the John D. and Catherine T. MacArthur Foundation.

Table 1. Combined statement of financial position as of December 31, 2018 and 2017 (thousands of U.S. dollars).

	2018	2017
ASSETS		
Current assets:		
Cash and cash equivalents	108,548	99,223
Program-related cash and cash equivalents	1,081	1,735
Accounts receivable, net	8,213	11,028
Inventory and supplies, net	1,026	1,158
Total current assets	118,868	113,144
Non-current assets:		
Property and equipment, net	8,952	48,111
Intangible assets	3	31
Prepaid rent	142	342
Total non-current assets	49,097	48,484
TOTAL ASSETS	167,965	161,628
LIABILITIES AND NET ASSETS		
Current liabilities:		
Short-term employee benefits	672	644
Program - related accounts payable	1,097	2,042
Accounts payable	62,113	54,703
Deferred revenue	27,057	27,062
Total current liabilities	90,939	84,451
Non-current liabilities:		
Employee benefits	11,501	12,442
Provisions	563	707
Total non-current liabilities	12,064	13,149
TOTAL LIABILITIES	103,003	97,600
Net assets:		
Unrestricted net assets:		
Undesignated	45,280	45,172
Designated	21,586	20,785
Total unrestricted net assets	66,866	65,957
Temporary net assets-other comprehensive income	(1,904)	(1,929)
TOTAL UNRESTRICTED NET ASSETS	64,962	64,028
TOTAL LIABILITIES AND NET ASSETS	167,965	161,628

2018 and 2017 financial statements

A summary of the combined statements of financial position and combined statements of activities and other comprehensive income for CIMMYT and CIMMYT, A.C., are set out in tables 1 and 2. Total revenues for 2018 amounted to US \$120.8 million and US \$133.8 million in 2017 (excluding financial income). The surplus for 2018 totaled US \$0.9 million and US \$1.5 million for 2017. Total net assets increased by US \$0.9 million in 2018 to US \$64.9 million.

Table 2. Combined statement of activities and other comprehensive income for the years ending on December 31, 2018 and 2017 (thousands of U.S. dollars).

	2018	2017
OPERATING		
Grant revenue		
Windows 1 and 2	27,213	25,037
Window 3	43,916	55,138
Bilateral	48,581	51,922
Total grant revenue	119,710	132,097
Other revenue and gains	1,120	1,725
Total operating revenue	120,830	133,822
Expenses and losses		
Research expenses	81,203	82,545
CGIAR collaborator expenses	10,047	10,980
Non CGIAR collaborator expenses	17,174	25,859
General and administration expenses	11,160	13,663
Other expenses and losses	293	(1,824)
Total operating expenses and losses	119,877	131,223
Operating surplus	953	2,599
NON-OPERATING		
Gain on sale of assets	162	34
Finance income	1,266	873
TOTAL NON-OPERATING INCOME	1,428	907
Finance expenses	1,472	592
TOTAL NON-OPERATING EXPENSES	1,472	592
NON-OPERATING (DEFICIT)/SURPLUS	(44)	315
SURPLUS FOR THE YEAR	909	2,914
OTHER COMPREHENSIVE INCOME		
Actuarial gain/deficit - defined benefit plan	25	(1,453)
Sub-total other comprehensive income	25	(1,453)
Total comprehensive surplus for the year	934	1,461
EXPENSES BY FUNCTION		
Personnel costs	48,167	47,671
CGIAR collaborator expenses	10,047	10,980
Non CGIAR collaborator expenses	17,174	25,859
Supplies and services	34,701	34,788
Travel	4,955	4,252
Depreciation/amortization	3,134	6,674
Cost sharing percentage	1,699	999
TOTAL OPERATING EXPENSES AND LOSSES	119,877	131,223

2018 and 2017 revenue overview

Total grant revenues for 2018 was US \$119.7 million and US \$132.1 million in 2017 (Table 3). Other revenues and gains (excluding financial income) amounted to US \$1.1 million in 2018 and US \$1.7 million in 2017.

Table 3. Schedule of grants revenues For the years ending in December 31, 2018 and 2017 (thousands of U.S. dollars).

Donors	2018	2017
WINDOWS 1 & 2		
CGIAR RESEARCH PROGRAMS (CRPs) / PLATFORMS		
PHASE II		
CRP on Maize	8,536	9,617
CRP on Wheat	12,845	10,116
CRP on Climate Change, Agriculture and Food Security	1,675	1,656
CRP on Policies, Institutions, & Markets	333	415
CGIAR Genebank Platform	1,204	999
CGIAR Excellence in Breeding Platform	2,087	1,190
CGIAR Platform for Big Data in Agriculture	528	171
SUBTOTAL-WINDOWS 1 & 2	27,206	24,164
WINDOW 3		
Agricultural Research, Education and Extension Organization (AREEO)	1,158	213
Australian Centre for International Agricultural Research	2,545	3,151
Bill & Melinda Gates Foundation (BMGF), USA	22,077	17,777
Chinese Academy of Agricultural Sciences (CAAS)	541	340
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Germany	-	-
HarvestPlus	2,040	800
Indian Council of Agricultural Research (ICAR), India	900	911
Instituto Nacional de Innovación Agraria (INIA), Peru	-	2
International Fund for Agricultural Development (IFAD), Italy	209	187
Michigan State University, USA	36	-
Ministry of Food, Agriculture & Livestock, Republic of Turkey	181	167
Ministry of Foreign Affairs of Japan (MOFA)	46	108
U.S. Agency for International Development (USAID)	14,607	29,095
SUBTOTAL-WINDOW 3	44,340	52,752
BILATERAL		
African Agricultural Technology Foundation (AATF), Kenya	130	2,174
Agricultural Research, Education and Extension Organization (AREEO)	(77)	102
Agrovet S.A., Spain	100	32
Arcadia Biosciences, USA	-	115
Australian Centre for International Agricultural Research (ACIAR)	3,078	3,460
Bangladesh Institute of ICT in Development	-	98
Bayer CropScience NV, Belgium	87	7
Bill & Melinda Gates Foundation (BMGF), USA	-	65
Biotechnological and Biological Sciences Research Council (BBSRC), United Kingdom	1,055	750
Borlaug Institute for South Asia, India	160	332
CGIAR Integrated Breeding Platform (IBP), Mexico	394	99
Canadian International Development Agency (CIDA)	977	1,278
Catholic Relief Services, USA	286	301
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia	-	262
Compañía Nacional Almacenedora, S.A. de C.V. (Gruma), Mexico	93	-
Consejo Nacional de Ciencia y Tecnología (CONACyT), Mexico	27	25
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Germany	2,067	1,191

BILATERAL		
Development Fund, Norway	274	196
Euroconsult Mott MacDonald (Mott MacDonald), Netherlands	22	-
Fomento Social Banamex, A.C., Mexico	390	63
Food and Agriculture Organization (FAO), Italy	406	530
Global Crop Diversity Trust (GCDDT), Germany	734	992
Grains Research and Development Corporation (GRDC), Australia	357	494
Grupo Bimbo, S.A. de C.V., Mexico	148	-
Grupo Cuauhtémoc Moctezuma, S.A. de C.V., Mexico	177	-
Institute of Development Studies (IDS), United Kingdom	107	14
International Center for Agricultural Research in the Dry Areas (ICARDA), Lebanon	115	-
International Center for Research in Agroforestry (ICRAF), Kenya	-	123
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India	365	1,033
International Development Enterprises (IDE UK), United Kingdom	24	222
International Food Policy Research Institute (IFPRI), USA	-	72
International Institute of Tropical Agriculture (IITA), Nigeria	126	690
International Livestock Research Institute (ILRI), Kenya	28	126
International Plant Nutrition Institute (IPNI), USA	30	29
International Potato Center (CIP), Peru	204	155
International Rescue Committee (IRC), USA	139	27
Japan International Research Center for Agricultural Sciences (JIRCAS), Japan	21	43
KazAgroInnovation, Kazakhstan	-	138
Kellogg Company, Mexico	311	121
Minister of Agriculture and Rural Development for Alberta, Canada	-	86
Ministry of Agriculture, Forestry and Fisheries, Japan	69	241
National Research Council, Canada	96	65
Nestlé México S.A. de C.V., Mexico	170	-
Norsk institutt for bioøkonomi (NIBIO), Norway	93	57
Rezatec (UK Services) Limited, United Kingdom	238	198
Rothamsted Research Limited, United Kingdom	79	121
Rwanda Agricultural Board (RAB)	4	31
Secretaría de Desarrollo Agropecuario del Estado de Querétaro, Mexico	7	274
Secretaría de Agricultura y Desarrollo Rural (SADER), Mexico	21,912	21,824
Secretaría de Desarrollo Agropecuario y Rural (Gobierno de Guanajuato), Mexico	845	1,293
Secretaría de Desarrollo Rural del Estado de Chihuahua (SDR Chihuahua), Mexico	-	54
Syngenta Foundation for Sustainable Agriculture, Switzerland	798	1,144
Total Land Care (TLC), Malawi	-	130
United Way Worldwide/Kellogg, USA	23	137
Cornell University, USA	4,997	714
Harvard University, USA	-	78
Henan Agricultural University (Henan AU), China	349	162
Kansas State University (KSU), USA	308	643
Norwegian University of Life Sciences (NMBU), Norway	32	-
Purdue University, USA	78	89
University of California at Davis (UC Davis), USA	426	475
University of Cambridge, United Kingdom	9	-
University of Edinburgh, United Kingdom	61	-
University of Florida, USA	80	7
University of Nebraska (UNL), USA	31	48
University of Nottingham/BMGF, United Kingdom	114	-
University of Texas at Austin (UT Austin), USA	98	167
U.S. Agency for International Development (USAID)	2,434	2,379
U.S. Department of Agriculture (USDA)	231	717
Various, public and private sector	115	123
Wageningen University, Netherlands	130	30
Walmart Foundation, USA	337	-
World Food Program (WFP), Italy	12	-
SUBTOTAL-BILATERAL	46,533	46,647
MISCELLANEOUS RESEARCH GRANTS	1,631	8,535
GRAND TOTAL	119,710	132,097

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Acronyms

A4NH	CGIAR Research Program on Agriculture for Nutrition and Health	IFPRI	International Food Policy Research Institute
ACIAR	Australian Centre for International Agricultural Research	IITA	International Institute of Tropical Agriculture
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa	INIFAP	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias
BARI	Bangladesh Agriculture Research Institute	IRRI	International Rice Research Institute
BBSRC	Biotechnology and Biological Sciences Research Council	IWGSC	International Wheat Genome Sequencing Consortium
CA	conservation agriculture	IWIN	International Wheat Improvement Network
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security	KALRO	Kenya Agricultural & Livestock Research Organization
CIAT	International Center for Tropical Agriculture	LFSP	Livelihood and Food Security Program
CRP	CGIAR Research Program	MAIZE	CGIAR Research Program on Maize
CSISA	Cereal Systems Initiative for South Asia	MARPLE	Mobile and Real-time Plant Disease Diagnostics
CSISA-MI	Cereal Systems Initiative for South Asia-Mechanization and Irrigation	MLN	maize lethal necrosis
CtEH	Crops to End Hunger Initiative	NARO	Uganda's National Agricultural Research Organization
DFID	Department for International Development	PIM	CGIAR Research Program on Policies, Institutions and Markets
DGGW	Delivering Genetic Gain in Wheat	QAAFI	Queensland Alliance for Agriculture and Food Innovation
EIAR	Ethiopian Institute of Agricultural Research	QPM	quality protein maize
EIB	Excellence in Breeding	R4D	research for development
FAO	Food and Agriculture Organization of the United Nations	RAB	Rwanda Agricultural Board
FAW	fall armyworm	RARS	Regional Agricultural Research Station
FTF	Feed the Future	SADER	Secretaría de Agricultura y Desarrollo Rural
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	SAWBO	Scientific Animations Without Borders
ICAR	Indian Council of Agricultural Research	SIMLESA	Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa
ICARDA	International Center for Agricultural Research in the Dry Areas	USAID	United States Agency for International Development
		WHEAT	CGIAR Research Program on Wheat
		WIT	Women in Triticum

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