Message from the WHEAT director

High returns to global wheat research

Building on more than a half-century of proven impacts, the global wheat improvement system led by CGIAR centers continues to be the chief source for wheat farmers in Africa, Asia and Latin America of critical traits such as high yields, disease resistance and enhanced nutrition and quality.

A recently-published study found that CGIAR-derived varieties—nearly all traceable to CIMMYT and ICARDA breeding programs—cover more than 100 million of 220 million hectares worldwide and bring economic benefits of as much as $3.1 billion each year. To achieve impacts in wheat agri-food systems, CIMMYT and ICARDA depend on national partnerships in over 100 countries and critical support from CGIAR Fund Donors and other contributors, whom we sincerely thank on behalf of the world’s wheat farmers and consumers.

A critical juncture

Consumers in particular are benefiting from current low wheat grain prices, thanks in part to the success of WHEAT, but many studies foreshadow a future of rising demand and food price instability that could wreak havoc, particularly among poor consumers.

The unfolding scenario implies a yearly growth in wheat demand of 1.4 percent to 2030, at constant prices. But yield gains in wheat remain below 1 percent per year over the last decade, mainly because the easiest gains in wheat have already been achieved and more dramatic progress will require new approaches.

To ensure the affordable availability of wheat—a food staple that provides around 20 percent of protein and calories consumed worldwide—researchers need to expand field testing for disease resistance and heat and drought tolerance and to significantly raise wheat’s genetic yield potential.

For their part, during 2015 CIMMYT and ICARDA made excellent progress in merging their wheat programs to ensure partners and farmers’ quick and effective access to high-yielding, climate-resilient breeding lines, productive and resource-conserving cropping practices and knowledge needed to face the future of wheat, the vital grain of civilization and food security.
Billions in benefits from CGIAR wheat breeding

Launched in the 1950s by Norman Borlaug, a wheat scientist whose research and development contributions helped save hundreds of millions from starvation in the 1960s-70s, the international wheat improvement network coordinated by the International Maize and Wheat Improvement Center (CIMMYT) and the International Center for Agricultural Research in the Dry Areas (ICARDA), both members of CGIAR, has been the main source of improved traits for wheat breeding programs and farmers in developing countries and often high-income nations. This has raised wheat yields, grain quality and disease resistance, among other traits.

But what is the precise economic value of this breeding pipeline, which in recent times leverages annual donor contributions of approximately $30 million to test, select and share wheat lines worldwide, as well as supporting seed production and distribution to farmers?

To find the answer, CIMMYT socioeconomists undertook a momentous study, gathering survey responses from breeding programs in 66 major wheat producing countries, analyzing the pedigrees of 4,604 wheat varieties released during 1994-2014, and poring over countless published reports and on-line resources.

The study found that farmers’ use of this improved seed brings benefits in more bountiful harvests of between $2.2 and $3.1 billion each year, helping to raise farmers’ incomes and to keep wheat affordable for low-income consumers.

The new study proves that international collaboration on wheat research continues to provide impressive returns on investments, as occurred during the 1960s-70s, according to Olaf Erenstein, director of the CIMMYT socioeconomics program. “Consistent and secure funding is crucial to maintain the research and institutional capacities required to deliver such impact,” says Erenstein, “particularly given the mounting challenges facing wheat food security and farm livelihoods in developing countries.”

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WHEAT pursues progress for women and disadvantaged groups

Despite often performing vital farm work, including cleaning seed to sow, weeding, harvesting and preparing grain for cooking, nearly all women in Pakistan’s rural households are marginalized from economic control or decision-making in agriculture, not being allowed to own land or obtain credit and rarely taking part in selecting which varieties to grow.

According to Akhtar Ali, Agricultural Economist for the Agricultural Innovation Program (AIP), fewer than one percent of women have land rights in Pakistan.

“Focusing on gender activities in agriculture is incredibly important,” said Ali. “Take Pakistan for example, 52 percent of our population is female. We cannot progress as a country if we continue to ignore half of the population.”

Pakistan is one of 26 countries across Asia, Africa and Latin America, involved in a field study known as GENNOVATE, which investigates how gender roles and behaviors can shape women and men’s contributions and innovations in agriculture, particularly in developing countries.

As of late 2015, the study has completed case studies across 48 major wheat-producing villages in Afghanistan (4), Bangladesh (6), Ethiopia (4), India (12), Morocco (3), Nepal (3), Pakistan (12) and Uzbekistan (4). With 48 case studies worldwide, WHEAT is investing in better understanding gender constraints, so that in the future more farmers will be able to make good use of improved technologies and practices developed under WHEAT.

GENNOVATE, which joins 20 researchers from 11 CGIAR Research Programs, aims to engage gender and social development specialists to identify actions that strengthen the ability of agricultural research for development organizations to support poor rural women, men and youth. “Building the right teams to do field work for this was crucial,” said Huma Khan. “We faced many challenges, particularly regarding gender constraints. As a female, I was unable to speak with males in the villages, and it took a lot of community organization to speak with the females.”

Field teams lived and worked within the village among the locals for up to seven days to complete the necessary field work.

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“The field teams in Uzbekistan and Morocco were incredibly dedicated,” said Dina Najjar, gender specialist at ICARDA. “In one instance I had a team that realized the questions had not been answered sufficiently and the team immediately organized a trip back to meet with the community.”

On the ground researchers explored the differences in women and men’s opportunities to access, adopt and benefit from innovations in agriculture. Case studies were selected by analyzing different socio-economic backgrounds and age groups of individual villages.

“Our work is incredibly challenging,” explained Ali. “But I can already see the potential benefits of our findings, and hopefully this research can make a difference for our smallholder farmers, particularly the females.”

Preliminary CRP-level results are expected in 2016.

GENNOVATE is funded by the Bill & Melinda Gates Foundation and CGIAR Fund Donors.
Domestic production: A solution to Nigeria’s wheat dependence

High-yielding, heat-tolerant wheat developed in Sudan has convinced Nigeria’s policymakers to invest more in wheat production.

Working through the wheat component of the project “Support to Agricultural Research for Development on Strategic Commodities in Africa (SARD-SC),” funded by the African Development Bank (AfDB), ICARDA is mobilizing a fast-track seed multiplication program that has already distributed 58 tons of improved seed to 1,600 Nigerian farmers, who live in the country with the world’s 7th largest population.

The improved wheat varieties deliver up to 5-6 tons per hectare on farmers’ fields using optimal agronomic management, much more than the average 1-2 tons per hectare, when farmers employ traditional varieties and agronomic practices. A functioning seed system is crucial to Nigeria’s wheat transformation, but high quality seeds alone will not bring the required change, according to Solomon Gizaw Assefa, ICARDA’s SARD-SC/Wheat coordinator.

“We are supporting Nigerian farmers through the dissemination of proven technologies such as raised-bed irrigation and other agronomic practices to ensure optimal growing conditions,” said Assefa. “We are also pursuing policies that foster public-private partnerships to spread new technologies and improved seed, as well minimum price guarantees for farmers and other approaches that encourage Nigerian millers to buy domestic wheat.”

SARD-SC/Wheat has had a positive impact on policy change and the enabling environment in Nigeria. In collaboration with the government’s Agricultural Transformation Agenda (ATA), the project will contribute to raising national production to 1.5 million tons, potentially reducing Nigeria’s wheat imports, which is a major concern of the government. Via the ATA, subsidized small and medium-size milling machines were provided to rural entrepreneurs, to foster local value chains. 40,000 farmers received free wheat seed, as well as subsidized fertilizer, at half the market price. Last but not least, the Federal Minister of Agriculture and Rural Development has committed to increase wheat area from 70,000 hectares to 300,000 hectares in the coming 5 years. The ministry estimates that only 40 percent of the 84 million hectares of arable land are currently farmed.

The SARD-SC Wheat project is active in 11 countries throughout Sub-Saharan Africa until the end of 2016. The African Development Bank will be extending its commitment, under the 2017-2022 Technologies for African Agricultural Transformation (TAAT) program. It is a major contribution to the Wheat-for-Africa (W4A) strategy, by which WHEAT brings together major stakeholders.

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Climate-resilient wheat farming for food security in South Asia

The use of resource-conserving practices like zero-tillage can improve livelihoods through efficient and sustainable farming.

With an average of just over 2.1 tons per hectare, wheat yields in the eastern Indian state of Bihar are the lowest in the Indo-Gangetic Plains and the state imports more than 800,000 tons of wheat each year to feed its expanding population. But according to a study published in 2015 by the Cereal Systems Initiative for South Asia (CSISA), a practice known as zero-tillage – the direct sowing of seed into unplowed soil and the residues of previous crops – may be able to close the gap between wheat production and consumption.

The study stated that Bihari farmers who used zero-tillage produced 19 percent more wheat per hectare. Combined with the significant savings in fuel costs by not plowing, the total economic benefit for zero-tillage users amounted to 6 percent of their annual household income.

“The positive effect of zero-tillage appears to be greater in low-productivity areas such as Bihar than in high-output zones like, for instance, Punjab State,” said CIMMYT senior agricultural economist Alwin Keil and first author of the study.

Most smallholders in eastern India cannot afford the specialized seeder needed for zero-tillage, according to Keil. Thus, widespread adoption of the practice depends on an expanded network of entrepreneurs who have the seeder and hire out their services to sow wheat.

“In Bihar and the neighboring state of Uttar Pradesh, the number of zero-tillage service providers went from only 17 in 2012 to more than 1,900 in 2015,” he said.

The region’s farmers must also contend with high temperatures during wheat’s grain-filling stage, which can reduce yields by more than 50 percent, McDonald explained. With zero-tillage, wheat farmers can plant earlier so their crop matures before the spring heat.

“Large-scale adoption of zero tillage for wheat saves farmers money by reducing tractor and fuel costs, explained McDonald. “It also improves soil and water quality, suppresses weeds, and can put Bihar on track to self-sufficiency in wheat.”

“Enhancing the productivity of rice-wheat cropping in South Asia’s Indo-Gangetic Plains is essential to ensure food security for the region, which is home to more than 20 percent of the world’s population,” said Andrew McDonald, principal scientist at the International Maize and Wheat Improvement Center (CIMMYT) and South Asia team leader for sustainable intensification. The eastern Indo-Gangetic Plains are characterized by pervasive poverty and high population density.

According to a study published by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the International Food Policy Research Institute (IFPRI), zero-tilled wheat also saves water by better capturing rainfall, reducing evaporation and lessening the need to irrigate before sowing.

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These results were achieved through working partnerships with the CGIAR’s International Rice Research Institute (IRRI), International Food Policy Research Institute (IFPRI) and International Livestock Research Institute (ILRI); as well as national research and extension systems, the Indian Council of Agricultural Research (ICAR) of India’s Department of Agricultural Research and Education; and private companies and farmers. CSISA is funded by key donors, the United States Agency for International Development (USAID) and the Bill & Melinda Gates Foundation (BMGF).
Taking part in wheat training: A professor’s dream

Visiting CIMMYT had always been a dream of Daisy Basandrai. Basandrai spent her career at the Himachal Pradesh Agricultural University in Northern India researching lentil rusts and diseases. When it became clear there was a need for wheat researchers at the university, an opportunity arose for Basandrai to follow her true passion, wheat.

In the spring of 2015 Basandrai was on a plane to Mexico. Basandrai was one of 29 participating in the basic wheat improvement course at CIMMYT. A three-month intensive program at the Campo Experimental Norman E. Borlaug (CENEB, by its Spanish name), in Ciudad Obregón, Sonora, Mexico, it targets young and mid-career scientists from across the globe, focusing on applied breeding techniques in the field.

In 2015, 29 trainees from Afghanistan, China, Egypt, Ethiopia, Georgia, India, Japan, Morocco, Nepal, Pakistan, Sudan, Tunisia and the USA attended the course, which distributes equal time among field, lab and classroom activities.

Over the years, the proportion of women in the course has increased. Courses have been restructured to encourage female participation by adjusting courses and accommodating for those who are unable to stay for extended periods. During the Global Wheat Program Visitor’s Week, female participants joined CIMMYT staff and Jeannie Borlaug, daughter of former CIMMYT wheat breeder and Nobel Peace Prize Laureate, Norman Borlaug, for a meeting on “Women in Agriculture.” The discussion focused on issues women in science face every day, as well as triumphs and outcomes.

“When I arrived at the course, the first thing Amor Yahyaoui (CIMMYT wheat training officer) said to me was, I know you are a professor at home, but here everyone is a student,” said Basandrai. “That was the most important piece of advice I could have received. I put being a professor aside, and I became a student again.”

The training has benefited national research programs since its inception in the 1950s, as part of a Rockefeller Foundation program that predated CIMMYT. In 2015, 29 trainees from Afghanistan, China, Egypt, Ethiopia, Georgia, India, Japan, Morocco, Nepal, Pakistan, Sudan, Tunisia and the USA attended the course, which distributes equal time among field, lab and classroom activities.

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“They think the most important part of this course, especially coming from India, was coming to Mexico and researching and studying in the same fields as Norman Borlaug did when the Green Revolution began,” explained Basandrai.

Over the years, a clear increase in training is evident as well as support for advanced degree students, a trend partially attributable to WHEAT investments in learning and capacity development in developing countries. This year was a peak year for training, a trend expected to continue in 2016 and subsequent years during WHEAT Phase II.

In 2015, along with the 29 course participants, 17,000 farmers and scientists took part in nearly 400 regional training events in Afghanistan, Bangladesh, Mexico, Tunisia, Uruguay, China, Ethiopia, India, Kenya and Nepal, organized by different projects across WHEAT. They included field days, workshops and intensive training courses in sustainable intensification, breeding/seed systems and socioeconomics research.

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“The increasing number of wheat scientists in major wheat producing countries reflects the great need and interest of national programs in training young scientists. One of the most frequent requests from countries and national programs is for more trained scientists.

The training program has helped form positive bonds between CIMMYT and partner countries. Course alumni have gone on to lead national programs, receive advanced degrees and contribute nationally and internationally to wheat improvement.

The 2015 Basic Wheat Improvement Course trainees in Ciudad Obregón.

Daisy Basandrai and fellow trainee Hoda Monatufai El Gharahawy observing plots at CENEB in Ciudad Obregón, in northwestern Mexico.
Scientists have sequenced and described a gene that can help wheat resist four serious fungal diseases, potentially saving billions of dollars in yearly grain losses and reducing the need for farmers to use costly fungicides. According to Ravi Singh, CIMMYT wheat breeder and co-author of the new study, Lr67 belongs to a group of three currently-known “magic” genes that help wheat to resist all three wheat rusts and powdery mildew, a disease that attacks wheat in humid temperate regions. The genes act in different ways but all slow — rather than totally stopping — disease development. When combined with other such partial resistance genes through breeding, they provide a strong, longer-lasting protection for plants, boosting food security.

“With climate change and more intensive cropping, we’ve observed the emergence and rapid spread of new, highly-virulent strains of various fungi that are able to overcome the genetic resistance in today’s widely-sown wheat varieties,” said Singh. “The worst are the three wheat rust diseases, which cause grain losses worldwide estimated at $2.9 billion every year.”

Breakdowns in the resistance of popular wheat varieties can lead to massive, catastrophic disease outbreaks, such as the U.S. stem rust epidemics of the 1950s, or the yellow rust outbreak in Africa and Central Asia in 2009-10.

“In developing country wheat-growing regions, these epidemics bring hunger and economic hardship to resource-poor rural communities,” said Julio Huerta-Espino, principal researcher at INIFAP and a co-author of the Nature Genetics study. “They also require large-scale use of costly fungicides to avoid crop losses, and emergency initiatives to multiply and distribute seed of new, resistant varieties.”

A global research team isolated the wheat gene Lr67, revealing how it hampers fungal pathogen growth through a novel mechanism. Published in Nature Genetics, the study involved scientists from the CIMMYT, the Chinese Academy of Agricultural Sciences (CAAS), Mexico’s National Institute of Forestry, Agriculture, and Livestock Research (INIFAP), the Norwegian University of Life Sciences and scientists from Australia, including the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the University of Newcastle, and the University of Sydney.

For more than two decades CIMMYT has worked with advanced laboratories to identify “slow rusting” partial resistance genes and cross them into high-yielding varieties, as part of the Australian Cereal Rusts Program, funded through the Grains Research & Development Corporation (GRDC).

The cloned gene will be much easier to deploy widely in CIMMYT breeding lines, according to Singh. Efforts to develop wheat varieties that carry combinations of Lr67 and other genes which provide strong, diverse, and more durable resistance to the rusts, including the dangerous Ug99 stem rust race group, have progressed under the Borlaug Global Rust Initiative led by Cornell University and funded by the Bill & Melinda Gates Foundation, the UK Department of International Development (DFID), and the Indian Council of Agricultural Research (ICAR).

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“The late Nobel Prize laureate and father of the Green Revolution, Dr. Norman Borlaug, used these types of genes from the beginning of his breeding program last century, recognizing their potential if not understanding their role,” said Hans-Joachim Braun, director of CIMMYT’s global wheat program. “Now, 65 years later, we are finally getting a grasp on how they work.”
Rescuing wheat seed collections from conflict

With Syria torn apart by civil war, a team of scientists in Mexico and Morocco are rushing to save a vital sample of wheat’s ancient and massive genetic diversity, sealed in seed collections of an international research center formerly based in Aleppo, but forced to leave during 2012-13.

Researchers at CIMMYT and ICARDA began restoring and genetically characterizing more than 30,000 unique seed collections of wheat from the ICARDA Syrian genebank.

“With war raging in Syria, this project is incredibly important,” said Carolina Sansaloni, genotyping and DNA sequencing specialist at CIMMYT. “It would be amazing if we could be just a small part of reintroducing varieties that have been lost in war-torn regions.”

The team as part of the Seeds of Discovery (SeeD) project at CIMMYT has been sequencing DNA from 2,000 seed samples a week, as well as deriving molecular markers for breeder- and farmer-valued traits, such as disease resistance, drought or heat tolerance and qualities that contribute to higher yields and grain quality. They are using a high-end DNA sequencing system located at the Genetic Analysis Service for Agriculture (SAGA), a partnership between CIMMYT and Mexico’s Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) and with the support of a private company from Australia, Diversity Arrays Technology (DArT).

According to Sansaloni, the collections, which have been untouched for nearly twenty years, could hold the key for future breeding to feed an expanding world population.

Safeguarding and preserving genetic diversity is crucial as population rises and man-made and natural disasters, climate change and diseases continue to plague farmers’ fields.

SeeD recently released multiple studies highlighting the potential of untapped genetic material safeguarded in genebanks, to benefit breeding programs worldwide by adding in diversity for tolerance to drought and rising temperatures.

A study by a team of researchers from CIMMYT, ICARDA and the Global Crop Diversity Trust uncovered large, previously unknown gene sequences by reviewing the molecular diversity of 1,423 spring bread wheat accessions that represent major global production environments. They employed “genotyping-by-sequencing,” a rapid and cost-effective approach that allows for an in-depth, reliable estimate of genetic diversity.

The results of the study suggested that many of the landraces and synthetics (crosses of wheat with wild grasses) have untapped genetic variation that could be used to improve modern wheat varieties. They discovered thousands of new DNA marker variations in landraces known to be adapted to drought and heat, opening the potential to enrich elite breeding lines with novel alleles for drought and heat tolerance. This new genetic diversity will help bread wheat breeding programs around the world to create new varieties and feed the world’s growing population in a changing environment.

Also in 2015, researchers at SeeD genetically characterized a collection of 8,400 centuries-old Mexican wheat landraces adapted to varied and sometimes extreme conditions, offering potential genes to combat wheat’s climate-vulnerability. Published in Nature Scientific Reports, the study details critical genetic information about Mexican landraces for use in breeding to boost global wheat production.
Financial highlights

Financial summary by natural classification (in million $)

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Top donors (in million $)

- CGIAR: 14.41
- USAID: 13.32
- SAGARPA: 3.30
- BMGF: 3.32
- GTZ: 2.3
- USDA: 1.19
- SFS: 0.87
- GTZ: 0.48
- CRP: 0.37

Summary report by Flagship Project

- Project 1: WHEAT R4D investments
- Project 2: Novel diversity and tools to adapt to climate change and resource constraints
- Project 3: Global partnerships to accelerate genetic gains in farmers’ fields
- Project 4: Sustainable intensification of wheat-based cropping systems
- Project 5: Human and institutional capacities for seed systems and scaling-out; a new generation of wheat scientists

Flagship project 1 - Maximizing value for money, and social inclusivity thus prioritizing WHEAT R4D investments.

Flagship project 2 - Novel diversity and tools to adapt to climate change and resource constraints.

Flagship project 3 - Global partnerships to accelerate genetic gains in farmers’ fields.

Flagship project 4 - Sustainable intensification of wheat-based cropping systems.

Flagship project 5 - Human and institutional capacities for seed systems and scaling-out; a new generation of wheat scientists.

* Amounts may not add up precisely due to rounding