

Resilience • Renewal • Transition
Annual Report 2020





The 2030 Agenda for Sustainable Development, adopted by all United Nations (UN) Member States in 2015, provides a shared blueprint for peace and prosperity, for people and the planet. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries to achieve a better and more sustainable future for all.

The SDGs set the pathway for agricultural, social, and economic development. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice.

CGIAR transformed its approach to ensure that its work is aligned with the ambitious goals. CIMMYT, through its research-for-development activities, contributes to empower women, reduce greenhouse gas emissions, and improve the health and nutrition of the world's poorest people.

CIMMYT's work contributes to the following SDGs:



◀ **Front cover.** Farmers carry clay pots on their heads as they walk back home in Bagan, Myanmar. A plant sprouts from the ground.

ABOUT CIMMYT

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.

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Message from the CHAIR OF THE BOARD OF TRUSTEES



Nicole Birrell

The year 2020 has been unprecedented, in terms of both the challenges from the COVID-19 pandemic and the initiation of a far-reaching transformation of CGIAR into a more aligned and stronger organization.

This was the fourth year in the execution of CIMMYT's Strategic Plan 2017-22. Notwithstanding some pandemic-induced reduction in research activities, we witnessed the continued delivery of its research and partnerships outcomes for the benefit of millions of the poorest smallholder farmers. The wide-ranging adoption of CIMMYT varieties in farmers' fields and continued progress in fighting pests and diseases by exploiting the rich diversity of CIMMYT's genebanks are particular highlights. More generally, CIMMYT continues to pivot further towards a systems-based approach to addressing the pressing challenges of enhancing the livelihoods of smallholder farmers in a climate change crisis.

The pandemic required a significant risk management response which was successfully implemented and continues to date, limiting as much as possible adverse impacts on both Center operations and the health and wellbeing of its staff. The Board acknowledges and applauds the tremendous efforts of staff at all levels in these difficult times.

CIMMYT was able to maintain its funding pipeline and achieved a break-even financial result for the year. CIMMYT has concluded

the 2020 financial year with a \$0.6 million deficit. The financial result, before taking into account actuarial losses as a consequence of declining discount rates globally, was kept at a \$0.1 million surplus. Reduced indirect cost recovery was compensated by lower overhead costs, a result of cost-saving measures initiated by management. For 2021, CIMMYT is well-positioned – with the available budget, estimated carryover of 2020 funding, and pipeline aligned with the organization's high-level resource mobilization goal – to maintain at least the same level of funding as in recent years.

In 2020, the One CGIAR transition gathered real momentum. With an ambitious aim to further synergize assets, partnerships, and operations to deliver greater impact, the reformulation of CGIAR will ensure that we can fully and effectively respond to new and emerging global challenges.

As part of this transformation, in January, a Transition Consultation Forum was formed to allow for multi-stakeholder input and advice on the transition, along with thematic Transition Advisory Groups and a Transition Program Management Unit.

CIMMYT was a key participant in the gradual execution of the One CGIAR Recommendations adopted by the CGIAR System Council in November 2019. With full support from the Board, Center leadership was actively involved in this initiative across a range of Communities of Practice

and played an important role in the development of key documents. A major milestone in 2020 was the approval in December of the new CGIAR 2030 Research and Innovation Strategy and the CGIAR Performance and Results Management Framework, which constitute a bold and relevant blueprint for impactful research and transformative change.

Also, in 2020, welcome steps toward unified governance were made. The CGIAR System Board was reconstituted in September, at which time the three members of the Executive Management Team (EMT) began their tenure. The EMT will further steer the One CGIAR transition, under the oversight of the CGIAR System Board.

In October 2020, the Board endorsed significant amendments to CIMMYT's Constitution to enable the Center to participate in the governance aspects of the One CGIAR reform. These changes enabled a reconfiguration of the Center's Board, with CGIAR System Board members joining the CIMMYT Board and several existing Board members departing. The strong contributions of the latter are much appreciated.

Due to the pandemic, the Board was unable to meet in person. Nevertheless, it was able to follow closely the Center's progress in meeting the year's objectives. The Board acknowledges the tremendous efforts and achievements of CIMMYT staff and partners, and looks forward to another successful year.

Nicole L. Birrell
Chair, Board of Trustees

Message from the DIRECTOR GENERAL

This has indeed been a year of resilience, renewal, and transformation.

We began 2020 with grim news of the COVID-19 pandemic spreading from country to country, wreaking havoc on national economies, causing countless personal tragedies, and putting additional pressure on the livelihoods of the poor and hungry. The global crisis exposed the enormous vulnerability of our food system. If we have learned anything from the crisis, it is the absolute necessity to deliver science for renewed food systems that deliver affordable, sufficient, and healthy diets produced within planetary boundaries.

The dedication and resilience of the CIMMYT community this year allowed us to make important advances toward that vision.

Our decades-long joint work with the International Institute of Tropical Agriculture (IITA) was validated this year in a comprehensive review. Between 1995-2015, nearly 60% of all maize varieties released in 18 African countries were CGIAR-related, with yearly aggregate benefits from using post-1994 CGIAR-related varieties estimated in 2015 at between \$660 million and \$1.05 billion.

In just one year, through the Accelerating Genetic Gains in Maize and Wheat for Improved Livelihoods (AGG) project, CIMMYT and partners implemented rapid-generation breeding methods to shorten the wheat breeding cycle and developed



Martin Kropff

three fall armyworm-tolerant elite maize hybrids for eastern and southern Africa.

Considered a game-changing partnership for smallholder Mexican farmers, the MasAgro project moved to a new level in 2020, with the support of the Mexican government. Today, more than 300,000 farmers grow maize, wheat and rotation crops with sustainable technologies on more than one million hectares across Mexico. Many collaborate with agri-food companies, providing fair wages to farmers and high-quality, sustainably produced maize and wheat products to customers.

The pandemic has seen many of us renew our working style. While we cannot replace our essential field and lab work, we will keep on meeting partners and colleagues partly online, a change that is certain to reduce our future ecological footprint.

Transformation is also occurring in our global research community. CIMMYT staff have been actively involved in working groups, task forces and communities of practice to support the One CGIAR transition. Personally, it has been an honor to co-lead the group of Directors General, funding partners, and science leaders to develop the foundation for the CGIAR 2030 Research and Innovation Strategy.

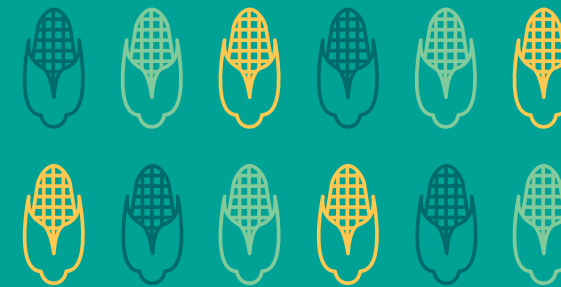
I want to close by expressing my deepest gratitude to the staff, partners, and community of CIMMYT who overcame unprecedented challenges this year. Thank you to CIMMYT staff and research partners, especially those working in the field and labs, who went above and beyond their usual activities and work schedules to keep CIMMYT's core business going. Thank you to our funding partners for believing in our mission. To those juggling care for children and ill family members with the challenges of working remotely. To those managing CIMMYT's crisis response across the countries where we work. To those who have remained committed – both in their work and in their minds – to CIMMYT's mission. And I wish to express my sincere condolences for the CIMMYT family members who lost their lives to this dreadful pandemic.

I invite you to read this report and join me in continuing to actively work towards resilience, renewal, and transition in our work and in our agri-food systems, to ensure that they are strong in the face of current and future crises.

Martin Kropff
Director General

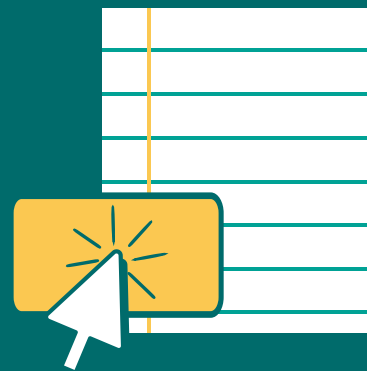
2020 in NUMBERS

135K followers
on social media and
175K video
views on YouTube.



48 unique CGIAR-derived maize varieties released by national partners in Africa, Asia and Latin America.

405 peer-reviewed journal articles published by CIMMYT researchers.



More than **2.3M downloads** from the publications repository.



1,241 media mentions, including *Bloomberg*, *Forbes Mexico* and *Vice*.

63 unique CGIAR-derived wheat varieties released by national partners in Africa, Asia and Latin America.



1.7M pageviews on the CIMMYT website.



28 webinars with CIMMYT researchers sharing in-depth knowledge.

11 special speakers, including Jeffrey Sachs, talking to the CIMMYT community on climate change, food security and the role that cereals play in feeding the world sustainably.

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

Shipments contain over **500,000** individual seed packets.



1,253 staff of **50 nationalities** working at CIMMYT.



HIGHLIGHTS FROM AROUND THE WORLD

AFRICA

Ethiopia

A study of plant DNA showed that farmers in Ethiopia have widely adopted improved rust-resistant bread wheat varieties since 2014. Ten varieties accounted for over 81% of the wheat area sampled; of these, four were rust-resistant varieties released after 2010, corresponding to an estimated additional 225,500 tons of production in 2016-17, valued at \$50 million.

One of the initiatives contributing to this impact was the Wheat Seed Scaling project. CIMMYT and its partners identified and developed new rust-resistant wheat varieties, championed the speedy multiplication of their seed, and used field demonstrations and strategic marketing to reach thousands of farmers in 54 districts of Ethiopia's major wheat growing regions.

The project points up the need to identify new resistance genes, develop wheat varieties with durable, polygenic resistance, promote farmers' use of a genetically diverse mix of varieties, and link farmers to better and more profitable markets. The United States Agency for International Development (USAID) funded the project, and the Ethiopian Institute of Agricultural Research (EIAR) was a key partner.

Kenya

CIMMYT announced the successful development of three CIMMYT-derived fall armyworm-tolerant elite maize hybrids for eastern and southern Africa.

By leveraging tropical insect-resistant maize germplasm developed in Mexico, coupled with elite stress-resilient maize germplasm developed in sub-Saharan Africa, CIMMYT worked intensively over the past three years to identify and validate sources of native genetic resistance to fall armyworm in Africa.

Together with national agricultural research system (NARS) partners, CIMMYT will nominate these hybrids for varietal release in target countries in sub-Saharan Africa, especially in eastern and southern Africa. After national performance trials and varietal release and registration, the hybrids will be sublicensed to seed company partners on a non-exclusive, royalty-free basis. This will allow accelerated seed scaling and deployment, for the benefit of farming communities.

Zimbabwe

As part of a rural resilience project, CIMMYT published a guide to stress-tolerant crop varieties for smallholder farmers in Zimbabwe.

The guide is a critical output of a project led by CIMMYT and the international humanitarian response agency GOAL, in collaboration with the United Nations World Food Programme (WFP), the Government of Zimbabwe and other partners.

Among the project components is the promotion of stress-tolerant seed and climate-smart agriculture practices to rural smallholders.

AMERICAS

Mexico

CIMMYT released a new category of maize inbred lines called CIMMYT Maize Genetic Resource Lines (CMGRL). They are derived from crosses between elite CIMMYT lines and landrace accessions, populations or synthetics from the CIMMYT Germplasm Bank.

The inaugural class of CMGRLs includes five subtropical-adapted lines for tolerance to drought during flowering and grain-fill, and four tropical-adapted lines for tar spot complex resistance. CIMMYT will periodically release CMGRLs as superior lines are identified for economically important abiotic and biotic stresses as well as end-use traits.

The 2020 Innovative Applications in Analytics Award (IAAA) – which emphasizes novelty and creativity in analytics applications along with real-world impact – was awarded to CIMMYT, the Alliance of Bioversity International and CIAT, and the International Institute for Applied Systems Analysis (IIASA) for their Integrated Analytics for Sustainable Agriculture in Latin America project.

The winning submission recognizes groundbreaking data systems and tools by publicly funded research and field technicians who advise more than 150,000 farmers who participate in MasAgro, CIMMYT's bilateral collaboration project with Mexico for sustainable maize and wheat production.

ASIA

China

The CGIAR Research Program on Wheat (WHEAT) and the International Center for Agriculture in the Dry Areas (ICARDA) announced a partnership with the Jiangsu Academy of Agricultural Sciences (JAAS) in China to open a new screening facility for the deadly and fast-spreading fungal wheat disease Fusarium head blight, or FHB.

The new facility, based near the JAAS headquarters in Nanjing, aims to identify and characterize genetic sources of resistance to FHB and, ultimately, develop new FHB-resistant wheat varieties that can be sown in vulnerable areas around the world. It will capitalize on CIMMYT's world-class collection of disease-resistant wheat materials and the diversity of the more than 150,000 seed samples in its Wheat Germplasm Bank.

India

Research by an international team of scientists, including CIMMYT agricultural systems and climate change scientist Tek Sapkota, identified the optimum rates of nitrogen fertilizer application for rice and wheat crops in the Indo-Gangetic Plains of India.

By measuring crop yield and nitrous oxide (N₂O) fluxes over two years, Sapkota and his colleagues reported that the optimum rate of N fertilizer for rice is between 120 and 200 kilograms per hectare,

and between 50 and 185 kilograms per hectare for wheat. The results of the study have the potential to save farmer's money and minimize dangerous greenhouse gas emissions while maintaining crop productivity.

Nepal

The Nepal Agricultural Research Council (NARC) announced the release of six new wheat varieties for multiplication and distribution. They will offer increased production for Nepal's nearly one million wheat farmers and boosted nutrition for its 28 million wheat consumers.

The varieties are tailored to the conditions in a range of wheat-growing regions in the country and to stresses including wheat rust diseases and wheat blast.

The five high-zinc, biofortified varieties were developed through conventional crop breeding, by crossing modern high-yielding wheat with high-zinc progenitors such as landraces, spelt wheat and emmer wheat.

GLOBAL

Genomic atlas for wheat improvement

In a landmark discovery for global wheat production, an international team led by the University of Saskatchewan and scientists from CIMMYT sequenced the genomes for 15 wheat varieties representing breeding programs around the world, enabling scientists and breeders to identify influential genes much more quickly for improved yield, pest resistance and other important crop traits.

The research results, published in *Nature*, provide the most comprehensive atlas of wheat genome sequences ever reported. The 10+ Genome Project collaboration involved more than 95 scientists from universities and institutes in Australia, Canada, Germany, Israel, Japan, Mexico, Saudi Arabia, Switzerland, the United Kingdom, and the United States.

Massive-scale genomic study

Researchers working on the Seeds of Discovery (Seed) initiative have genetically characterized 79,191 samples of wheat from the germplasm banks of CIMMYT and the International Center for Agricultural Research in the Dry Areas (ICARDA).

The findings of the study, published in *Nature Communications*, are described as "a massive-scale genotyping and diversity analysis" of the two types of wheat grown globally – bread and pasta wheat – and of 27 known wild species.

The results show distinct biological groupings within bread wheats and suggest that a large proportion of the genetic diversity present in landraces has not been used to develop new high-yielding, resilient and nutritious varieties.



8



“Within 10 years, it is expected that at least 80% of all new wheat lines from the CIMMYT pipeline targeted for release in Asia, Africa, and Latin America will have higher levels of zinc.”

Ravi Singh,
head of wheat
breeding at CIMMYT.

BRIGHT HORIZONS FOR BIOFORTIFICATION

Nepal is one of the many countries starting to reap the health benefits of biofortified crops

In most grocery stores, bread packaging labels will often tout the nutrients that the flour has been enriched with. In its natural form, wheat can carry essential nutrients, such as zinc and iron, but declining soil health and harsher climates are making crops less nutritious. In many developed countries, commercial flour mills add those and other micronutrients, or industrially fortify flour, so that wheat products are more nutritious.

In Nepal, farmers collectively produce nearly two million tons of wheat each year. Most of them are smallholders with less than one hectare of land. In remote regions, families consume wheat products, such as chapati, roti, *momo* dumplings, and noodles made from grain that is known to be low in essential micronutrients, contributing to poor nutrition in the areas.

“The tendency to consume wheat directly on the farms and in the communities where it is grown means that fortified wheat from commercial mills is unlikely to reach poor rural communities,” said CIMMYT senior scientist and wheat breeder Velu Govindan.

Research has shown that food security improvements in Nepal over the last several decades can be accredited in part to rising cereal production. Although the situation is improving, malnutrition is still considered a major issue in rural subsistence populations. According to the Global Hunger Index 2019, 36% of children in the country suffer from stunting, an indicator of chronic undernutrition.

This is an important reminder that a simple increase in food availability does not guarantee the population

is getting the nutritional content needed to break out of the poverty cycle – a growing issue known as “hidden hunger.” In addition, most of the popular wheat varieties grown in the country have become vulnerable to increasing climatic stresses, new types of wheat diseases or virulent strains of the existing pathogens.

Start with the seed

Huge strides are being made in the world of crop breeding to improve the nutrient quality, yield, and other farmer-preferred traits of staple grains. Now, the seeds themselves can be an agent for an integrated food systems transformation.

Biofortification – the development of micronutrient-dense staple crops through breeding – has become a powerful tool in combatting hidden hunger.

Using conventional breeding methods, CIMMYT has become a leader in the development of biofortified maize and wheat.

The future is looking brighter

In 2020, CIMMYT worked with the Nepal Agricultural Research Council (NARC) to develop what ended up

being a historic release of six new wheat varieties in the country. Five of them were biofortified, developed by crossing modern high yielding wheats with wild relatives that are nearly 20-40% higher in zinc and iron content than local commercial crops. In addition, these varieties were superior in yield and resistance to prevalent diseases compared to existing varieties.

“Biofortification of staple crops such as wheat is a proven method to help reverse and prevent zinc deficiency, especially for those without access to a more diverse diet,” said Arun Joshi, CIMMYT regional director for South Asia.

The five new biofortified varieties – Bheri-Ganga, Himganga, Khumal-Shakti, Zinc Gahun 1 and Zinc Gahun 2 – and wheat blast-resistant variety Borlaug 2020 were developed in a “fast-track” approach. The team of NARC scientists was led by Dhruba Thapa at Khumaltar, who focused on the mid- and high-hill regions, and Roshan Basnet at the National Wheat Research Program in Bhairahawa, who focused on the Terai plains.

The scientists introduced, tested and identified the best varieties from trials sourced from CIMMYT’s biofortified wheat breeding program with support from Madan Bhatta, a CIMMYT consultant in Nepal. With these varieties, farmers in all wheat growing regions of Nepal will be able to reap enormous benefits.

“This is an especially impressive achievement by the NARC breeders and technicians during a time of COVID-related challenges and restrictions,” said NARC Executive Director Deepak Bhandari. Large-scale seed production is now underway for distribution to farmers for the 2021-22 wheat season.

The varieties are tailored for the environmental conditions of a range of wheat growing regions



A researcher and a farmer observe the newly released biofortified wheat varieties in the mid- to high-hills in Nepal.



Boxes of wheat seed ready for international shipping from Mexico.

in the country, including tolerance to diseases and heat stress. Breeders also considered processing quality, to create a diverse range of wheat-based food products.

Setting targets and hitting the mark

Biofortified wheat has several potential advantages as a delivery vehicle for micronutrients in diets, in South Asia and beyond. Since 2019, a project led by CIMMYT (Accelerating the Mainstreaming of Elevated Zinc in Global Wheat Breeding) aims to mainstream biofortification as a breeding standard. Scientists are following a population-wide approach, like adding fluoride to tap water. The support of funders and national partners enabled the release of the new varieties in Nepal in record time.

“Within 10 years, it is expected that at least 80% of all new wheat lines from the CIMMYT pipeline targeted for release in Asia, Africa, and Latin America will have higher levels of zinc. Given CIMMYT’s predominance as a global improved wheat breeding germplasm supplier, people who consume wheat products in developing countries will benefit from substantially increased levels of dietary zinc,” explained Ravi Singh, head of wheat breeding at CIMMYT. Since zinc and iron are highly correlated genetically, these efforts are simultaneously increasing iron content in the grain.



Biofortified bread wheat variety Bheri-Ganga at the Khumaltar research station in Nepal.



One of the newly released biofortified wheat crops in the field in Surkhet, Nepal.

In a recent interview with Reuters, Director General Martin Kropff explained how CIMMYT is already working to “mainstream” biofortified maize and wheat into global seed supply, with major releases already underway in Bangladesh, Colombia, India, Mexico, and Pakistan, in addition to Nepal.

“This is something that is starting in a big way this year,” said Kropff in the exclusive interview.

Zinc wheat is currently grown by over one million households across South Asia, benefiting an estimated three to four million household members. Thanks to CIMMYT’s strong partnerships with national agricultural research systems, sustainable and cost-effective biofortified seeds will make their way to the farmers and consumers who need them most.

Partners and funders

Asian Development Bank (ADB), Bill & Melinda Gates Foundation, Foreign, Commonwealth & Development Office (FCDO) of the United Kingdom, HarvestPlus, and Nepal Agricultural Research Council (NARC).



A BIGGER BITE

A call to reassess the value of cereals in food-systems and nutrition research

The world eats cereals. Maize and wheat alone make up nearly a quarter of the world’s dietary energy intake, and are critical vessels for micronutrient and dietary fiber delivery. However, the essential role they play in global nutrition is concerningly understated when one looks at trends in agri-nutrition research. The number of hungry people globally has also started to increase again over recent years, a figure that has surely been exacerbated by the effects of the COVID-19 pandemic.

Undermining the role that cereal crops play in global food security poses risks not just to population health, but also to smallholder agricultural economies as many countries across Africa, Asia, and Latin America aim for self-sufficiency in cereal production. FAO data from 2019 shows that wheat and maize covers over 400 million hectares of farmland worldwide.

Current nutrition research focuses mostly on micronutrient malnutrition and stunting, which is indisputably important. However, bioactive food components, such as dietary fiber and flavonoids, have beneficial properties that are very important in the bigger picture of human health.



Wheat grain.



Maize grain.

In 2020, scientists from CIMMYT and the University of London published an important review of agri-nutrition research and dietary guidance revealing that the health benefits of cereals are often undervalued and overlooked. However, cereal grains will play a large role in reducing global malnutrition.

Current nutrition research focuses mostly on micronutrient malnutrition and stunting, which are indisputably important. However, bioactive food components (BIOFOCS), such as dietary fiber and flavonoids, have beneficial antioxidant, anticarcinogenic, anti-inflammatory

and antimicrobial properties that are very important in the bigger picture of human health. Additionally, food group categorization does not account for the effect that modern crop breeding, food processing and manufacturing can have on nutritional quality – for better or for worse.

According to the study, co-authored by CIMMYT economists Jason Donovan and Olaf Erenstein, the argument “is for agri-nutrition research to open up to a broader perspective on the nexus of agriculture, food, nutrition and health. At the heart of this complexity is

acknowledgment that foods contain more than the conventional macro- and micronutrients, and that agri-nutrition research should address the nutrition and health requirements for all the essential bioactive food components.”

In a new working paper, the authors look at the links between agriculture, food security, and human nutrition and health, and the contribution of maize and wheat to achieving the nutrition objectives of the UN Sustainable Development Goals (SDGs). Their work builds on previous research from CIMMYT scientists on nutrition and health, an area of increasing importance.

Partners and funders

CGIAR Research Program on Maize (MAIZE) and CGIAR Research Program on Wheat (WHEAT).



WOMEN ENTREPRENEURS

lead their families through the COVID-19 crisis

When COVID-19 struck India, the government ordered strict lockdowns on March 24, 2020 to limit the spread of the disease. But for much of India's labor force, lockdown meant lost jobs and being stranded in towns or cities away from their families, struggling to survive.

The lockdown was particularly agonizing for Sashimoni Lohar, a 53-year-old farmer from Badbil village, in the state of Odisha. Both her sons lost their jobs as laborers, one in a town near home and the other in a city on the opposite side of the country. Her son Debodutta was left stranded for two months in the city of Bengaluru when the midnight lockdown was announced, managing to return home two months later, downtrodden and penniless.

“Maize farming has supported us during this low-income and very critical period. I shall continue maize cultivation and hope to increase our lease in land next year.”

Sashimoni Lohar, a farmer from Badbil village, in India's Odisha state.

With her husband the sole earner and the family's income and rations dwindling, the threat of hunger became as deadly as the virus.

But Lohar refused to give up. Supported by her village self-help group, she cultivated two acres of hybrid maize, selling her produce from a roadside stall beside her farm to provide for her family. With the extra income, the Lohars managed to feed their family of seven.

"Maize farming has supported us during this low-income and very critical period. I shall continue maize cultivation and hope to increase our lease in land next year," said a visibly triumphant Lohar.

After lockdown restrictions were eased, Lohar expanded her successful maize business. She invested the equivalent of \$165 in maize cultivation and erected an additional stall to sell to travelers on the highway. Making back almost double her investment from less than an acre of land, Lohar has now established herself as a successful maize farmer and entrepreneur, with plans to open a small grocery shop in the coming months.

Lohar is just one of many rural women in the tribal villages of Odisha who have led their families



Farmer and budding entrepreneur Sashimoni Lohar proudly shows her new maize stall next to her farm.

through the COVID-19 pandemic. Supported by projects such as CIMMYT's Cereal Systems Initiative for South Asia (CSISA), these women were able to generate enough income from similar roadside maize stalls when the pandemic left many male family members jobless.

The women from Badbil and the nearby villages have become well-known, in and around the district, for their high-quality green cobs and marketing smarts. The rows of industrious women selling maize by

the national highway became news. These women had the courage to change their circumstances and lifted their families out of situations of uncertainty and hardship.

Many hailed their determination as a symbol of women's empowerment in the tribal community.

Engaging tribal groups

Mayurbhanj is a district in Odisha where almost two thirds of the population are from tribal groups. During the *kharif* season, from June to November, thousands of hectares of upland are left fallow, as farmers prefer not to take risks against the unpredictable monsoon weather. From 2013 to 2020, CIMMYT researchers from the CSISA project, in collaboration with government departments, NGOs, private companies, women's self-help group federations and the Integrated Tribal Development Agency (ITDA), helped develop maize cultivation in the district as a sustainable livelihood option for tribal farmers.

Thousands of hectares of fallow lands are now being converted to cultivate maize, focusing on sustainable agriculture and



Women from a farmer producer group sell green cobs by the national highway next to their maize farm.

livelihoods, and predominantly involving women. In 2020 alone, more than 100 tribal women from Badbil village had cultivated approximately 120 acres of commercial hybrid maize.

Support to farmers extends all the way from sowing to crop harvesting. To strengthen dry grain marketing and to avail the benefits of different schemes under the government of Odisha's support for farmer producer groups, CIMMYT staff working under the CSISA project have formed two women's farmer producer groups in Badbil village, which have been registered by the Odisha Rural Development and Marketing Society (ORMAS). All the women maize farmers of the village are now registered members of the groups, with twenty members each.

Lohar is a member of the Shakti Mayee producer group and has already planned to increase the area of maize farming and to cultivate vegetables for marketing through the group's support.

CIMMYT and its partners are building on this initiative, creating market linkages to make maize farming more sustainable. As a next step, CIMMYT and ORMAS aim to form a farmers production company formed entirely by women, for joint marketing of maize and other crops.

Partners and funders

Bill & Melinda Gates Foundation, Government of India's Odisha state, India's Ministry of Agriculture and Farmers Welfare, Integrated Tribal Development Agency (ITDA), International Food Policy Research Institute (IFPRI), and International Rice Research Institute (IRRI).

QUANTIFYING THE IMPACT OF COVID-19 LOCKDOWNS

Over a third of the 61 million people who make up Bangladesh's labor force are paid daily. A nationwide lockdown from March 26 to May 30, 2020, restricted the spread of COVID-19 but, without adequate support, daily-wage workers faced severe food and nutrition insecurity.

In a study published in PLOS ONE, CIMMYT Agricultural Economist Khondoker Mottaleb examined the food security and welfare impacts of COVID-19 lockdowns on daily-wage

workers in Bangladesh – both in farming and other sectors. With comparatively lower resources than salaried and self-employed workers, daily-wage workers are more likely to be hit hardest by COVID-related loss in earnings.

Using information from more than 50,000 workers in Bangladesh, collected by the Bangladesh Bureau of Statistics (BBS), the study quantified the economic losses from COVID-19 lockdowns, based on daily-wage workers' lost earnings.

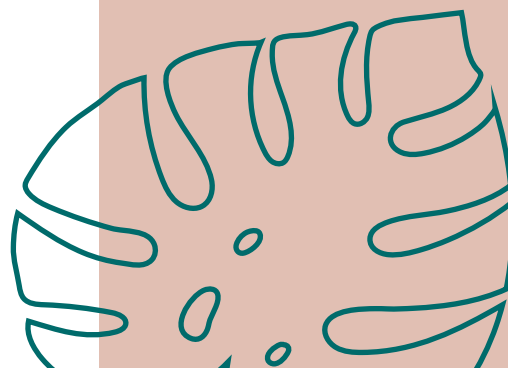
The authors estimated that each day of complete lockdown represented an economic loss of \$64.2 million for all daily-wage workers – on average, more than \$3 per worker per day.

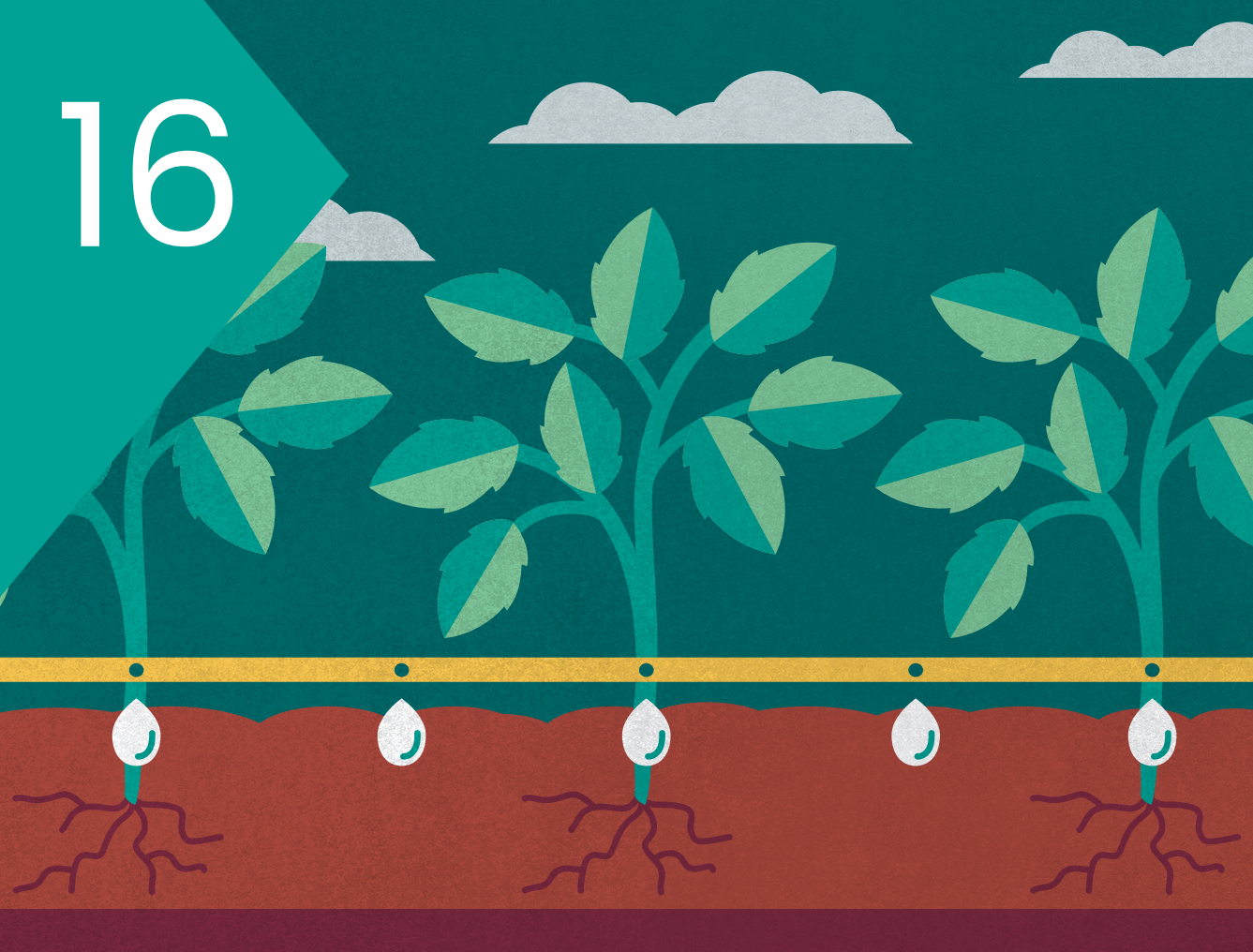
Researchers also calculated the subsidies needed to ensure basic food and nutrition security during the lockdown period. After assessing the daily per capita food expenditure for farm and non-farm households, the study estimated the need for a

minimum compensation of around \$1 per day for each household supported by daily-wage workers.

As the COVID-19 crisis continues to threaten already vulnerable food systems around the world, CIMMYT remains committed to its mission of achieving food security and improving livelihoods around the world through science. Understanding the impacts of global shocks such as the COVID-19 pandemic remains a crucial part of this research agenda.

In Bangladesh, CIMMYT contributes to food and nutritional security and improved livelihoods. Through collaborative research and partnerships, CIMMYT advances sustainable agricultural practices, including improved varieties. CIMMYT works to bolster the productivity of cereal-based farming systems, to improve value chains and market development, and to empower farmers and service providers with personalized advice.





“I used to walk to a well about 500 meters away to fetch water using a bucket. This was challenging given my condition and by the time I finished, I would be exhausted and unable to do any other work.”

Simon Makanza, a farmer in Nyanga, Zimbabwe, with physical disability.

WATER BREAKS BARRIERS

Drip irrigation improves the lives of farmers with disabilities in Zimbabwe

Zimbabwe's eastern highlands are renowned for their diverse and abundant fresh produce. In districts like Nyanga, farming families grow a variety of crops all year round for personal consumption and for sale: from maize, potatoes, and sugar beans to leafy vegetables and garlic.

Long plastic pipes lining the district – some stretching for more than 10 kilometers – use gravity to transport water from the mountains down to the village gardens. However, over the last decade, increasing climate-induced water shortages, prolonged dry spells and high temperatures have depleted local water reserves.



Maize experimental plot with drip irrigation.

To manage this limited resource, farmers in the area access it based on a rationing schedule managed by the local council – but availability is inconsistent. Often during the lean season, there is not enough water to irrigate vegetable plots efficiently and in good time, which leads to moisture stress and poor crop performance.

When water availability is low, it is not uncommon for conflict to develop in villages, as households compete for access. Despite efforts to schedule distribution across all areas, reports of farmers cutting off or diverting the water supply abound.

Less waste, more time

Traditionally, farmers in the district have used flood, drag hose, bucket, and sprinkler systems for irrigation – laborious methods that tend to waste water and require the services of young, able-bodied workers.

For Prudence Nyanguru, a maize farmer in Nyanga who also grows tomatoes, potatoes, cabbages, and sugar beans, the limited number of sprinklers available for her garden meant that she previously had to irrigate manually every other day, alternating between the sprinkler and hose pipe and taking more than five hours to cover her 0.05-hectare plot.

But now, new, affordable garden drip irrigation kits installed by CIMMYT are making it easier for farmers like

her to manage their limited resources efficiently. They now have more control over application and reduce water waste to a minimum.

“Whereas before I would spend six hours shifting the sprinklers or moving the hose,” said Nyanguru, “I now just switch on the drip and return in about two or three hours to turn off the lines.”

Ease and efficiency for all

CIMMYT researchers supported the use of small pumps for irrigation after noticing that farmers would not reap the full benefits of mechanization if they continued to depend exclusively on erratic rainfall. After the rainy season, two-wheel tractors and other implements were often parked and unused for the rest of the year.

This new form of irrigation has brought many benefits to rural farming communities in Nyanga, from reducing costs to supporting weed management. The reduction of labor intensity has been particularly important to strengthen the resilience of those who may have previously struggled to withstand and recover from stresses like water scarcity.

Of the 30 farmers who received CIMMYT drip kits in 2020, at least five had previously experienced limitations to full participation in farming activities as a result of physical barriers, access challenges and strenuous irrigation methods. The new irrigation kit was intentionally designed with the needs of people with disabilities in mind.

For 37-year-old Simon Makanza, for example, his physical disability made accessing and carrying water to use in his homestead extremely difficult. “I used to walk to a well about 500 meters away to fetch water using a bucket,” he explained. “This was challenging given my condition and by the time I finished, I would be exhausted and unable to do any other work.”

The installation of the drip kit in Makanza's garden has removed physical barriers, transforming the way he works. He can now operate the pump and drip-line switches with minimal effort, and no longer grapples with uneven pathways to fetch water, or wells and pumps that are heavy for him to operate.

The families of people with disabilities are also benefiting from the advantages of the drip systems. “I don't spend all day in the field like I used to,” said George Nyamakanga, whose brother Barnabas has a psychosocial disability. “Now, I have enough time to assist and care for my brother while producing enough to feed our family of eight.”

The ease of operation and efficiency of the drip kits also enables elderly farmers to engage in garden activities where they might previously have struggled, with direct benefits for the nutrition and incomes of the wider community.

Partners and funders

This work was carried out under the Program for Growth and Resilience (PROGRESS) consortium, managed by the Zimbabwe Resilience Building Fund (ZRBF) with support from the Ministry of Lands, Agriculture, Fisheries, Water and Rural Resettlement, the European Union (EU), the Embassy of Sweden, the United Nations Development Programme (UNDP), and the Foreign, Commonwealth & Development Office (FCDO) of the United Kingdom.

CIMMYT trained 2,801 farmers – 38% of them women – on postharvest management, with maize grain losses dropping from 19.5% to less than 0.2% as a result.

INCLUSION BY DESIGN

Targeted outreach increases women participation in trainings

In tropical parts of Mexico, high humidity and pervasive crop pests regularly cause smallholder farmers to lose up to 40% of their grain after harvest, often with severe consequences for local food security. Fortunately, such losses are largely avoidable when farmers adopt best postharvest practices and appropriate grain storage technologies, which CIMMYT has been promoting for many years.

However, while testing these technologies as part of a large-scale study on dozens of sites across the country, CIMMYT researchers discovered a new obstacle. In rural Mexico, as in many rural communities worldwide, women play an important role in postharvest activities, but researchers noted that it was

mostly men who attended relevant trainings on how to process and store grain. To address this, they had to find new approaches to ensure that future CIMMYT trainings would reach those who stand to benefit the most – namely, the women who carry out the bulk of postharvest work in their communities.

Strategies to increase participation included organizing trainings specifically for women, purposefully scheduling trainings at times when women would be available to attend, working in collaboration with female agricultural extension agents, and designing invitations with inclusive language. For example, those sharing invitations – whether using flyers or through word of mouth – were specifically asked to refer to both *productores* and *productoras* (the male and female words for “farmers” in Spanish), or use the gender neutral *jóvenes* when referring to young people.

The new gender inclusion strategies were most recently implemented during a project to strengthen market access for smallholder maize and legume farmers in the states of Campeche, Chiapas and Oaxaca,



Women identify postharvest damage in seeds during a workshop in Campeche, Mexico.

which ran from 2018 to 2020 and featured a large postharvest management component.

Despite the challenges posed by COVID-19 restrictions in the final project year, CIMMYT trained 2,801 farmers – 38% of them women – on postharvest management, with

maize grain losses dropping from 19.5% to less than 0.2% as a result of using hermetic technologies.

Researchers are now looking to build on this success by incorporating this gender-sensitive approach into future projects with the Walmart Foundation, harnessing women's managerial and technical competencies and encouraging their participation in decision-making over income, cash-crop farming, and autonomy in agricultural production.

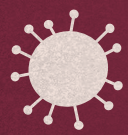
Partners and funders

This project was supported by the Walmart Foundation.



Farmers learn best practices to avoid postharvest damage in a training in Campeche, Mexico.

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“Some rural communities in Mexico closed off completely for fear of COVID ... but household members did go to the field and work, aware that the grain they produced might prove critical.”

Jelle Van Loon,
CIMMYT mechanization
specialist in Latin
America.

MAIZE AND WHEAT HARVESTS KEEP PACE DESPITE THE PANDEMIC

Despite COVID-19 pandemic disruptions and extreme weather events, maize and wheat farmers in Africa, Asia, and Latin America were mostly able to salvage good harvests from their 2020 crops.

Smallholders overcame many challenges, including the high costs and shortages of field labor, qualms about hiring outside field workers, and being cut off from inputs, credit, or technical support, according to Jelle Van Loon, CIMMYT mechanization specialist in Latin America.

“Some rural communities in Mexico closed off completely for fear of COVID, with farmers reluctant to attend to more than their basic needs, avoiding risks and minimizing long-term plans,” Van Loon said, “but household members did go to the field and work, aware that the grain they produced might prove critical if food supplies grew short and more expensive.”

Erratic rains during the onset of the pandemic, coinciding with the start of the main cropping season, caused smallholder farmers in Mexico, who generally lack irrigation, to behave conservatively, Van Loon explained.

“This and a month-long drought that killed many early-sown maize crops forced farmers to adjust to the ‘new normal’ and plant again when the rains came back,” he added. “In the meantime, cell phones and social media applications have proven vital for farmers to stay in touch and conduct business during the pandemic, allowing access to technical and administrative support and even the online purchase of inputs.”

In Africa, COVID-related lockdowns impeded the movement of rural inhabitants who, in addition to farming, depend on trade, part-time jobs as crafts persons and artisans, and small-scale mining. “Off-farm income is a mainstay of rural households in Africa,” observed Frédéric Baudron, CIMMYT systems agronomist based in Zimbabwe.

What it takes to keep farming going

In South Asia’s extensive maize and wheat lands, particularly in Bangladesh and northern India, excess rainfall and powerful typhoons flooded fields early in the cropping season. However, COVID-19 disrupted agriculture in new, diverse ways, according to T.S. Amjath-Babu, CIMMYT agricultural economist based in Bangladesh.

“International and domestic supply chains for fertilizers, agrochemicals, machinery, and seeds have been impeded by import and movement restrictions,” Amjath-Babu said. “Stay-in-place orders and limitations on migration have created labor shortages, and social distancing hinders farm operations.”



Mechanical shellers and threshers reduce drudgery, greatly speed grain processing, and offer opportunities for machinery owners, such as Pinnot Karwizi of Zimbabwe, to contract their services to smallholder farmers.

In northern India, where 2.4 million farmers grow variations of the rice-wheat cropping rotation, researchers had feared that the COVID-19 lockdown would delay rice sowing and disrupt the fine-tuned cropping system. Worst-case scenarios forecast economic losses of nearly \$1.5 billion and more severe pollution from the late burning of rice straw. Fortunately, technologies that CIMMYT had refined for decades with national partners, along with policies to promote them, helped ward off the worst effects of the crisis.

In a recent study, Amjath-Babu and colleagues concluded that if the COVID-19 crisis lasts longer than many expect, resilient food systems will require stable supply chains, infection-free logistics, extended social safety nets, adequate credit facilities, innovative labor management, and appropriate farm mechanization.

Mechanization turns the wheels of small-scale farming

To mitigate labor shortages and make agriculture more manageable, CIMMYT has been testing and promoting scale-appropriate farm machinery for smallholder maize and wheat farmers.

“We facilitate and promote farmers’ acquisition and use of the right equipment, along with business models whereby those who already own machinery offer services to farmers for land preparation, planting, irrigation, harvesting, processing, and other activities,” said Timothy Krupnik, systems agronomist and CIMMYT country representative in Bangladesh. “This is a win-win situation for farmers who can’t access or afford field laborers, and allows crucial farm work to take place while maintaining social distancing.”



The use of small machinery lowers production costs and relieves pressure on available labor, Krupnik explained. “In a COVID-altered world, this will remain an essential support for food production in rural areas, particularly by the growing number of women-headed households, as the outmigration of working-age men increases.”

Developing and fostering use of appropriate mechanization is just one way CIMMYT helps pandemic-stricken farmers, according to Van Loon. “We continue to spread sustainable intensification technologies and practices, including cropping diversification, better post-harvest management of grain, business model development, and the targeted use of fertilizers and improved varieties.”

OPPORTUNE SCIENCE AND PROMOTION BOOST CLIMATE-SMART FARMING IN INDIA

With the pandemic lockdown driving millions of migrant workers and day laborers away from northern India to their home villages, prospects for the region's rice-wheat cropping rotation, which feeds the nation and relies heavily on field workers, looked grim. But scientists of CIMMYT and India seized a glimmer of promise for farmers and policymakers, amid the dark crisis.

“Any delay in the labor-intensive transplanting of rice seedlings pushes back rice harvests; this then causes wheat to be sown later and sorely affects wheat yields,” explained M.L. Jat, a systems agronomist who leads CIMMYT’s

climate-smart agriculture research portfolio in South Asia. “Also, farmers normally gather and burn millions of tons of rice straw before sowing wheat, generating regionwide pollution. That’s always harmful but would be worse if burning were delayed until the cold weather of late fall or winter.”

For long, CIMMYT and national partners have studied and advocated for resource-conserving farming practices to help address perennial rice-wheat rotation problems, including severe water and soil depletion and falling profitability. Among alternatives are sowing rice in non-flooded fields, adding or substituting crops in the rotation, and planting wheat directly into just-harvested rice fields without burning the straw or plowing.

The latter is called “zero tillage” and has been adopted already on a limited area in northern India.

The practice helps lessen severe seasonal air pollution, profits farmers by \$150-200 in reduced costs and improved yields per hectare, saves an average 15% in irrigation water, and allows early wheat planting so that the crop can be harvested before the pre-monsoon heat scalds the grain, according to Harminder S. Sidhu, principal research engineer at the Borlaug Institute for South Asia (BISA), a research center for which CIMMYT shares oversight with the Indian Council of Agricultural Research (ICAR).

“Zero tillage for wheat requires use of a special tractor-mounted implement that opens grooves in the soil, drops in wheat seed and fertilizer, and covers the seeded row with shredded rice residues, all in one pass,” Sidhu explained. He and colleagues in India and CIMMYT developed and refined the implement, known as the Happy

Partners and funders

In Africa, this work was carried out through the Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) project, funded by the Australian Centre for International Agricultural Research (ACIAR) and the CGIAR Research Programs on Maize (MAIZE), Wheat (WHEAT), and Climate Change, Agriculture & Food Security (CCAFS). Partners include Ethiopia’s Ministry of Agriculture, the University of Southern Queensland, the University of Zimbabwe, Zimbabwe’s Ministry of Lands, Agriculture, Fisheries, Water and Rural Resettlement, service providers and training centers from Zimbabwe, and the private sector in Zimbabwe and Ethiopia.

In Bangladesh, this work was carried out through the Cereal Systems Initiative for South Asia Mechanization and Irrigation (CSISA-MI) and the Cereal Systems Initiative for South Asia Mechanization Extension Activity (CSISA-MEA), both funded by the Feed the Future initiative of the United States Agency for International Development (USAID).

In Mexico, the Crops for Mexico project is supported by Mexico’s Secretariat of Agriculture and Rural Development (SADER). MasAgro-Guanajuato activities are supported by the state of Guanajuato.



Farmer Paresh Chandra Sarkar uses a bed planter mounted on a two-wheel tractor to obtain higher yields in Horinofolia, Bangladesh.

Seeder, over 15 years. Conventional wheat seeding practices involve first gathering and burning rice straw, followed by numerous and costly tractor passes to plow, harrow, and plank the field, reforming it from a paddy, and then to sow the wheat.

Unprecedented challenges require visionary measures

After a 2020 study by researchers at CIMMYT, ICAR and the International Rice Research Institute (IRRI) described the potentially disastrous outcomes of rice-transplanting delays, Jat and the other authors shared with policymakers their findings and recommendations, including the alternatives described above. Notably, after receiving a one-page summary, the Chief Minister of Punjab, the leading rice-wheat farming state, released a video address supporting the scientists’ conclusions.

Jat and colleagues then moved quickly to promote adoption of the alternative practices, helping to facilitate subsidies for purchases of the Happy Seeder and ensuring the timely availability of machines and other inputs.

As a result, in 2020 farmers substituted dry-seeded rice for flooded and manually-transplanted rice on 500,000 hectares, which represents 34% more area converted to the new practice than the cumulative total for the previous 10 years. Additionally, 330,000 hectares were sown to alternative crops, principally cotton, maize and legumes.

“The central and state governments in northwestern India, as well as extension agencies, are promoting no-burn alternatives that include direct seeding of wheat using the Happy Seeder, and there are

state directives and fines to stop straw burning, especially in this unprecedented time of the COVID-19 pandemic,” Sidhu said.

Partners and funders

Borlaug Institute for South Asia (BISA), governments of India and of the states of Haryana and Punjab, Indian Council of Agricultural Research (ICAR), an Punjab Agricultural University (PAU), This work benefits from the partnerships and support of the Bill & Melinda Gates Foundation, Georgia Institute of Technology (Georgia Tech), iDE, the International Food Policy Research Institute (IFPRI), and the International Rice Research Institute (IRRI).

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COVID-19 minted millions of armchair epidemiologists. But important lessons about the relationship between agriculture, biodiversity loss and disease threats – to humans, crops and livestock – are still being overlooked.

PLANTS, PEOPLE AND THE NEXT PANDEMIC

R-numbers, fomite versus airborne transmission, droplets versus aerosols, mRNA and viral vector vaccines. For over a year the argot of epidemiology, virology and other scientific and medical disciplines has seeped into everyday language, as people across the globe grappled with the unprecedented challenges of the COVID-19 pandemic.

Meanwhile, scientists and communicators have struggled to limit the spread of misinformation and ensure that reliable facts are what ultimately goes viral.

As the world is still fighting to handle the COVID-19 crisis, what are the messages and lessons that we must adopt now to better prepare for future challenges?

Global agriculture is a key battleground

Globalization, climate change, ecosystem degradation and biodiversity loss are key variables in the growing threat of infectious disease outbreaks. Agriculture overlaps with each of these processes and is vulnerable to the disease risks they amplify.

Former director of CIMMYT's Global Wheat program, Hans Braun, recently stressed the parallel between what we have witnessed with COVID-19 and disease threats facing global agri-food systems. "The epidemiology models for humans ... we see now have a lot in common with plant epidemiology," Braun said in a conversation on wheat diseases. There are currently over 1,300 pests and pathogens known to infect agricultural crops worldwide.

"When it comes to epidemics, what applies to humans applies to plants. If there is a new race of a given crop disease, in that moment, the plant does not have a defense mechanism, like humans in the case of COVID-19, because we haven't developed any immunity," Braun explained.

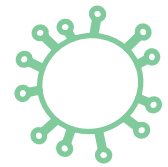
As with a human pandemic, investments in prevention, containment and preparedness measures – such as the global wheat rust monitoring systems managed by the Borlaug Global Rust Initiative at Cornell University and CIMMYT – are of key importance. "If 'doomsday' happens, it will be too late to react," Braun said. "At present, with a human pandemic, people are worried about the supply chain from food processing to the supermarket. But if we have an epidemic in plants, then we do not have the supply chain from the field to the food processing industry. And if people have nothing to eat, they will go to the streets and we will see violence. We simply cannot put this aside."

Agriculture accounts for 30% of global GDP, yet only 5% of global research and development investment goes to the sector. "If there is any flip side to the COVID-19 disaster, it is that hopefully our governments realize that they have to play a much more serious role in many areas, in particular public health and disease control in humans but also in plants," Braun said.

The butterfly and the bulldozer

The exponential growth trajectory of a disease outbreak can lead one to think of the famous butterfly effect. A single fateful encounter between a host and a pathogen can lead to world-shaking consequences. However, this overlooks how human activity is creating massive environmental and ecosystem changes that impact the likelihood and severity of future disease outbreaks.

Recently Frédéric Baudron, systems agronomist at CIMMYT, and Florian Liégeois, virologist at the Institut de Recherche pour le Développement (IRD) recalled that, "60% of infectious diseases are zoonotic,



Wheat leaf rust symptoms in the field. The fungus, *Puccinia triticina*, forms small reddish-orange pustules or uredinia, which rupture the upper surface of the leaf blade as the spores mature.



meaning that they are spread from animals to humans, and 72% of these zoonoses originate from wildlife.” They noted that biodiversity loss caused by “land use changes, generally due to changes in agricultural practices, has been the leading driver” of recent zoonotic disease outbreaks.

“There are at least three mechanisms at play,” Baudron and Liégeois explained. “First, increased contact between wildlife and humans and their livestock because of encroachment in ecosystems. Second, selection of wildlife species most able to infect humans and/or their livestock – often rodents and bats – because they thrive in human-dominated landscapes. Third, more pathogens being carried by these surviving wildlife species in simplified ecosystems. Pathogens tend to be ‘diluted’ in complex, undisturbed, ecosystems.”

Reducing the impact of our global agricultural system on biodiversity will be a gargantuan, complex task requiring a global effort like the Paris Climate Agreement, they argued. Policies incentivizing sustainable intensification and the growth of supportive markets are part of the solution. “But these

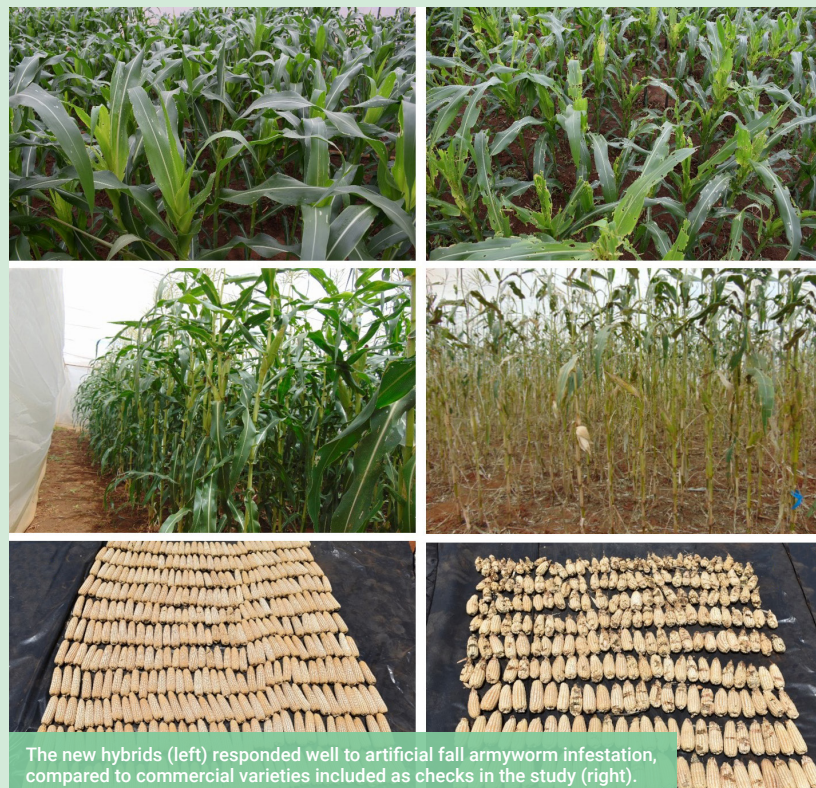
SCIENCE WINS A ROUND IN THE FIGHT AGAINST FALL ARMYWORM

CIMMYT announces three fall armyworm-tolerant elite maize hybrids for eastern and southern Africa, following intensive research and trials in Kenya.

Fall armyworm is a fearsome adversary, especially for maize farmers. The second half of its scientific name, *Spodoptera frugiperda*, literally means “lost fruit.” Native to the Americas, the pest was first encountered in Africa in 2016. It quickly spread to over 40 African countries, causing an estimated \$3 billion worth of crop losses. By 2018 it spread to Asia.

Faced with this crisis, researchers at CIMMYT – bolstered by strong global collaboration and partnerships – worked at breakneck speed to respond.

The pest cannot be eradicated. So CIMMYT and its partners raced to create awareness about the pest, the need for monitoring and early



detection during the crop season and agronomic best practices for managing the pest in Africa and Asia.

“Fall armyworm poses a complex challenge and cannot be sustainably tackled by a single solution,”

explained B.M. Prasanna, director of CIMMYT’s Global Maize program and the CGIAR Research Program on Maize. “We need to adopt an integrated pest management strategy based on scientifically validated technologies and

measures are likely to be insufficient alone,” Baudron and Liégeois pointed out, “as a large share of the global food doesn’t enter the market but is rather consumed by the small-scale family farmers who produce it.”

CIMMYT and, by extension, CGIAR are in a position to play an important role in addressing this challenge. “Interestingly, many of these [zoonotic disease hotspots] are located in regions where CIMMYT’s activities are concentrated: Central America, East Africa and South Asia,” Baudron and Liégeois said. “This, in addition to the fact that agricultural changes are a major driver of the emergence of zoonoses, means that CIMMYT researchers may have a role to play in preventing the next global pandemic.”

Partners and funders

Borlaug Global Rust Initiative at Cornell University, CGIAR, and Institut de Recherche pour le Développement (IRD).

management practices – including host plant resistance, biological control, environmentally safer pesticides, and agroecological management – considering the socioeconomic contexts of farming communities.”

The host has entered the chat

Researchers at CIMMYT leveraged the insect resistance of tropical maize germplasm developed in Mexico in the 1990s and the stress resilience of elite maize germplasm developed in sub-Saharan Africa. They worked intensively over the past three years to identify and validate sources of native genetic resistance to fall armyworm in Africa. This involved screening over 3,000 inbred lines and 3,500 hybrids during 2018 and 2019, in partnership with Kenya Agricultural & Livestock Research Organization (KALRO), at a screenhouse complex in Kiboko, Kenya.

In 2020, eight promising CIMMYT-developed maize hybrids – and four popular commercial hybrids which were included as checks – were subjected to a battery of trials:

fall armyworm artificial infestation in screenhouses at Kiboko, on-farm trials in Kenya, and evaluations for other farmer-preferred traits in eastern Africa.

Based on these trials, three CIMMYT-derived hybrids emerged as the strongest candidates. When artificially infested with fall armyworm, these hybrids yielded 7 to 8.5 times more maize than the commercial checks.

CIMMYT is now partnering with research programs in over 10 countries across eastern and southern Africa to further evaluate these hybrids in national performance trials before their release. Once these hybrids are released as varieties in the target countries, they will be sublicensed to seed companies for scale-up to better reach farming communities. This process is expected to begin in 2022.

“Host plant resistance is an important pillar of integrated pest management. And the identification of the first set of fall armyworm-tolerant maize hybrids for Africa is a major development,” Prasanna said. “We intend to extend this success to

Asia, where the pest is also causing havoc in many countries. A strong pipeline of elite maize varieties with farmer-preferred traits, including genetic resistance to fall armyworm, is the need of the hour in both Africa and Asia.”

Partners and funders

The Stress Tolerant Maize for Africa (STMA) project is funded by the Bill & Melinda Gates Foundation, the CGIAR Research Program on Maize (MAIZE), and the United States Agency for International Development (USAID).



CGIAR RESEARCH PROGRAMS AND PLATFORMS



Comprehensive, science-based solutions with parallel positive impacts for farmers, consumers, and the environment were a hallmark of research for development in 2020 under the CIMMYT-led CGIAR Research Programs on Maize (MAIZE) and Wheat (WHEAT). Scientific advances were all the more remarkable by their impact during a year marked by COVID-induced health, workforce and field research challenges.

WHEAT research partners generated scientific evidence that led to policy changes in India, encouraging smallholder farmers to adopt climate-smart farming practices such as zero tilling, the Happy Seeder, earlier planting and precision nutrient management. These changes could, in the future, benefit around 14 million smallholders with extra production, providing around \$1.3 billion additional revenue, while reducing around 3.4 million tons of CO2e greenhouse gas each year.

A farm management approach developed by MAIZE partners, now incorporated in extension programs in countries from western Africa to South Asia, uses comprehensive integrated pest management to control fall armyworm, focusing on indigenous natural enemies, host plant resistance, and environmentally safer pesticides. Under good agronomic management, this approach allows farmers to recover their crop after a fall armyworm invasion, safeguarding their income and avoiding environmentally harmful

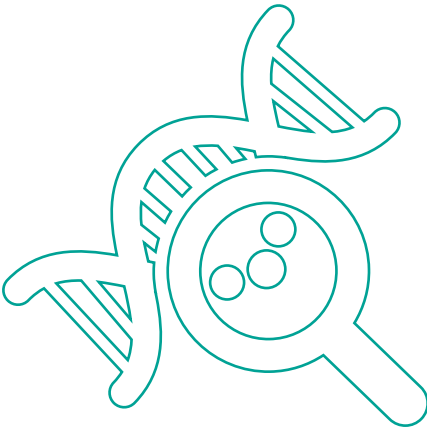
pesticides. MAIZE developed and announced 48 new varieties across Africa, Asia and Latin America in 2020, as well as three new hybrids with native genetic resistance to fall armyworm for uptake by partners in eastern and southern Africa.

A comprehensive study of MAIZE impacts in sub-Saharan Africa shows that 60% of all maize varieties released between 1995 and 2015 in the region have known or reported CGIAR parentage. In 2015, the aggregate yearly economic benefits of using CGIAR-related maize varieties released after 1994 were estimated to be between \$660 million and \$1.05 billion.

Under WHEAT, scientists estimated the annual gains in grain yield of CIMMYT's High Rainfall Wheat Trials – CGIAR-derived wheat grown by national partners around the world – from 2006 to 2017. They found 3.8% annual genetic gains in the high rainfall environment (compared to 1.17% in local varieties), and 0.93% in low rainfall (compared to 0.73%), benefiting farmers on around 61 million hectares of wheat farmland.

A CGIAR-commissioned review of WHEAT found it has “a track record of delivering local solutions with a global perspective” and its work is “essential” to meet the rising global demand for wheat.

Likewise, a MAIZE Phase II review determined that MAIZE “uniquely fills a gap at the global and regional level.”



As both CGIAR Research Programs enter their final year, their achievements and impacts will serve as the foundation for future CGIAR research on essential cereal crops and cropping systems that are affordable, accessible, climate-resilient, an often-overlooked source of nutrition, and widely eaten by the world's most vulnerable populations.

For more information about MAIZE and WHEAT innovations, outcomes and impacts, please use the CGIAR results dashboard: <https://www.cgiar.org/dashboards/>

The CGIAR Research Program on Maize (MAIZE) receives Windows 1 & 2 support from the governments of Australia, Belgium, Canada, China, France, India, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, the United States, and the World Bank.

The CGIAR Research Program on Wheat (WHEAT) receives Windows 1 & 2 support from the governments of Australia, Belgium, Canada, China, France, India, Japan, Korea, Mexico, the Netherlands, Norway, Sweden, Switzerland, Turkey, the United Kingdom, the United States, and the World Bank. The International Center for Agricultural Research in the Dry Areas (ICARDA) is a primary research partner.



In a year of global challenges, CGIAR Excellence in Breeding (EiB) pushed forward with modernizing CGIAR and national agricultural research systems (NARS) breeding.

EiB described over 320 market segments and 120 breeding pipelines; led development of new breeding KPIs; launched shared genotyping services; and supported major operations upgrades through assessments, continuous improvement processes, breeding simulation use, a program costing process, and more. Integrated data management advanced to the next level and EiB developed a new model for collaboration between CGIAR and NARS. Meanwhile partners showed progress on delivering higher genetic gain and varietal turnover in market-focused products.

EiB is set to continue maximizing the full potential of Crops to End Hunger (CtEH) investments, helping partners meet six funder requests, and leading the One CGIAR transition.

For more information, visit excellenceinbreeding.org

FUNDERS

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Amount In thousands of U.S. dollars	Top funders Based on 2020 project execution
24,247	CGIAR Research Programs and Platforms (see Note 1)
19,071	Bill & Melinda Gates Foundation, USA
14,512	United States Agency for International Development, USA
7,920	Mexican Government Contributions, Mexico (see Note 2)
2,216	Cornell University, USA (see Note 3)
1,207	Walmart Foundation, USA
1,130	HarvestPlus (see Note 4)
699	Australian Centre for International Agricultural Research, Australia
950	Global Crop Diversity Trust, Germany
854	Ministry of Agriculture and Farmers Welfare, India

Amounts exclude deferred depreciation.

Note 1: Includes contributions from Australia, Belgium, Canada, Denmark, France, Global Crop Diversity Trust, India, Japan, Germany, Republic of Korea, The Netherlands, Norway, Sweden, Switzerland, the United Kingdom's Foreign, Commonwealth & Development Office, the United States Agency for International Development, and the World Bank.
Note 2: Includes federal and local state contributions.
Note 3: Bill & Melinda Gates Foundation and the United Kingdom's Foreign, Commonwealth & Development Office as back funders
Note 4: Includes contributions from the Bill & Melinda Gates Foundation, the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), the European Commission, the United Kingdom, the United States Government's Feed the Future initiative, and is supported by the John D. and Catherine T. MacArthur Foundation.

OTHER FUNDERS

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ACRONYMS

ADB	Asian Development Bank	FAO	United Nations Food and Agriculture Organization	KPI	Key performance indicators
AGG	Accelerating Genetic Gains in Maize and Wheat	FACASI	Farm Power and Conservation Agriculture for Sustainable Intensification	MAIZE	CGIAR Research Program on Maize
ACIAR	Australian Centre for International Agricultural Research	FCDO	Foreign, Commonwealth & Development Office of the United Kingdom	N2O	Nitrous oxide
BBS	Bangladesh Bureau of Statistics	FHB	Fusarium head blight	NARC	Nepal Agricultural Research Council
BIOFOCS	Bioactive food components	IAAA	Innovative Applications in Analytics Award	NARS	National Agricultural Research Systems
BISA	Borlaug Institute for South Asia	ICAR	Indian Council of Agricultural Research	ORMAS	Odisha Rural Development and Marketing Society
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security	ICARDA	International Center for Agricultural Research in the Dry Areas	PAU	Punjab Agricultural University
CIAT	International Center for Tropical Agriculture	IFPRI	International Food Policy Research Institute	PROGRESS	Program for Growth and Resilience
CIMMYT	International Maize and Wheat Improvement Center (<i>Centro Internacional de Mejoramiento de Maíz y Trigo</i>)	IIASA	International Institute for Applied Systems Analysis	SADER	Mexico's Secretariat of Agriculture and Rural Development (<i>Secretaría de Agricultura y Desarrollo Rural</i>)
CMGRL	CIMMYT Maize Genetic Resource Lines	IITA	International Institute of Tropical Agriculture	SDGs	Seeds of Discovery
CO2e	Carbon dioxide equivalent	IRD	Institut de Recherche pour le Développement	SeeD	Sustainable Development Goals
CSISA	Cereal Systems Initiative for South Asia	IRRI	International Rice Research Institute	STMA	Stress Tolerant Maize for Africa
CtEH	Crops to End Hunger	ITDA	Integrated Tribal Development Agency	ZRBF	Zimbabwe Resilience Building Fund
EIAR	Ethiopian Institute of Agricultural Research	JAAS	Jiangsu Academy of Agricultural Sciences	UN	United Nations
EIB	CGIAR Excellence in Breeding Platform	KALRO	Kenya Agricultural & Livestock Research Organization	UNDP	United Nations Development Programme
EMT	Executive Management Team			USAID	United States Agency for International Development
EU	European Union			WFP	United Nations World Food Programme
				WHEAT	CGIAR Research Program on Wheat
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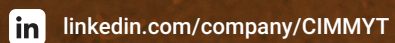
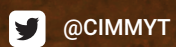
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