ANNUAL REPORT
maize and wheat for future climates
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 improvement of health and nutrition for the world’s poorest people.

In this issue, SDG icons attached to each story help signal how CIMMYT’s work ties to the SDGs.
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The next half century: Taking the legacy forward

In October 2016, I had the immense honor of taking over from John Snape, who made tremendous contributions as the chair of CIMMYT’s Board of Trustees. This change occurred at a particularly auspicious time in the Center’s history, as the depth and breadth of partnerships and donor support had just been evidenced in multiple events marking the Center’s 50th anniversary. These events showcased CIMMYT’s unique and distinctive comparative advantage in applying maize and wheat science to improve livelihoods.

As shown in the reports that follow and in the new “Strategic Plan 2017-2022: Improving Livelihoods through Maize and Wheat Science,” activities and outputs directly address efforts to meet key U.N. Sustainable Development Goals. In particular, they target critical challenges of food insecurity and malnutrition, climate change and environmental degradation.

The board takes a keen interest in the continuous improvement of Center scientific and corporate processes, its ability to respond to new and existing threats and to take advantage of emerging opportunities for partnerships and collaborations. To enhance the Center’s effectiveness, transparency and accountability, management is strengthening project management, with a focus on monitoring, evaluation, learning, and improving internal communications.

CIMMYT also played a significant role in the CGIAR’s 2016 transformation, with donors uniting to ensure that food and nutrition security can be realized through research with impact.

As we enter the next 50 years in CIMMYT’s history, I take this opportunity to thank our worldwide donors, collaborators, fellow board members, management committee, scientists and staff for their commitment and dedication to CIMMYT’s mission.

Nicole L. Birrell
Chair, Board of Trustees
CIMMYT at 50: New pathways to sustainable food and nutritional security

In 2016, CIMMYT marked 50 years of applying excellence in maize and wheat science to improve the livelihoods of the disadvantaged. The work has brought remarkable returns on the funding we receive. A study published this year showed that as many as 63 percent of wheat varieties grown by farmers worldwide carry genetic contributions from the breeding programs of CIMMYT or of the International Center for Agricultural Research in the Dry Areas (ICARDA).

Dominating our awareness as well are several weighty facts: 800 million people go hungry today and, by 2030, projections indicate there will be 8.4 billion people to feed – 1 billion more than at present. While we do what we can to increase yields of two of the world’s key staple crops, achieving widespread food and nutritional security is more complex than simply boosting production.

However, sobering concerns put any self-congratulatory impulse on hold. In 2016, news reports described the tragic effects of severe drought in Africa caused by the El Niño weather system. Worsening political instability in 2016 affected development initiatives in several countries whose inhabitants already suffered from chronic poverty and conflict.

Key collaborations and science

CIMMYT pursues strong partnerships and better science to create and share innovations that farmers can use now and in the future to grow more, earn more and reduce environmental impacts. Highlights from 2016 included these examples:

- Biofortification research to raise zinc and iron content in maize and wheat grain resulted in the release of zinc-enhanced wheat varieties embraced by farmers in India and Pakistan, to help improve the nutrition of low-income wheat eaters.
- In eastern Africa, CIMMYT and its partners released five new varieties that resist maize lethal necrosis, bringing security to maize farmers with crops affected by the disease.
- In eastern Africa, CIMMYT and its partners released five new varieties that resist maize lethal necrosis, bringing security to maize farmers with crops affected by the disease.
- With models predicting rising temperatures in South Asia, CIMMYT has intensified work with partners to produce affordable drought- and heat-tolerant maize seed for the region’s farmers.
- CIMMYT and Henan Agricultural University in China jointly launched a new maize and wheat research center in the historic Yellow River Valley.
- To deliver new heat-tolerant and disease-resistant wheat varieties, CIMMYT has expanded work in advanced physiological breeding, high-throughput phenotyping, and drawing out genetic traits from heirloom varieties and native grasses.
- Conservation agriculture and drought-tolerant maize varieties from CIMMYT were used by many farmers in southern Africa to obtain harvests even during the El Niño drought.
- The Center helped to develop and now leads the new CGIAR “Excellence in Breeding Platform,” designed to modernize crop and livestock breeding and increase its impact on food and nutrition security, climate change adaptation and development.

Taking stock and mapping a course

As part of CIMMYT 50th anniversary celebrations, more than 500 distinguished representatives of diverse partner and donor institutions, among them 5 ministers of agriculture, took part in a 3-day conference to reflect on CIMMYT’s past and plan for the future. Outcomes are reflected in the Center’s new Strategic Plan 2017-2022. The strategy aims to better enable maize and wheat agriculture systems to produce more using less land and inputs, create sustainable livelihood opportunities for farmers, support healthy and nutritious diets, mitigate and adapt to climate change and foster equitable access for women and marginalized groups to knowledge, markets, technology and training.

Those goals entail enormous challenges. Still, we are confident of success with the ongoing commitment and support of dedicated staff, partners and donors.

Sincerely,

Martin Kropff

Martin Kropff hosts Mexico’s Secretary of Agriculture, José Eduardo Calzada Rovirosa.
**CIMMYT in 2016**

**Farmers reached:**
More than 18,000,000 through improved maize and wheat system farming practices.

**Publications:**
Global Maize and Global Wheat Program scientists were authors for 286 publications.

**Trainings:**
64,000+ farmers, scientists, technicians and other partners trained in over 20 countries through MAIZE and WHEAT.

**Partners:**
300+ MAIZE and WHEAT partners.

**Maize and wheat seed distribution:**
- 795 shipments
- 40.6 tons sent to over 80 countries

**CIMMYT social media content generated:**
- 104,000 page visits
- 25,000 link clicks

**"CIMMYT News" online newsletter:**
- 236 news articles
- 21 news editions

**"CIMMYT News" top article:**
Maize: From Mexico to the world

**"CIMMYT News" top video:**
Nixtamalization Video Series
118,000+ YouTube views

**CIMMYT First:**
"Save a Seed" campaign
The Save a Seed crowdfunding campaign raised over $50,000 to support the maize and wheat germplasm bank’s seed collection and distribution.

**Social media highlight:**
CIMMYT50 Conference Day 1 Photo gallery
- 15,600 people reached
- 8,600 engagements
varieties developed by CIMMYT and its partners,” said Willy Bett, Cabinet Secretary, Ministry of Agriculture, Livestock and Fisheries, Kenya.

September events in Mexico opened with field and laboratory visits at CIMMYT headquarters and moved to a two-day, high-level conference in Mexico City. Presentations and discussions there acknowledged CIMMYT and CGIAR’s considerable impacts but also highlighted critical food security gaps and the intensifying social and environmental challenges facing agriculture, including climate change and the need to focus on better nutrition and health.

“Without a CGIAR there would be 100 countries in conflict and not the 60 that we know today,” said Juergen Voegele, Senior Director, Agriculture Global Practice, World Bank, and CGIAR System Council Chair, speaking to an audience of over 500 CIMMYT employees, donor representatives and partners and dignitaries, including the Ministers of Agriculture of Bangladesh, Chile, Kenya, Mexico and Pakistan. “The CGIAR has a major role to play in ensuring nutrition security and peace and conflict resolution.”

During the conference CIMMYT and DuPont Pioneer signed a Master Alliance Agreement on the use of CRISPR-Cas gene editing technology to jointly develop improved crops with traits of interest for smallholder farmers.

To mark 50 years of applying maize and wheat science to improve livelihoods, CIMMYT held events for celebration and reflection throughout 2016, including a momentous September gathering in Mexico. In celebrations organized by the CIMMYT offices in Kenya and Zimbabwe in April, distinguished participants enjoyed first-hand tours of research activities and provided input on plans for strengthening maize and wheat agri-food systems through partnerships in the sub-Saharan Africa.

“When we speak about Africa’s Green Revolution, it cannot take place without the improved

Vijay Chaikam, CIMMYT maize scientist, explains doubled haploids and their value in breeding research to visitors at the Kenya CIMMYT50 celebrations.

Celebrations in India, home of the Green Revolution, included ceremonies and talks during the First International Agrobiodiversity Congress.

Looking back to CIMMYT’s origins as an international center in 1966, the individuals who signed the launch agreement concurred that the institute “…should become a focal point for joining the critical battle now underway to provide enough food for the rapidly increasing population of the world.”

According to Martin Kropff, CIMMYT director general, the Center’s founders would probably agree that CIMMYT has gone a long way toward fulfilling their lofty aspirations. “But a modern CIMMYT is still needed,” Kropff said, “based on the original ideal of international collaboration in agricultural research for development.”
The two CGIAR Research Programs (CRPs) known as MAIZE and WHEAT and led by CIMMYT are international collaborations involving hundreds of partners worldwide. The MAIZE CRP focuses on increasing production for 900 million poor consumers in Africa, South Asia and Latin America with the overarching goals of doubling maize productivity and increasing incomes and livelihood opportunities from sustainable, maize-based farming systems. WHEAT couples advanced science with field-level research and extension in lower- and middle-income countries, working with public and private organizations to raise the productivity, production and affordable availability of wheat agri-food systems for 2.5 billion resource-poor consumers in 89 countries. Following a successful initial period (2011-2016), both CRPs received CGIAR and donor approval for an additional phase.
WHEAT: One-stop source of productivity, resilience, and farm-level technologies

A total of 48 bread wheat, 10 durum wheat and one winter wheat varieties released by WHEAT partners in 18 developing countries in 2016 were either CIMMYT or ICARDA breeding lines or direct crosses with such lines. In 2016, CIMMYT alone distributed 14.5 tons of seed of experimental wheat lines in 306 shipments to 284 partners in 83 countries. Years of biofortification research and breeding bore fruit in the form of three high-yielding, zinc-enhanced varieties released by partners for use by farmers in South Asia. As part of an emergency response funded by the United States Agency for International Development (USAID) and its Office of U.S. Foreign Disaster Assistance, CIMMYT rapidly procured emergency supplies of maize and wheat seed for free distribution to more than 226,000 households in 67 counties of Ethiopia, benefitting more than 1.3 million people whose seed was lost from the drought. A study showed that the Turkey-CIMMYT-ICARDA International Winter Wheat Improvement Program (IWWIP) had contributed to the development and release of 61 varieties sown on some 1.8 million hectares, as of 2016.

GENNOVATE, a cross-CRP initiative focused on gender equality, completed data collection and coded data for 137 case studies on 7,000 rural men and women in 26 countries. Among the preliminary findings for wheat farming systems is that, although women of all ages still lack equal access to education or training, many men in various countries are now seeing the advantages of involving women in farm decisions. Thanks to the joint efforts of national scientists, farmers, government, cooperation with the U.N. Food and Agriculture Organization (FAO), World Bank and other international organizations, the wheat area under zero tillage in Kazakhstan increased from virtually none in 2000 to 2.3 million hectares in 2016, providing an additional 0.72 million tons of grain in drought years and contributing to the annual sequestration of about 1.3 million tons of carbon dioxide.

MAIZE: High yields, stress tolerance and climate-smart practices

MAIZE made strong progress on both of its research strategies: stress-resilient and nutritious maize and sustainable intensification of maize-based systems. At least 5.6 million hectares were under improved MAIZE-derived technologies or management practices, directly reaching more than 11.4 million smallholder farmers. In total, 111 improved maize varieties, based on germplasm from CIMMYT or the International Institute of Tropical Agriculture (IITA), were released through MAIZE partners in 2016, including 76 in sub-Saharan Africa, 27 in Latin America and 8 in Asia. In addition to high and stable yield potential, special traits stacked in these varieties include drought tolerance, nitrogen use efficiency, tar spot complex resistance, enhanced protein quality, and resistance to tar spot complex, ear rot, mycotoxin production, and Turcicum leaf blight.

Across South Asia, MAIZE scientists under the Heat Tolerant Maize for Asia project licensed 20 new hybrids to public and private partners and 12 new seed companies, including 5 each from Pakistan and Bangladesh and 2 from Nepal, signed research collaboration agreements to join the project. MAIZE scientists are promoting climate-smart technologies such as conservation agriculture and drought-tolerant maize varieties to adapt to the negative effects of climate variability and to increase smallholder farmers’ productivity. Malawi maize farmers were able to harvest more in 2016 while spending 35 to 45 fewer days of labor through conservation agriculture farming practices such as direct seeding, in place of conventional ridging and traditional weed control strategies.

MAIZE and WHEAT are grateful to the generous CGIAR Window 2 donors that support their work, including Australia, China, Mexico, South Africa, the United Kingdom’s Department for International Development, and the United States Agency for International Development, as well as all Window 1 donors: Australia, the Bill & Melinda Gates Foundation, Canada, France, India, Japan, Korea, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and World Bank. Principal research partners for MAIZE and WHEAT are the International Institute of Tropical Agriculture and the International Center for Agricultural Research in the Dry Areas. For more information, visit www.maize.org or www.wheat.org.
Wheat versus chaff: Is the gluten-free diet fad waning?

An anti-wheat movement inspired by populist claims that gluten is bad for human health rumbles on, but scientists are now leading a strong campaign to refute trendy claims and promote the many nutritional benefits of wheat.

A vital food providing 20 percent of calories and protein in the human diet worldwide, wheat has taken a reputational beating from celebrity doctors who say it is responsible for causing obesity, mental malaise and other negative health conditions.

Scientists are concerned that false claims maligning wheat will lead to further food insecurity and poor health for low-income consumers with wheat-based diets who may reject this staple food due to misinformation.
Such assertions in “Wheat Belly” by William Davis (2011) and “Grain Brain” by David Perlmutter (2013) run counter to current medical and nutritional advice in international dietary guidelines established by FAO and the World Health Organization (WHO).

Much of the anti-wheat argument hinges on claims that the properties of current wheat varieties are somehow different and less healthy than the “ancient” wheat grains first grown and consumed 9,000 years ago, due to scientific intervention, according to Carlos Guzmán, head of the wheat chemistry and quality laboratory at CIMMYT.

“Since the anti-gluten movement began, scientific reports have shown that, contrary to claims stating otherwise, commercially available wheat does not lead to weight gains or chronic disease, and it’s certainly not transgenic,” said Guzmán.

Apart from the estimated 1 percent of populations in Europe and the United States with celiac disease and an estimated 5 to 10 percent who have gluten sensitivity, wheat is safe and healthy to eat, according to the authors of “Does Wheat Make Us Fat and Sick?”, a study that appeared in the Journal of Cereal Science.

“In fact, the research shows that regularly eating whole grain products is healthy and associated with significantly less risk of developing type 2 diabetes, heart disease, and certain forms of cancer, and it can also help with long-term weight management,” added Guzmán.

Guzmán works with scientists researching ancient grains and landraces, the predecessors to contemporary wheat that are estimated to be available in about 25,000 different forms. Bread wheat arose from the spontaneous, natural cross-pollination of a primitive wheat with a wild grass, rather than through any scientific intervention.

A recent study titled, “The contribution of wheat to human diet and health” argues that dietary fiber in wheat makes such a vital contribution to human health that research should focus on enhancing the characteristic through breeding.

Nutritionist Julie Miller Jones spoke at CIMMYT’s 50th anniversary conference in September 2016, adding clout to the arguments in favor of whole grain consumption, pointing out benefits and showing how wheat surpasses beef in protein levels. Miller Jones argues that the key to weight loss and good health is to eat a healthy, balanced diet featuring smaller portions and to exercise.
New maize varieties conventionally bred to withstand extreme weather are helping farmers stay one step ahead of climate change in sub-Saharan Africa. Temperatures are increasing in Africa and the past three decades have been the warmest on record, according to the International Panel on Climate Change. Farmers are especially feeling the heat in sub-Saharan Africa, where maize is the key staple food crop and nearly all of it is grown with increasingly erratic rainfall, rather than irrigation.

“We are no longer sure when to prepare the land for planting or when to start planting,” said Appollonia Marutsvaka, a 62-year-old farmer from Zaka, a rural village in Zimbabwe. “If the situation persists, then most of us who have small farms will sink deeper into poverty.”

Concerned by the expected impact of increasing heat on African maize yields, CIMMYT researchers began breeding heat tolerance into maize five years ago, crossing their lines with sources of heat tolerance and selecting the best offspring. In 2016, the new, hardy maize was put to the ultimate test by a severe regional drought, which was brought on by the El Niño weather phenomenon and described by the UN as the worst in decades.

“El Niño had a devastating impact on agricultural...”

Maize for dryer, hotter climates

New technologies such as drones are speeding up breeding to provide farmers with maize varieties that stand up to climate change. Despite severe drought in Zimbabwe, new maize varieties bred to withstand heat and drought have yielded twice as much as commercial varieties, helping farmers ensure household food security.
Maize breeders are working to speed up breeding efforts to help farmers stay ahead of climate change.

“It is more than just a single variety, it’s a process,” said Cairns. “Our investments in breeding efficiency through new molecular and phenotyping tools helped us develop heat-tolerant varieties that yielded so well under El Niño in just five years.”

Traditionally, varieties can take up to 20 years to reach farmers. However, new technologies, such as data from flying drones loaded with cameras and other sensors can cut the time to monitor crop health from days to minutes (see sidebar).

Scientists are also working in public and private partnerships to improve seed systems and speed the deployment of climate-ready varieties to farmers. The importance of adapting African agriculture to climate change was highlighted at the 2016 Marrakech Climate Change Conference, and the story of heat-tolerant maize in Zimbabwe was shared as an example of how crops adapt to the environment – a research area known as “phenotyping.”

In addition to learning from each other’s experiences, a half day was dedicated to drafting position papers on priority areas for future research and a keynote talk and discussion on harmonizing the many phenotyping platforms that have emerged in recent years.

CIMMYT partnered with the International Plant Phenotyping Network to organize the event.
Beating South Asia’s water crisis

CIMMYT and partners are promoting ways to use South Asia’s precious water more carefully and productively.

South Asia accounts for nearly a quarter of the world’s food production but has access to less than 5 percent of its annual renewable water resources, with per capita water availability decreasing by nearly 70 percent since the 1960s. Yields of wheat, maize and rice in South Asia could decrease by as much as 30 percent over this century, unless farmers adopt innovations to mitigate rising temperatures and changing rainfall patterns.

With a large and growing population, declining arable land, escalating energy costs and intensifying groundwater scarcity in many areas, South Asia’s food and nutritional security challenges typify those of lower- and middle-income regions worldwide: how to produce more food in a water-limited future.

Interruptions in electrical power supplies

Power failures directly threaten food security as demand for electricity-powered irrigation grows. While power outages have declined nearly 10% in South Asia since 2000, the region continues to have the most electricity disruptions in the world.

Annual power failures (% of total output)

South Asia

Latin America/Caribbean

Sub-Saharan Africa


Diminishing water resources

Global groundwater depletion for irrigation

Global groundwater withdrawals for irrigation rose over 20% from 2000 to 2010. Today, 70% of global water withdrawals are for agriculture.

Limited land for production

Arable land decline results from human and climatic factors, including degradation, extreme weather, soil quality and urbanization.


Sources:


2008. CGIAR-CSI.

2017. World Resources Institute.

2017. FAO.


2017. Land Use Policy.
Storing and restoring priceless maize seed collections in Guatemala

The CIMMYT maize germplasm bank serves as a backup for farmers and researchers in times of catastrophic seed loss by safeguarding maize genetic diversity, a crucial building block in global food security. CIMMYT also trains local and national seed bank staff in best practices to preserve maize genetic diversity.

Natural disasters can have a dramatic impact on crop genetic diversity, threatening local and global food security. When Hurricane Stan swept through Guatemala in 2005, leading to 1,500 deaths, many farmers lost entire crops. Some indigenous communities were unable to harvest seed from their traditional maize varieties, known as landraces.

Generations of selection by farmers under local conditions had endowed these varieties with resistance to drought, heat, local pests and diseases.
As the country struggled to rebuild and replant, it was found that the entire maize seed collection at Guatemala’s national seed bank had been damaged by humidity that made the seeds vulnerable to insects and fungus and could not be replanted.

In 2016, drawing upon the back-up seed stores in its maize germplasm bank in Mexico, CIMMYT sent Guatemalan collaborators seed of more than 700 native Guatemalan maize varieties, including some of the varieties that had been lost.

Guatemalan scientists are now planting seed from the historic CIMMYT samples to ensure the varieties will grow well under local conditions. The best materials will be returned to local and national seedbanks in Guatemala, where they will be available for farmers and researchers to grow, study and use in breeding programs.

The effective conservation of seeds in the genebank outside their natural habitat is complex and costly, according to Denise Costich, head of the maize germplasm bank at CIMMYT.

“Seeds must be stored at constant low temperatures and humidity,” Costich said. “Seed bank curators must also regularly monitor the seed’s ability to germinate and, when a sample’s capacity falls too low, grow out the healthy seed in controlled plantings at a location similar to the environment of origin of the collection.”

Given the challenges and resource constraints faced by many countries with important native maize collections, international seed banks play a vital role as “safe deposit boxes for the world,” she said.

In addition to natural disasters, civil wars can also impact genetic diversity as people are forced to flee their homes, leaving seed of their traditional crops behind.

“Many believe that seed banks are needed only in the case of an “Armageddon” – some sort of global disaster that would completely disrupt agriculture as we know it,” Costich said. “But vulnerable smallholder farmers may face several ‘mini-Armageddons’ in a lifetime, crises that cost them entire crops, and with that, the loss of traditional seed varieties. If such seed is not safely stored elsewhere, then the matchless diversity it represents is forever lost to humanity.”

CIMMYT’s maize germplasm bank team based at headquarters in Mexico conserves, studies and shares some 28,000 unique collections of seed of native maize varieties and wild relatives for the benefit of humanity in accordance with the 2007 International Treaty on Plant Genetic Resources for Food and Agriculture.

The germplasm bank also supports national initiatives such as the Buena Milpa project in Guatemala, which is improving storage practices in community seed reserves – tiny, low-tech seed banks meant to serve as backups for villages in cases of catastrophic seed-loss. A workshop for Guatemala’s national seed bank and Buena Milpa personnel on best practices for storing maize germplasm took place in 2016 at the CIMMYT maize germplasm bank in Mexico.

The Buena Milpa project is supported by funding from the United States Agency for International Development’s Feed the Future program.
India farmers put aside the plow, save straw and fight pollution

Researchers and policymakers are promoting zero tillage for wheat to stop rice residue burning in northern India and help prevent smog in New Delhi, as well as to cut farmers’ costs and conserve soil and water resources.

Farmers who deploy a sustainable agricultural technique known as “zero tillage” in the rice-wheat cropping rotations grown throughout northern India can significantly contribute to reduced air pollution in India’s capital, helping urban dwellers breathe more easily.

Traditional tillage to sow wheat in northern India involves removing or burning rice straw and driving tractor-drawn implements back and forth over fields to rebuild a soil bed from the rice paddy, a costly and protracted process.

Media reports in 2016 depicted the 19 million inhabitants of New Delhi under siege from a noxious haze generated by traffic, industries, cooking fires and the burning of over 30 million tons of rice straw on farms in the neighboring states of Haryana and Punjab.
Since the 1990s, CIMMYT scientists have worked with national agricultural partners and advanced research institutes in India, Nepal, and Pakistan to test and promote the resource-conserving approach of sowing wheat seed directly into untilled soil and rice residues in a single tractor pass, a method known as zero tillage.

Originally deemed foolish by many farmers and researchers, the practice or its adaptations are being used on as much as 1.8 million hectares in India. It has gained popularity because it allows farmers to save money and fuel through less work and tractor use, to reduce weather risks as well as to sow their wheat up to two weeks earlier; this means the grain fills before the withering heat of pre-Monsoon season.

Environmental benefits of zero tillage include healthier soils, significant water savings and a 90 kilogram-per-hectare reduction in greenhouse gas emissions, according to M.L. Jat, senior agronomist at CIMMYT.

“This emission savings figure considers only soil respiration,” said Jat, “but if we talk about carbon sequestration based on life cycle analysis, the greenhouse gas savings range from 500 to 1,000 kilograms of carbon dioxide equivalent per hectare, each crop cycle.”

Zero tillage requires the use of a special, tractor-mounted implement, which, in a single pass, chops rice residues, opens a rut in the soil, and precisely deposits and covers the seed.

Development of this special seeder was first funded by the Australian Centre for International Agricultural Research (ACIAR) and led by Punjab Agricultural University, with contributions from CIMMYT and other organizations. The latest version, the Turbo Happy Seeder, costs $1,900 – an investment that many farmers still struggle to make.

“As an alternative, we’ve been saying that not all farmers need to own a seeder,” according to Jat. “Many farmers can simply hire local service providers who have purchased the seeder and will sow on contract.”

In Bihar and the neighboring state of Uttar Pradesh, the number of zero-tillage service providers rose from only 17 in 2012 to more than 1,900 in 2015, according to Jat, who leads CIMMYT’s contributions to “climate-smart” villages in South Asia, as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Given New Delhi’s smog troubles, Haryana and Punjab policymakers are providing limited subsidies for purchases of the seeder and other policy support for burn-free, climate-smart agricultural practices.
Seed companies and farmers improve maize yields in Mexico

The Mexican maize seed industry has upgraded its portfolio of products to better address the needs of smallholder farmers. More than 50 local companies have seen sales increase by 70 percent in the last 5 years. In 2016 alone, these small and medium-sized enterprises (SMEs) sold over 1.1 million bags of 100 maize hybrids.

Mexican seed companies have traditionally marketed obsolete maize hybrids and open pollinated varieties on a land area of about 1.25 million hectares, representing 42 percent of the seed market in Mexico. At the same time, large multinational seed companies dominated a market of 1.75 million hectares in the best rain-fed and irrigated regions of Mexico. Meanwhile, Mexican smallholder farmers have struggled to raise their maize yields.
Maize is grown in highly-diverse settings throughout Mexico, often by smallholder farmers who prefer specific types of grain for local dishes or use maize plants in varied ways. CIMMYT and its partners work with these farmers to raise productivity and profitability of landrace maize and heirloom varieties, which have often been grown for generations in tough, local conditions and carry landrace traits such as preferred grain and cooking quality.

This participatory breeding work, or breeding that involves close farmer-researcher collaboration to bring about plant genetic improvement within a species, is conducted in these communities through the MasAgro project, in which traditional landraces are selected by farmers with the assistance of Mexico’s National Institute of Forestry, Agriculture, and Livestock Research (INIFAP), the Chapingo Autonomous University and CIMMYT scientists. Selection and crosses are made using the best samples from farmers in the community and, where needed, seed collections from CIMMYT’s germplasm bank or breeding lines and populations. This allows communities to develop new, improved maize varieties with higher yields and stress resistance, while preserving valued landrace traits such as preferred grain and cooking quality.

Now, most Mexican seed companies offer high-yielding, stress-tolerant hybrids adapted to rain-fed conditions. These hybrids yield from two-to-four times the average yield of obsolete varieties in target areas. Three larger local companies are now challenging multinational companies’ share of the most valuable markets in the country, fostering competition that will eventually push seed prices down. Access to better seed in new areas could increase average maize yields on a scale that would lead Mexico to become self-sufficient in the production of its most important crop.

Today, local companies control 30 percent of the seed market in Mexico and their total sales of improved seed have increased by 70 percent, since first partnering with CIMMYT in 2011.

“Improved maize seed is grown on 3 million hectares across Mexico, of the total of 8 million hectares sown to the crop,” said Arturo Silva, leader of the International Maize Improvement Consortium for Latin America. “As a result of public and private efforts, the market of improved seed will grow to cover 5.5 million hectares by 2020.”

These encouraging results are the product of a partnership with public research institutions and more than 50 local seed companies that annually test dozens of high-yielding, disease-resistant and climate resilient maize hybrids developed by breeders in the Sustainable Modernization of Agriculture (MasAgro) project, which is supported by Mexico’s Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA).

After five years of collaborative field trials and pre-commercial tests since 2011, 49 new white and yellow CIMMYT hybrids were released to the Mexican seed sector. These materials contributed to more than 500,000 of the 1.1 million bags of improved seed sold by Mexican companies in 2016.

These maize hybrids have been specifically adapted to the needs of smallholder farmers and are put to the test on hundreds of sites across Mexico. Seed companies help farmers by hosting training sessions on hybrid seed production and commercialization.

In 2016, participatory trials in 9 target communities were conducted in the state of Oaxaca, involving 240 men and 160 women farmers from 46 communities who attended multiple training events.

“We are targeting the poorest and most underserved farmers and have helped to increase their yields,” said Martha Willcox, maize landrace improvement coordinator at CIMMYT. “This has helped communities increase their local food security as they no longer have to purchase additional maize to eat, and has allowed some to access markets specific to landrace maize at prices higher than hybrid grain.”

Added to other benefits, improved livelihoods from these efforts have allowed some farmers to stay with their families all year, rather than migrating to the United States to work.
The new Maize Molecular Atlas comprises an online resource of data, knowledge, and tools to describe, explore, and use the genetic diversity of more than 28,000 maize samples. It will help plant breeders and scientists respond to the challenges of new diseases, heat, and drought stresses affecting crops.

Key data and tools to identify and use crop genetic resources are being linked in a powerful, emerging maize molecular atlas that provides new and easier ways to access valuable contents from the black box of maize genetic diversity.

Like a car navigation system that helps drivers to steer through a complex network of information, the Atlas synthesizes valuable physical information to reach a desired destination — in this case, the maize genetic regions associated with desirable traits and in the most appropriate germplasm.

The goal is to enable scientists to use knowledge about maize diversity to respond to existing and new breeding challenges.

Most Atlas information relates to maize landraces, ancestral varieties that farmers adapted...
The goal is to enable scientists to use knowledge about maize diversity to respond to existing and new breeding challenges.

The Atlas combines genetic fingerprint data of 28,000 seed samples that form the entire maize collection in CIMMYT’s germplasm bank, together with collection site geographic data for more than 19,000 landraces and wild relatives of maize and data from targeted phenotypic evaluations.

The system also features data collection and visualization software, search and statistical analysis tools and training links, allowing users to find landraces of interest online.

The data are interpreted against background knowledge on maize biodiversity generated by MasAgro Biodiversidad, the Mexican government’s contribution to the CIMMYT-led Seeds of Discovery project, which associates desirable agronomic traits to known regions in the maize genome.

SAGARPA invited CIMMYT to present the Maize Molecular Atlas during the 13th Meeting of the Conference of the Parties (COP 13) to the Convention on Biological Diversity that took place in Cancún, Mexico, in December 2016.

More than 250 Mexican researchers and students have participated in workshops to learn how to use molecular atlas data and tools in their work to develop climate change-responsive maize varieties for the future.

At its headquarters outside Mexico City, CIMMYT maintains a vast “seed library” holding the world’s most important collection of maize and wheat genetic diversity. The diversity embodied in these seed collections, which number 180,000, includes original races of maize and wheat that were domesticate over millennia by farmers. The seed is conserved, studied and shared by CIMMYT with breeders, specialists and farmers worldwide. In 2016, 41 tons of wheat and maize seed were shipped to 100 countries. For decades, CIMMYT maize and wheat breeders have drawn on this diversity for genes to strengthen the disease resistance and climate resilience of modern, improved varieties.

The CIMMYT genebank also safeguards and restores seed collections lost or threatened by conflicts. Genebank staff are working with ICARDA to preserve and genetically analyze ICARDA wheat seed collections that were relocated from Syria with the outbreak of civil war.

Under the Seeds of Discovery project, a joint initiative of CIMMYT and SAGARPA through the MasAgro project, scientists have genetically analyzed approximately 90,000 CIMMYT maize and wheat seed collections from more than 100 countries and nearly 30,000 wheat and wheat wild relative samples from ICARDA.

Protecting maize and wheat genetic diversity across the globe

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Maize and wheat farmers worldwide are facing the emergence and spread of new or modified strains of deadly crop diseases and pests, including insects and micro-organisms such as fungi and viruses. Chemical controls are costly and potentially harmful to human and environmental health. Genetically-bred crop resistance and pesticides work for a time, but the organisms evolve to overcome those restraints or spread to susceptible crop varieties at new locations.

CIMMYT applies science and partnerships to draw resistance genes from maize and wheat landraces, global seed collections, and other crop genetic resources. The genes are used to breed and test new, resistant varieties, whose seed is then increased and made available to farmers. Scientists also wield modern systems to track pest and pathogen evolution and movements. They analyze pest and pathogen interactions with crops and create combinations of new genes that offer longer-lasting resistance. The diseases and pest described here are examples of those that have made the news recently.

**Wheat stem rust**

The Ug99 race of wheat stem rust, a fungal disease, emerged in eastern Africa in the late 1990s and has spawned 13 new strains, spreading to 13 countries. Ug99 is highly-virulent for nearly all popular wheat varieties. The national research programs in Ethiopia and Kenya have supported the yearly screening of as many as 50,000 wheat lines from breeding programs worldwide under strong natural Ug99 infections, allowing rapid identification of new, resistant varieties. Enough seed has been multiplied so many countries in the projected path of Ug99’s spread are safe from serious outbreaks. Another stem rust race group known as TKTTF has spread to over a dozen countries in Africa, Asia, and Europe, since its detection in Turkey in 2005.

**Wheat blast disease**

Long confined to South America, the mysterious fungal disease known as wheat blast suddenly appeared in Bangladesh in 2016, causing 25-30 percent losses on 15,000 hectares of wheat and threatening to spread quickly throughout South Asia’s vast wheat lands, where no varieties are resistant. CIMMYT and WHEAT partners are at the center of an urgent global response to monitor, characterize and control blast and, especially, to develop and deploy resistant wheat varieties.

**Maize lethal necrosis (MLN)**

Involving a deadly alliance of two viruses and first reported in eastern Africa in 2011, MLN disease kills plants before they can grow, and the pathogens are transmitted by insects or contaminated seed. Serious damage to the region’s maize has led many farmers to stop growing the crop. Progress to counter MLN includes the production and distribution of resistant hybrids.

**The fall armyworm**

A moth from the Americas that appeared in Africa in 2016 and whose larvae feed on numerous crops, the fall armyworm is able to destroy as much as 70 percent of a maize harvest and, once adult larvae are established, is not easily controlled by pesticides. Scientists from CIMMYT and IITA are working with partners worldwide on integrated approaches including chemical and biological controls, resistant varieties, agronomic management, and tracking and early-warning systems.
CIMMYT financial overview

Table 1. Combined statement of financial position as of 31 December, 2016 and 2015 (thousands of U.S. dollars).

<table>
<thead>
<tr>
<th>Category</th>
<th>2016</th>
<th>2015</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total assets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-current assets</td>
<td>22,690</td>
<td>23,253</td>
<td>(563)</td>
</tr>
<tr>
<td>Prepaid rent - ICRAF, Nairobi</td>
<td>500</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>Total non-current assets</td>
<td>23,190</td>
<td>23,753</td>
<td>(563)</td>
</tr>
<tr>
<td><strong>Current assets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash and cash equivalents</td>
<td>30,390</td>
<td>31,270</td>
<td>(880)</td>
</tr>
<tr>
<td>Cash set aside due to Breeding</td>
<td>4,898</td>
<td>4,756</td>
<td>142</td>
</tr>
<tr>
<td>Total current assets</td>
<td>35,288</td>
<td>36,026</td>
<td>(738)</td>
</tr>
<tr>
<td><strong>LIABILITIES AND NET ASSETS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total liabilities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-term employee benefits</td>
<td>723</td>
<td>1,018</td>
<td>(295)</td>
</tr>
<tr>
<td>Accounts payable</td>
<td>1,022</td>
<td>1,929</td>
<td>(907)</td>
</tr>
<tr>
<td>Accounts payable, net</td>
<td>1,252</td>
<td>1,128</td>
<td>34</td>
</tr>
<tr>
<td>Total current assets</td>
<td>111,059</td>
<td>113,283</td>
<td>(2,224)</td>
</tr>
<tr>
<td><strong>Non-current liabilities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property and equipment, net</td>
<td>22,190</td>
<td>22,733</td>
<td>(543)</td>
</tr>
<tr>
<td>Prepaid rent - ICRAF, Nairobi</td>
<td>500</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>Total non-current liabilities</td>
<td>22,690</td>
<td>23,253</td>
<td>(563)</td>
</tr>
<tr>
<td><strong>Total liabilities and net assets</strong></td>
<td>133,749</td>
<td>136,536</td>
<td>(2,787)</td>
</tr>
</tbody>
</table>

Table 2. Combined statement of activities as of 31 December, 2016 and 2015 (thousands of U.S. dollars).

<table>
<thead>
<tr>
<th>Category</th>
<th>2016</th>
<th>2015</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenues and gains</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grant revenue</strong></td>
<td>132,091</td>
<td>135,115</td>
<td>(2,024)</td>
</tr>
<tr>
<td>Other revenue and gains</td>
<td>405</td>
<td>425</td>
<td>(20)</td>
</tr>
<tr>
<td>Total revenue and gains</td>
<td>132,066</td>
<td>135,540</td>
<td>(3,474)</td>
</tr>
<tr>
<td><strong>Expenses and losses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research expenses</td>
<td>77,305</td>
<td>76,922</td>
<td>383</td>
</tr>
<tr>
<td>CGIAR collaboration expenses</td>
<td>11,033</td>
<td>12,926</td>
<td>(1,893)</td>
</tr>
<tr>
<td>Non-CGIAR collaboration expenses</td>
<td>32,039</td>
<td>31,924</td>
<td>115</td>
</tr>
<tr>
<td>General and administration expenses</td>
<td>13,425</td>
<td>11,320</td>
<td>2,105</td>
</tr>
<tr>
<td>Other expenses and losses</td>
<td>8</td>
<td>30</td>
<td>(22)</td>
</tr>
<tr>
<td>Total expenses and losses</td>
<td>124,429</td>
<td>123,114</td>
<td>1,315</td>
</tr>
<tr>
<td>Financial incomes</td>
<td>205</td>
<td>227</td>
<td>(22)</td>
</tr>
<tr>
<td>Financial expenses</td>
<td>497</td>
<td>718</td>
<td>(221)</td>
</tr>
<tr>
<td><strong>Surplus</strong></td>
<td>(1,985)</td>
<td>2,035</td>
<td>(3,980)</td>
</tr>
</tbody>
</table>

Table 3. Schedule of grant revenues for the years ending 31 December, 2016 and 2015 (thousands of U.S. dollars).

<table>
<thead>
<tr>
<th>Donor</th>
<th>2016</th>
<th>2015</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CGIAR Funds</td>
<td>6,628</td>
<td>7,057</td>
<td>(429)</td>
</tr>
<tr>
<td>Bangladesh Institute of ICT in Development</td>
<td>40</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>CGIAR Centers</td>
<td>8</td>
<td>36</td>
<td>(28)</td>
</tr>
<tr>
<td>International Centre for Agricultural Research in the Dry Areas (ICARDA)</td>
<td>-</td>
<td>252</td>
<td>252</td>
</tr>
<tr>
<td>International Institute of Tropical Agriculture (IITA)</td>
<td>1,004</td>
<td>1,173</td>
<td>(169)</td>
</tr>
<tr>
<td>International Potato Center (CIP)</td>
<td>38</td>
<td>42</td>
<td>(4)</td>
</tr>
<tr>
<td>Center for International Forestry Research (CIFOR)</td>
<td>43</td>
<td>79</td>
<td>(36)</td>
</tr>
<tr>
<td>International Potato Research Institute (IPRRI)</td>
<td>65</td>
<td>62</td>
<td>3</td>
</tr>
<tr>
<td>International Centre for Climate Change, Agriculture and Food Security (CRP-CCAFS)</td>
<td>2,540</td>
<td>2,789</td>
<td>(249)</td>
</tr>
<tr>
<td>CRP on Policies, Institutions and Markets (CRP-PIM)</td>
<td>451</td>
<td>541</td>
<td>(90)</td>
</tr>
<tr>
<td>Challenge Programs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HarvestPlus</td>
<td>2,790</td>
<td>3,547</td>
<td>(757)</td>
</tr>
<tr>
<td>CGIAR Funds</td>
<td>12,031</td>
<td>11,889</td>
<td>142</td>
</tr>
<tr>
<td>CRP on Maize</td>
<td>11,708</td>
<td>9,776</td>
<td>1,932</td>
</tr>
<tr>
<td>CGIAR Funds</td>
<td>1,311</td>
<td>1,187</td>
<td>124</td>
</tr>
</tbody>
</table>

2016 and 2015 financial statements

A summary of the combined statements of financial position and combined statements of activities for CIMMYT and CIMMYT A.C., are set out in tables 1 and 2. Total revenues for 2016 amounted to $133.3 million and $135.8 million in 2015 (including financial incomes for each year). The loss for 2016 totaled $1.6 million and the surplus for 2015 $2.9 million.

Total net assets decreased by $1.9 million in 2016, to $63.2 million and increased by $2.9 million in 2015, to $65.1 million.

2016 and 2015 revenue overview

Total grant revenue for 2016 was $132.7 million and $135.1 million in 2015 (Table 3). Other revenues, and financial incomes amounted to $0.7 million in 2016 and $7.9 million in 2015.
We refer to the 2016 annual report of CIMMYT for this information. Here is the text converted into a plain text representation:

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maize and wheat for future climates