

CIMMYT continues to sustainably

address global hunger

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Global hunger is on the rise again, affecting over 815 million people - 11% of the world's population. Malnutrition is affecting the health of millions of people worldwide, especially in Asia and Africa. To address these issues, achieving zero world hunger (United Nations Sustainable Development Goal 2) is the major focus of different governments and institutions around the world. CIMMYT is working closely with other CGIAR centers, national governments and a wide range of public and private stakeholders on a long-term sustainable development agenda that will transform people's lives and improve their food security today and in the future.

Key words: Global, Hunger, Maize, Wheat

THE world population in 2050 is projected to be around 9.7 billion (<http://www.un.org>), and nearly 60% more food will be needed to feed this population. Most of that food will need to come from smallholder farmers who produce most of the world's food. Despite significant efforts made in the past, the food situation is still far from satisfactory in Asia and Africa. The 2018 *Global Report on Food Crises* indicated that around 124 million people in 51 countries are currently facing food insecurity crises or worse (<https://www.wfp.org>).

Micronutrient deficiencies are also serious. World Bank studies showed that productivity losses due to various types of malnutrition in low-income Asian countries constitute about 2-3% of their gross national product and 8% in Bangladesh (<http://www.worldbank.org>). Therefore, it is extremely important to deploy all that is possible through science and technology in agriculture, and everyone must be involved. As staple foods, maize and wheat provide vital nutrients and health benefits, making up close to two-thirds of the world's food energy intake, and contributing 55 to 70%



Fig. 1 First two biofortified wheat varieties released in India in 2017
(Source: Ravi Singh and Govindan Velu, CIMMYT)

of the total calories in the diets of people living in developing countries.

Headquartered in Mexico, the International Maize and Wheat Improvement Center (known by its Spanish acronym, CIMMYT) works to reduce poverty and hunger by sustainably increasing the productivity of maize- and wheat-based farming systems in Asia, Africa and Latin America. CIMMYT was formally launched as an international organization in 1966. In 2016, we celebrated CIMMYT's Golden Jubilee, 50th anniversary. The India-CIMMYT agricultural research partnership is one of the oldest and most productive collaborations in the world, with a rich history that spans five decades. The collaboration started when Nobel Laureate Dr Norman E. Borlaug visited India in 1963 to ushering in the Green Revolution in active partnership with the Government of India. In 2011, the Borlaug Institute for South Asia (BISA), a joint initiative of CIMMYT and the government of India (ICAR), was established with three centers (Ludhiana, Jabalpur and Samastipur) to address food, nutrition, the environment and livelihood security in South Asia.

As a member of the CGIAR, which is composed of 15 agricultural research centers, CIMMYT leads the CGIAR Research Programmes on Maize and Wheat, which align and add value to the efforts of more than 500 partners. Over the years, CIMMYT has made significant impacts on global food security and livelihoods through the following (<https://www.cimmyt.org>):

CIMMYT generates benefits of US\$3.5-4 billion annually; CIMMYT alumni include a Nobel Peace Prize laureate and three World Food Prize winners; more than 70% of the wheat grown in developing countries and more than 50% of improved maize varieties derive from CIMMYT breeding materials; more than 10,000 scientists have trained at CIMMYT and gone on to become leaders in their own countries. Besides the Center empowers thousands of students, extension workers and farmers through courses, workshops and field days.

Wheat research

Wheat provides 20% of the calories and protein people consume globally. An estimated 80 million farmers in the developing world rely on wheat for their livelihoods. Demand for wheat by 2050 is predicted to increase by 70% from today's levels due to population growth and dietary changes, but the challenges to wheat production are stark and growing. The crop is at risk from new and more aggressive pests and diseases, diminishing water resources, limited available land and unstable weather conditions related to climate change.

Through its Global Wheat Programme, CIMMYT collaborates with national agricultural research institutions, non-governmental and community-based organizations, seed sector organizations, regional research networks, private companies, advanced research institutions and other CGIAR centers, to provide farmers the best seed, agronomy, training and information needed to increase yields. The Wheat Programme works with more than 200 international research and breeding institutions, including the International Center for Agriculture Research in the Dry Areas (ICARDA) and the CGIAR Research Programme on Wheat.

CIMMYT's wheat breeding programme is built on strong partnerships with national institutions worldwide with the aim of rapidly developing and sharing genetically diverse improved germplasm combining multiple traits for adaptation on about 60 million ha sown to spring wheat in Asia, Africa, the Middle-East and Latin America. The new germplasm is distributed annually through international yield trials and screening nurseries. The new wheat lines have been through CIMMYT's rigorous shuttle breeding system, which tests them in different locations and climate conditions. An annual yield gain of about 1% is being realized by current CIMMYT germplasm in all environments, and higher yielding, more productive varieties continue to be released in various countries including eastern India, where they are enhancing

productivity. Marasas *et al.* (2004) reported that CIMMYT's work on leaf rust resistance alone generated US \$5.4 billion in net present value for the period 1973–2007. Dubin and Brennan (2009) estimated that resistance to all types of wheat rusts produced annual benefits of US \$600 million to US \$2.0 billion globally in 2006 dollars.

It is a historical fact that just four short years after Borlaug's first visit, the India-CIMMYT partnership doubled India's wheat harvest to 20 million tonnes and the nation reached self-sufficiency in wheat. The success has continued and in 2018, India harvested a record 98.6 million tonnes of wheat. However, in 2015 the wheat harvest dropped to 86.5 million tonnes, which emphasized the need to continuously invest in wheat research. CIMMYT's Wheat Improvement Programme in Mexico targets 60 m ha, about half of which are in India. During 2010-2016, more than 60 CIMMYT-derived wheat varieties were released, with 34 being direct releases in different parts of India. The first two biofortified (zinc rich grain) wheat varieties (WB 2 and HPBW 01) were also released by CIMMYT in India in 2017 (Fig. 1). A biofortified wheat variety named Zincol 2016 was released in Pakistan in 2016.

More than half of the wheat area in developing countries is sown to either straight CIMMYT introductions or varieties derived from crosses with CIMMYT lines. Besides improving bread and *durum* wheat, the CIMMYT Global Wheat Programme uses wild relatives of wheat to introduce such traits as drought tolerance and improved nutritional quality. CIMMYT's Wheat Molecular Marker Laboratory develops tools and information that breeders around the world are using to improve disease resistance, among other traits. CIMMYT's Wheat Quality Laboratory ensures that CIMMYT wheat varieties meet market demands for flour and bread quality.

Wheat in South Asia is now being threatened in 2016 introduction of the wheat blast fungus into Bangladesh from South America. As



Fig. 2. Bari Gom 33 – the wheat blast tolerant variety released in Bangladesh in 2017 (Source: NCD Barma, BARI, Bangladesh)

a result of brilliant collaborative work, a wheat blast resistant variety Bari Gom 33 was released in Bangladesh in 2017 (Fig. 2). It is being disseminated in affected areas to control the dreaded disease; however, a stronger effort will be required to control and manage this disease in upcoming years. The efforts have to be no less than those adopted to contain stem rust race Ug99, which threatened wheat production a decade ago (Fig. 3). In summary, the challenges to wheat continue to emerge and will need continued attention to sustain production while leaving a minimum climatic footprint.

Maize research

Over the past decades, CIMMYT has developed and deployed a wide range of maize germplasm with high yield, stress resilience and nutritional quality for over 600 million maize-dependent people in the world, including about 120 million malnourished children in Africa, Latin America and Asia. The major focus of CIMMYT's Global Maize Programme has been on developing germplasm with tolerance to drought, heat, poor soil fertility, water-logging, acidity, diseases, insect-pests and parasitic weeds, in partnership with an array of public and private institutions. These objectives are met through a package of methodologies and processes that include deployment of molecular markers for key traits, and implementation of marker-assisted recurrent selection and genomic selection to increase genetic gains. The Programme also undertakes

strategic research on doubled haploid (DH) technology for the tropics to accelerate the development of homozygous parental lines. It routinely offers DH technology support to national agricultural research systems, and small-and medium-sized seed companies.

The maize breeding programme plays a key role in facilitating the deployment of improved maize seed in the tropics, especially targeting women farmers and disadvantaged groups to maximize impact. Work includes identifying easy-to-produce, best-bet hybrids and improved open-pollinated varieties, seed production research and recommendations, promoting scale-up and delivery of new and promising products through seed company partners.

For India, CIMMYT has focused on developing climate resilient maize hybrids that are tolerant to heat and drought (Fig. 3). It also focuses on breeding quality protein maize (QPM) that produces competitive yields under optimal conditions and superior yields under abiotic and biotic stresses. About nine QPM hybrids were developed in the last decade with extensive use of CIMMYT's maize germplasm. Maize lines resistant to *Turicum* leaf blight (TLB), downy mildew, and bacterial leaf and sheath blight were also

developed and distributed to national maize programmes. A strong germplasm base that combines drought, heat and waterlogging tolerance with high yield potential was also created. CIMMYT's maize team in India has shared hundreds of improved maize lines and trait donors with national partners. Climate-resilient (drought tolerant and heat tolerant) maize varieties were developed in India in partnership with ICAR/AICRP centers, and released by public and private sector institutions, especially in the last 4 to 5 years, based on maize germplasm from CIMMYT.

Germplasm research

CIMMYT manages humankind's most diverse maize and wheat collections. Wheat holdings at CIMMYT comprise some 150,000 seed samples from more than 100 countries; the largest unified collection in the world for a single crop. CIMMYT's maize germplasm bank contains 28,000 seed samples, including the world's largest collection of maize landraces – varieties developed by farmers over decades, centuries or even millennia – along with maize wild relatives *teosinte* and *Tripsacum*, and improved varieties. Through its breeding programmes, each year

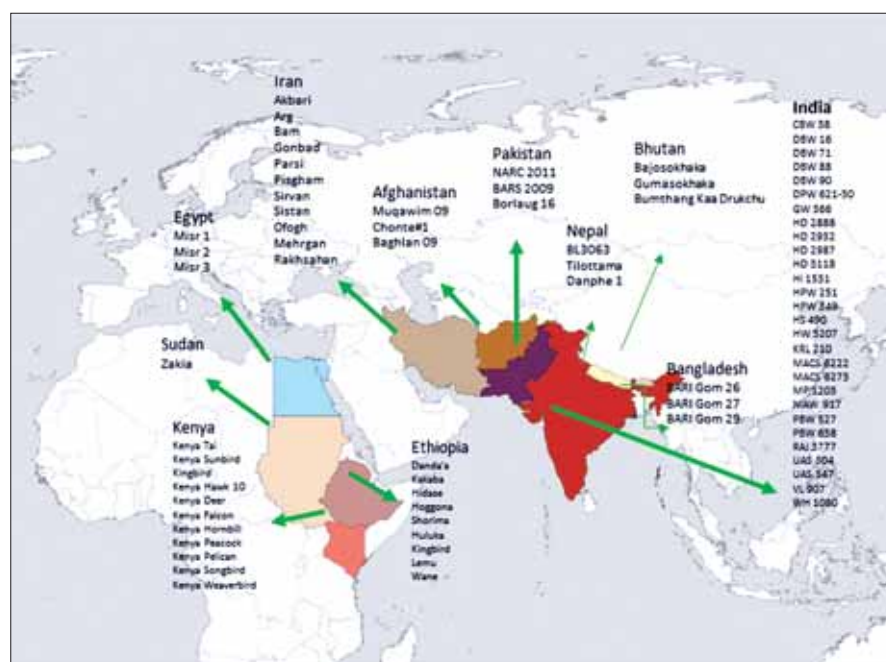


Fig. 3. Ug99 resistant wheat varieties released in the world in last 10 years (Source: Ravi Singh, CIMMYT)

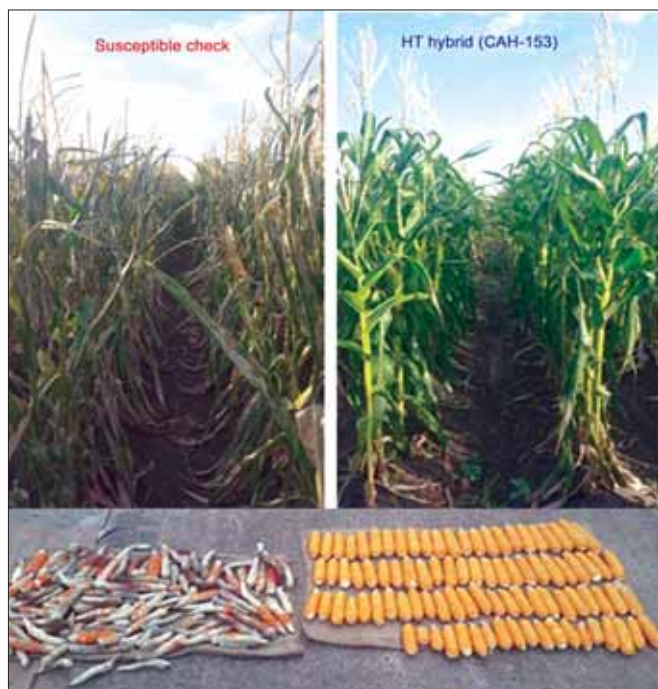


Fig. 4. The new heat tolerant maize hybrids developed at CIMMYT (Source: P.H. Zaidi, CIMMYT)

CIMMYT sends half a million seed packages to 600 partners in 100 countries. With researchers and farmers, the Center also develops and promotes more productive and precise maize and wheat farming methods and tools that saves money and resources such as soil, water, and fertilizers.

Sustainable intensification

Sustainable intensification agricultural practices are aimed at enhancing the productivity of labour, land and capital, and contribute significantly to the livelihoods of smallholder farmers. CIMMYT offers sustainable agronomic practices such as zero tillage and laser-leveling, as well as new machines and irrigation tools that increase water and nutrient use efficiency, help farmers adapt to climate change, sustainably manage land, soil, nutrient and water resources, improve food and nutrition security, and ultimately reduce rural poverty. Along with improved varieties, these practices also significantly help improve productivity and therefore increase food availability and income, and benefit the livelihoods of smallholder farmers, natural resource integrity, social equity, nutrition, health and resilience against biophysical or socio-economic shocks.

agriculture. BISA farms demonstrated the implementation of large-scale rice straw management with no burning of residue.

A significant contribution to small-holder farmers in South Asia was made through the Cereal System Intensification in South Asia project, which facilitated the emergence of 738 new zero tillage service providers for wheat in Bihar and Eastern Uttar Pradesh, representing an annual growth rate of 25%. Aided by the project, 63,718 households implemented zero tillage on 58,695 ha in 2016–2017 from a near zero base in 2012. With this level of uptake, there is now a strong rationale for the Indian State Department and state agricultural universities to regard zero tillage as an accepted technology with broad

applicability, rather than as being “under research.” Building on the advances made by breeders, Cereal System Intensification in South Asia provided further evidence that earlier wheat sowing produces high yields. This work, coupled with a policy change by the Bihar Government on planting recommendations backed by public awareness campaigns, shifted the median planting date 5 days earlier after just one year, and increased the average yield by a quarter tonne (Fig. 6).

A report by the International Food Policy Research Institute suggests that the Indian conservation agriculture programme has saved US \$ 164 million with an investment of only US \$ 3.5 million, and an internal rate of return of 66%, from 1990 to 2010. Research on other technologies such as zero-tillage, bed planting and Conservation Agriculture has been conducted and up-scaled in a range of environments/locations. For small holder precision nutrient management, new decision support tools (Nutrient Expert), a calibration curve for the Green Seeker sensor (Variable Rate Technology) and an Android phone-based app to support Green Seeker calibration were developed and validated through large on-station and on-farm participatory validation trials. A full technology package for residue management in rice-wheat rotations with multiple benefits, including yield gains, farm profits, water savings, reduced weather risks as well as environmental footprints, improved soil health and reduced chemical applications was developed, validated and shared with stakeholders.



Fig. 5. QPM hybrids of maize developed at CIMMYT (Source: B.S. Vivek, CIMMYT)

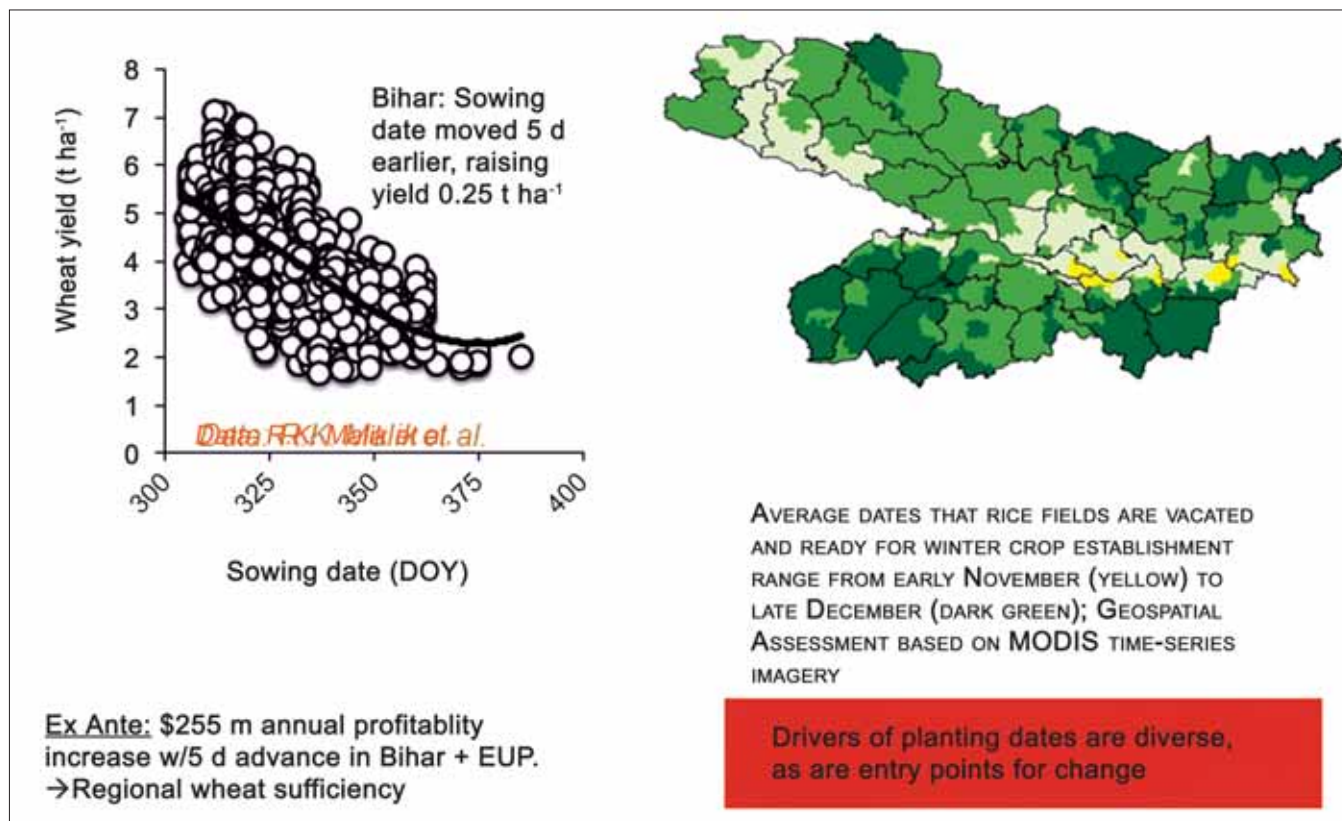


Fig. 6. Use of zero-tillage wheat sowing advanced by 5 days in Bihar (Source: AK Malik, Andrew McDonald, CIMMYT)

Other contributions

CIMMYT, through the CGIAR programme on Climate Change Agriculture and Food Security and Bourlaug Institute for South Asia, was instrumental in introducing the concept of climate smart agriculture in several hundred villages in Asia and Africa. In India alone, more than 1,500 villages in Maharashtra, Punjab, Haryana, Bihar and Madhya Pradesh were benefitted through this programme.

CIMMYT's Socio-economics Programme has evaluated and prioritized wheat and maize interventions for achieving greater impact around the world. Cross-cutting agricultural research was conducted to ensure social and

gender inclusiveness, which has helped small holder farmers greatly. The Socio-economics Programme provides guidance on whether interventions are making changes that are transforming agriculture and rural landscapes.

Since 1969, more than 350 Indian visiting scientists and nearly 80 trainees were hosted at CIMMYT. Between 1969 and 2015, more than 2,000 Indian scientists improved their knowledge and skills through various capacity building activities with CIMMYT. At present around two dozen international scientists from India are engaged in CIMMYT.

SUMMARY

Given the challenges imposed by

climate change, increasing population, dwindling resources and a range of socio-economic issues in the developing world, CIMMYT has made a significant contribution to the overall sustainability of food security and poverty reduction. To achieve the required productivity gains, strong emphasis on enhancing yield potential together with climate resilience, appropriate crop management and policy support must continue.

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Why should we care about World Food Day and #ZeroHunger?

- The right to food is a basic human right.
- Investing in sustainable food systems and rural development means addressing some of the major global challenges - from feeding the world's growing population to protecting the global climate, and tackling some of the root causes of migration and displacement.
- Achieving the 17 SDGs cannot happen without ending hunger, and without having sustainable and resilient, climate-compatible agriculture and food systems that deliver for the people and the planet.
- Despite a recent increase in hunger figures, reaching **#ZeroHunger** is possible: out of the 129 countries monitored by FAO, 72 have already achieved the target of halving the proportion of people who suffer from hunger by 2015; over the past 20 years, the likelihood of a child dying before age five has been nearly cut in half, with about 17,000 children saved every day; extreme poverty rates have been cut in half since 1990.

(Courtesy: FAO)