2015 WHEAT CRP Annual Report

for the Consortium and the Fund Council

CGIAR

RESEARCH PROGRAM ON Wheat

Contents

Acronyms and abbreviations

ACIAR	Australian Centre for International Agricultural Research
ANEP	Agriculture, Nutrition and Extension Project
BBSRC	UK Biotechnology and Biological Sciences Research Council
BGRI	Borlaug Global Rust Initiative
BMGF	Bill & Melinda Gates Foundation
BMZ	Federal Ministry for Economic Cooperation and Development, Germany
BPAT	Plant Breeding Assessment Tool
CRP	CGIAR Research Program
CA	Conservation agriculture
CAAS	Chinese Academy of Agricultural Sciences
CCAFS	CGIAR research program on Climate Change, Agriculture and Food Security
CIMMYT	International Maize and Wheat Improvement Center
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organization
CSISA	Cereal Systems Initiative for South Asia
CSSRI	Central Soil Salinity Research Institute
DArTseq	Diversity Arrays Technology
DRRW	Durable Rust Resistance in Wheat Project
EIAR	Ethiopian Institute of Agricultural Research
FACASI	Farm Mechanization and Conservation Agriculture for Sustainable Intensification project
FAO	Food and Agricultural Organization of the United Nations
FP	Flagship Projects
GBS	Genotyping-by-sequencing
GFSF	Global Futures and Strategic Foresight Project
GM	Genetically modified
GRDC	Grains Research and Development Corporation of Australia
GSI	genomic selection index
ha	hectares
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics –add first mention
IDOs	Intermediate development outcomes
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILAC	Institutional Learning and Change Initiative
INIFAP	Mexico's National Institute of Forestry, Agriculture, and Livestock Research
ISPC	CGIAR Independent Science and Partnership Council
IWIN	International wheat improvement network
IWYP	International Wheat Yield Partnership
JIRCAS	Japan International Research Center for Agricultural Sciences
KALRO	Kenya Agricultural & Livestock Research Organization
MasAgro	Modernización Sustentable de la Agricultura Tradicional
MC	Management committee
MEL	Monitoring, Evaluation, and Learning
NARS	National agricultural research systems
PIM	CGIAR Research Program on Policies, Institutes and Markets
PSI	phenotypic selection index
QTL	Quantitative trait loci
R&D	Research and development
R4D	Research for development
RCA	resource-conserving agriculture
SAGA	Genetic Analysis Service for Agriculture
SAGARPA	Mexico's Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food
SARD-SC	Support to Agricultural Research for Development on Strategic Commodities of the African Development Bank
SeeD	Seeds of Discovery
SLO	System level outcomes
USAID	U.S. Agency for International Development
USDA-ARS	United States Department of Agriculture - Agricultural Research Service
WIT	Jeanie Borlaug Laube Women in Triticum Early Career Award
W-ISC	WHEAT-Independent Steering Committee
WPEP	Wheat Productivity Enhancement Program for Pakistan
ZT	Zero tillage

Part I – Technical report

A. Key messages

A.1 Progress and challenges in 2015

Wheat blast has apparently moved outside of Latin America to South Asia (see p.7 in this report and the news post "Deadly disease wheat blast reaches South Asia"). Bad weather in India, home to 25% of the world's smallholder farmers, is likely to reduce the country's previously predicted bumper crop of wheat by 14%, according to the Times of India. A recent report from the Agricultural Market Information System (AMIS) predicts that global wheat production will decline in 2016 from 2015 record levels and fall short of demand, causing a net draw-down on global inventories. Research funded by WHEAT from Windows 1 and 2 documented the past impact of CGIAR varieties and established and annual value of more than US $2-3 billion from CGIAR wheat research (see A.2). This report also documents the use of **Windows 1 & 2 funding** to increase socioeconomics capacity (see C.1); unlock genetic diversity in wheat; identify and characterize disease resistance genes (see C.1); study trajectories and trade-offs for sustainable intensification, jointly with MAIZE, Wageningen University, and the Netherlands Royal Tropical Institute (KIT); build and strengthen partnerships as part of FP1 (University of Pretoria/BFAP and JIRCAS/BNI); study gender in wheat-based cropping systems (see A.4); and manage and oversee WHEAT.

The Institutional Learning and Change (ILAC) Initiative delivered the draft report of its study "Mapping the research networks of WHEAT," as part of a project to develop a mechanism for monitoring CGIAR research activities and networks. The findings show that **there has been substantive new collaboration and shifts in partnering, as a result of WHEAT activities**. For more information, see section E.1.

Numerous reports herein depict the strong and diverse science underpinning WHEAT's research-for-development portfolio; click here to see a complete, searchable list of 2012-15 publications, including web links to specific articles.

The CGIAR Independent Science and Partnership Council (ISPC) gave the WHEAT Phase II Pre-proposal a "B" grade and the Consortium Office ranked WHEAT second best among all CRPs, based on four criteria to establish a performance-related budget for 2016.

A.2 Synthesis of two most significant achievements

Rising use of — and dramatic benefits from — CGIAR wheat varieties. A global study by WHEAT on the impacts of international collaboration in wheat research during 1994-2014 found that CGIAR-derived varieties — nearly all traceable to CIMMYT and ICARDA breeding programs — covered more than 100 million hectares in 2014 and that the yearly value of the added grain produced ranged from $2.2 billion to $3.1 billion (in 2010 dollars) each year. With annual funding of $30 million, that represents a return of investment of between 73:1 and 103:1. More information is available under C.3. The World Bank also recently posted a blog, "Global wheat breeding returns billions in benefits but stable financing remains elusive," which describes outcomes of the impact study and the need for funding for global wheat productivity to grow, given rising demand and unstable markets.

Ethiopia: Wheat rising to demand and disease challenges. In a region where wheat faces deadly droughts and rapidly-evolving pathogens, concerted action and high-yielding, disease resistant varieties from WHEAT partners, along with supportive government policies and better cropping practices, have helped Ethiopia's wheat production to more than double in a decade, rising from 1.6 million tons in 2003-04 to around 3.9 million tons during 2013-15, representing a 6% p.a. yield growth, of which 2% was driven by area expansion (FAOSTAT). A key contribution has been CIMMYT and ICARDA's partnership with the Ethiopian Institute of Agricultural Research (EIAR) to develop, release, multiply, and spread seed of improved, disease resistant wheat varieties. To combat the continual rise of new,

virulent disease strains, seed of Kingbird, a wheat variety that resists the Ug99 and TKTTF stem rust strains, as well as yellow rust, septoria, and spot blotch, was fast-tracked for release and multiplication. By 2015, through the Durable Rust Resistance in Wheat (DRRW) project and its global development and testing pipeline, which includes the Kenya Agricultural & Livestock Research Organization (KALRO), 80 tons of Kingbird seed was available for farm demonstrations and scaling up. **Varieties and lines released by WHEAT partners** - 73 CGIAR-derived wheat lines in 2015 in 20 major wheat-producing nations – are listed in **Annex 2 (p. 26)**.

A.3 Financial summary, 2015 (US $ millions).

	As per PIA*	Budget**	Actual spent**	Spending on gender
W1&2 †	19.14	14.41	12.79	
W3	Part of bilateral	11.35	7.41	
Bilateral	29.29	19.16	15.27	
Total	48.43	44.91	35.46	5.14 (L-Series)

* Refers to the WHEAT Extension Period Proposal budget, incorporated into the Program Implementation Agreement (PIA) extension signed with the Consortium.

** These columns are based on L-Series reports and incorporate ICARDA decentralization funding (US $1.03 M).

† Refers to WHEAT-Management Committee endorsed W1&2 budget, ultimately US $13.5 M plus commitments from 2014, adding up to US $14.41 M.

The WHEAT-MC reviewed the 2015 budget three times between December 2014 and March 2015, as Consortium Financial Plans moved WHEAT from US $16.6 M to US $13.5 M. Specific consequences of W1&2 cuts are described throughout this report. See the *Financial Report* (p. 11), for more detail.

A.4 Gender

Gender norms and agricultural innovation. In 26 countries across Asia, Africa, and Latin America, a field study on gender norms and agricultural innovation known as GENNOVATE continues. GENNOVATE brings together 11 CGIAR Research. As of late 2015, fieldwork was competed in 48 villages in eight countries. For more information, see section D.

A.5 CRP governance and management

The WHEAT-Independent Steering Committee is led by an independent Chair (Tony Fischer) since December 2014, whilst Hans-Joachim Braun became CRP Director in January 2015.

The IEA-led External Evaluation of WHEAT (2014-15) stated that the "revised governance structure and processes (are) suitable for effectively implementing WHEAT and facilitating increased programmatic collaboration between CIMMYT, ICARDA and other partners …. will help promote greater authority and capacity of CRP director to manage for results; ensure that the CRP governance is free of conflicts of interest, thereby addressing issues of legitimacy and independence." The ISPC review of the WHEAT Phase II pre-proposal rated the Governance & Management content A (as one of 6 pre-proposals).

WHEAT communications. Key products included the quarterly WheatWire Newsletter sent to 300 stakeholders, with an average 30% open and 15% click rate; a revamp of the WHEAT website; and 25 stories published on http://wheat.org and other online channels. Initial efforts to better use social media are encouraging: the WHEAT Facebook page increased its follower base nearly 50% and is used primarily as a platform to share WHEAT and partner stories and discuss with our audience benefits and

landmarks in wheat research. CIMMYT ran an interactive campaign to shed light on the important role maize and wheat play in global nutrition and underline the dietary value of these food staples, linked to World Food Day on 16 October.

2015 prize for video outreach to farmers in Bangladesh. CIMMYT and the Bangladesh Agricultural Advisory Society (AAS) received a prestigious international Access Agriculture Award for more than 480 village and television screenings during 2012-14 of the Bangla language video "Save more, grow more, earn more," which introduces farmers to the use of small-scale agricultural machinery (two-wheeled tractors), to save fuel and labor, increase profits and reduce irrigation. A study on learning by farmers and other actors will appear in the *Journal of Agricultural Education and Extension* in 2016.

B. Impact pathway and intermediate development outcomes (IDOs)

WHEAT has aligned its CRP and FP impact pathways and theories of change in preparation for Phase II, contributing to 7 sub-IDOs and 6 cross-cutting sub-IDOs und the CGIAR-SRF's 14 IDOs and 3 System Level Outcomes (SLOs), thus linking to 7 Sustainable Development Goals (SDGs) and targets.

The completion rate on 2015 deliverables for projects under WHEAT was 86% of planned outputs (annual progress calculated over all projects reported), while reporting completion over Windows 1&2 funded projects was 92%. An overview of FP outputs delivering towards sub-IDOs and SLOs is provided in Annex 1.

During Phase I and the extension period (2012-16), the most upstream component of the **WHEAT up-/downstream research mix** was FP2. WHEAT categorizes its project portfolio into discovery, validation, and scaling-out research, hence all FPs incorporate some upstream research, including translating R&D partners' and other CRPs' upstream research into developing country contexts: FP3 scope includes research on faster and more precise approaches to breeding and adapting new methodologies to germplasm improvement. FP4 focuses on systems intensification and incorporates new approaches to multi-scale framework analysis at landscape level and innovations at the farm level, including remote-sensing-based farmer decision support, precision agriculture solutions. The scope of FP1 includes strategic gender research and impact assessment innovations, such as DNA fingerprinting to assess variety adoption.

WHEAT FP downstream R4D relies on cross-CRP collaboration and partnerships. Within FP1, the focus is on site-specific understanding of farmer adoption and impacts, as well as gender mainstreaming. FP2 focuses on validation and scaling-out of new knowledge and methods to WHEAT and other researchers. FP3 focuses on partnerships to involve farmers in improved variety selection, to facilitate greater adoption over time. Applied wheat quality research targets value chain participants and consumers. Innovation system approaches under FP4 validate a combination of solutions with first users and innovation networks to facilitate greater adoption. Under FP5, WHEAT participates in country coordination and multi-stakeholder practices at national and regional levels, co-leads seed system innovation projects and implements capacity development activities.

C. Progress along the impact pathway

C.1 Progress towards outputs (see also Annex 3)

FP1 -- Maximizing value for money and social inclusivity through prioritization of investments

WHEAT socioeconomics capacity has grown to planned levels with two new staff working on impact assessment and value chains and adoption.

Solving groundwater management challenges in Bangladesh. In the last two decades Bangladesh has been increasing groundwater accessibility for its farmers and attained near self-sufficiency in rice

production, with national output reaching over 15 million tons. A study published in *Water Resources Management* that analyzed the overuse of groundwater, declining water tables, deteriorating water quality, and increasing energy costs and carbon emissions concluded that, to avoid permanently damaging the water supply of Bangladesh, surface water sources and water conserving practices such as reduced tillage, raised bed planting, and use of water-use friendly crops must be adopted.

Fingerprinting to follow adoption in Ethiopia. The CIMMYT-led project "Mainstreaming the use and application of DNA fingerprinting in Ethiopia for tracking crop varieties" was officially approved for funding by the Bill & Melinda Gates Foundation at US $3.5 M over 4 years. To begin in mid-2016, work will track adoption of maize and wheat varieties and key traits, based on previous FP2/3 research.

FP2---Novel diversity & tools

Mobilizing seed bank diversity for wheat improvement. As part of Seeds of Discovery (SeeD), a recent study by a global team of researchers from CIMMYT, ICARDA, and the Global Crop Diversity Trust uncovered large, hereto undiscovered sources of wheat genetic diversity to address drought and rising temperatures. The team studied the molecular diversity of 1,423 spring bread wheat accessions that represent major global production environments, using high quality genotyping-by-sequencing (GBS) loci and gene-based markers for various adaptive and quality traits. They discovered thousands of new DNA marker variations in landraces known to be adapted to drought (1,273 novel GBS SNPs) and heat (4,473 novel GBS SNPs), opening the potential to enrich elite breeding lines with novel alleles for drought and heat tolerance. New allelic variation for vernalization and glutenin genes was also identified in 47 landraces from Afghanistan, India, Iran, Iraq, Pakistan, Turkmenistan, and Uzbekistan. In related SeeD work, a research team 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. Reported in *Nature Scientific Reports*, the study details critical genetic information about Mexican landraces for use in breeding to boost global wheat production. SeeD is funded by the Mexican Ministry of Agriculture and by the CGIAR Fund (MAIZE and WHEAT).

Cloning disease-resistance gene sheds light on new defense mechanism. Scientists have sequenced and described the wheat gene *Lr67*, which belongs to a group of three currently-known "magic" genes that help wheat to resist all three wheat rusts and powdery mildew, potentially saving billions of dollars in yearly grain losses and reducing the need for farmers to use costly fungicides, once the gene is bred into high-yielding varieties. This type of gene provides partial resistance, slowing — rather than totally stopping — disease development. A combination of partial resistance genes can provide wheat varieties with a strong, longer-lasting disease resistance, and constitutes a key pursuit of FP3.3. Published in *Nature Genetics*, the study involved scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), CIMMYT, Mexico's National Institute of Forestry, Agriculture, and Livestock Research (INIFAP), the Norwegian University of Life Sciences, the Chinese Academy of Agricultural Sciences (CAAS), and the University of Newcastle and the University of Sydney in Australia.

Global science team rescues rare wheat seed from the Fertile Crescent. Researchers at CIMMYT and ICARDA began restoring and genetically characterizing more than 30,000 unique seed collections of wheat from the ICARDA Syrian genebank. The team at CIMMYT has been sequencing DNA from as many as 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). ICARDA and CIMMYT will share seed and data from the project and make the results available worldwide. In March, scientists at ICARDA received

the Gregor Mendel Foundation Innovation Prize for courage in securing and preserving their seed collections at Svalbard and keeping the ICARDA genebank operational in Syria even amidst war. Click here to read the full story.

FP3---Global partnerships to accelerate genetic gain in farmers' fields

Global Phenotyping Platforms Network: WHEAT partners have progressed in expanding a global network of Precision Field-Based Wheat Phenotyping Platforms (PWPP) with co-investment of national agricultural research systems. The aim is to generate high-quality phenotypic data, essential for faster and superior varietal development and for maximizing the potential of new genotyping technologies. Each PWPP acts as a hub for generating and sharing data and knowledge on particular traits, building good protocols, and promoting linkages among national program partners, such as earlier access for partners to elite CGIAR lines and evaluation of nationally-developed lines. This new initiative relies on W1&2 funding and national co-investment. The W1&2 budget in the Extension Period Proposal was not achieved and decreased 2015/2016 funding will slow down network expansion to 15 partners. WHEAT-CRP/CIMMYT signed three partnership agreements with national systems in December 2014, subsequently undertaking initial evaluations, for the following platforms:

- **Septoria tritici blotch in durum wheat (Tunisia)**. Over 2,500 wheat accessions from CIMMYT (1,067 accessions), ICARDA (249 accessions), INRAT (365 accessions), INAT (272 accession), and CRRCG (540 accession), as well as materials for student research, were planted at Beja (CRRCGB experimental station, IRESA) and highly susceptible or resistant lines were identified. A consultative/training workshop organized in Tunisia in April resulted in recommendations to assure the precision and quality of data. Current research activities are carried out in collaboration with INRAT, INAT, CRRGB, and INGC; other institutions will be involved in 2016. Planting for 2015-16 was conducted at 3 locations with over 5,000 accessions of durum wheat. A lab is being set up and working groups defined and reviewed the research agenda and contributed to capacity development, thus strengthening linkages among national and international research programs.
- **Multi-disease (septoria leaf blotch, leaf rust, and Fusarium head blight; Uruguay)**. About 1,000 wheat accessions were evaluated under field conditions at INIA-Estanzuela, Uruguay, and tolerant and susceptible lines were identified. A field day in October marked the formal launch of the PWPP in the region and drew participants from INIA, CIMMYT, and public and private entities of Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay. There has been high interest for positioning this platform as part of a regional, multi-crop, precision-phenotyping collaboration.
- **Heat tolerance in spring wheat (Sudan).** Building on previous research by ICARDA and Sudan, more than 1,000 bread and durum wheat lines from 5 yield trials and 4 observation nurseries were phenotyped under heat stress at the Gezira Research Station Farm (GRSF), Agricultural Research Corporation (ARC), Sudan. Superior germplasm was selected and planted in a validation trial, together with new screening lines. Three young scientists (one female) were trained in a three-month course at CIMMYT. Equipment for precision phenotyping is expected to be purchased by ICARDA and sent to Sudan this season. The annual review and planning meetings were held at the Wad Medani experiment station in November.
- **Wheat blast (Bolivia).** First steps towards a partnership with the National Agricultural Research Institute in Bolivia (INIAF) were initiated in December. The urgency for action has since grown as blast disease, heretofore limited to South America, has apparently spread and caused damage in the 2015-16 crop in southwestern Bangladesh, a potentially disastrous threat to the major breadbaskets of South Asia.

A high-density GBS map of bread wheat and its application for dissecting complex disease resistance traits. In this study, researchers used genetic linkage mapping to construct a consensus map containing 28,644 GBS markers. Three RIL populations, PBW343 × Kingbird, PBW343 × Kenya Swara and PBW343 × Muu, which share a common parent, were used to minimize the impact of potential structural genomic variation on consensus-map quality. The consensus map was validated by comparing positions of known rust resistance genes, and comparing them to wheat reference genome sequences recently published by the International Wheat Genome Sequencing Consortium, Rye and *Ae. tauschii* genomes. Three well-characterized rust resistance genes (Sr58/Lr46/Yr29, Sr2/Yr30/Lr27, and Sr57/Lr34/Yr18) and 15 published QTLs for wheat rusts were validated with high resolution. Fifty-two per cent of GBS tags on the consensus map were successfully aligned through BLAST to the right chromosomes on the wheat reference genome sequence.

Durum wheat production in Pakistan: Keeping up with changing demands. In response to rapidly-changing food preferences in Pakistan, including a latent unmet demand for pasta products, CIMMYT-Pakistan has been working in a USAID-funded project to develop the country's durum wheat market, based on varieties that satisfy the required grain quality attributes, in addition to high yields and disease resistance. With rapid urbanization, demand for durum wheat products like macaroni or spaghetti is rising but farmers are not growing durum wheat because there is no clear price advantage or assured markets. At the same time, private investors will not develop new milling facilities or markets without guarantees of durum wheat grain supplies from farmers. To help break the "chicken vs egg" impasse, CIMMYT has been testing and evaluating 925 durum wheat accessions in Pakistan since 2011, and identified 40 durum wheat lines as having appropriate combinations of high yield, protein, yellowness, sedimentation, and disease resistance. The yield stability of lines across locations and years indicates that durum wheat could be grown in environments similar to those of the trial sites, increasing the chances for uptake of this new crop. The Center also led a 2014 durum value chain study involving 85 respondents including farmers, millers, the processing industry, restaurants, seed companies, grain dealers and consumers across five locations, to engage them in shaping future durum prospects.

Lines to varieties and seed awareness in Afghanistan. As part of ICARDA's work through the Community-based Livestock and Agriculture Project (CLAP) of the Afghan Ministry of Agriculture Irrigation and Livestock (MAIL) and CIMMYT-led efforts to build national breeding capacity, over 800 field demonstrations for improved wheat varieties (556) and combinations of wheat, mung bean, and lentil (255) were grown and visited by farmers, researchers and students in Kabul, Balkh, Herat, Logar, Nangarhar and Parwan Provinces. During field days, over 1,000 farmers could see for themselves the benefit of improved varieties, learnt about NRM practices and how to access high quality seed. Under CLAP, improved wheat varieties out-yielded local checks. The CIMMYT-led ACIAR-funded project conducted 122 yield evaluation trials involving a total of 1,167 wheat genotypes new to Afghanistan. A big challenge, outside the scope of current WHEAT projects, is improve the seed value chain and to replace still circulating, older, disease-susceptible varieties. The two bilaterally funded projects work together with the CRP on-Dryland Systems. Begun in 2014, CLAP is funded by the International Fund for Agriculture Development (IFAD). Click here for the full story on ICARDA's web page.

Bread-making quality in durum wheat analyzed. The effects of drought and heat stresses on grain morphology, grain composition, processing and pasta and bread-making quality in durum wheat varieties were analyzed and reported on in a study in *Field Crops Research*. The results revealed that there is genetic variability and potential in durum wheat for bread-making and that some durum wheat lines under drought or heat stress have the same quality for bread-making as traditional bread wheat. To develop durum wheat cultivars for bread wheat, it is necessary to achieve a better balance of

tenacity and extensibility. The development of durum lines with good bread-making quality could increase the commercial value of durum wheat.

Innovation in breeding: The Bill & Melinda Gates Foundation Review of the CIMMYT Breeding Program. To fairly examine strengths, weaknesses and opportunities of breeding programs worldwide that receive funding through the Bill & Melinda Gates Foundation (BMGF), a system referred to as the Plant Breeding Assessment Tool (BPAT) was established. The BPAT highlights strengths in breeding and program management and also identifies areas for strategic improvements. The BMGF used the BPAT to review the wheat breeding program at CIMMYT during March–April 2015. The review was positive and noted the strong foundations of the breeding program and CIMMYT's work, and suggested improvements in multi-disciplinary collaboration, strategic planning, and training of researchers to improve project management and budgeting skills.

FP4 -- Sustainable intensification of wheat-based cropping systems Sustainable wheat-based systems

Supporting sustainable and scalable changes in South Asia's wheat-based cropping systems. USAID and the Bill & Melinda Gates Foundation recently approved phase III of the Cereal Systems Initiative for South Asia (CSISA), running to November 2020. Building on the momentum and achievements of phases I and II, phase III will work to scale up innovations, strengthen local capacity and expand markets to support the widespread adoption of climate-resilient agricultural technologies, particularly in rice-wheat rotations grown on more than 13 million hectares in South Asia and which help feed the world's largest concentration of impoverished and food-insecure people, but whose wheat crops stand to lose 20% of their output due to rising temperatures by mid-century. CSISA fosters inter-CRP collaboration with CCAFS, GRiSP, PIM and Livestock&Fish and also works together with other bilaterally funded projects, such as the ACIAR-funded "Sustainable and resilient farming systems intensification in the eastern Gangetic Plains (SRFSI)" project, for example co-funding the First International course on Approaches for integrated analysis of agricultural systems in South Asia.

Long-term trials on conservation agriculture essential for assessing impacts. WHEAT research continued in 4 long-term experiments and 11 component technology trials in Mexico, as well as in Ethiopia, to determine the adaptive capacity and resilience of different management practices. The experiments focused on the principles of conservation agriculture: tillage practice, residue management and crop rotation. The component technology trials investigated the efficient use of nitrogen fertilizer, grass weed control, seed treatments, yield potential, sowing irrigation, and genotype by agronomic system interaction. In collaboration with national partners in Mexico, 4 experiments addressed the development and validation of conservation agriculture-based technologies for small grain-based farming systems under diverse conditions. As part of MasAgro and in collaboration with In collaboration with Mexico's Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV), scientists are investigating the effect of tillage, crop residue management, and crop rotation on bacterial community structure in contrasting wheat-based systems. The trials have provided a wealth of insights relevant to sustainable intensification, climate change adaptation and environmental stewardship. In 2015, four peer-reviewed publications were based on research associated with the long-term trials. Reliable and predictable funding is required to gain insights from the trials (see section C.3); W1&2 co-funding is essential.

Connecting bilateral projects on the ground. To broaden the systems perspective, WHEAT researchers linked the ACIAR-funded Farm Mechanization and Conservation Agriculture for Sustainable Intensification project (FACASI) activities in wheat-based farming systems in northern Ethiopia to the USAID-funded Africa RISING project, whose main goal is to sustainably intensify key African farming systems. Africa RISING works with 10 CGIAR centers as well as USAID's Feed the Future Initiative . For

more information, see this story on the ACIAR web page and this interview with the FACASI lead scientist.

FP5 -- Human and institutional capacities for seed systems and scaling-out

Building India's national capacity in conservation agriculture. Nearly 1.5 million hectares of arable cropland in India have been brought under conservation agriculture (CA). Outside of northwestern India, however, the concept remains relatively unfamiliar to farmers and extension personnel. During September 2015 the Cereal Systems Initiative for South Asia (CSISA) conducted an intensive CA training program at the Central Soil Salinity Research Institute (CSSRI) for researchers from the national agricultural research and extension systems. The program included hands-on training in use of the laser land leveler, turbo seeder, multi-crop planter, and mechanical transplanter, as well as visits to participatory and strategic trials and sites where agricultural implements are manufactured.

Impacts of wheat training in China. A study by the Center for Chinese Agricultural Policy showed that 350 Chinese researchers had taken part in CIMMYT wheat training programs since 1970, of which 15% were female during 1980-90, rising to 35% female during 2000-12. Since the 1990s, there was an increasing focus on young scientists. Of the total trained, 170 benefited from visiting scientist appointments at CIMMYT; many of the alumni now hold important positions in China's wheat research system.

C.2 Progress towards the achievement of outcomes (see also Annex 3)

Domestic production: a solution to Nigeria's wheat import 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. The improved wheat varieties produce 5-6 t/ha using optimal agronomic management, significantly more than the 1-2 t/ha average using traditional varieties and farmers' agronomic practices. Within the government's ATA Initiative, the project will help to generate an estimated 1.5 million tons of wheat, enough to cut Nigeria's wheat imports by as much 45%. Through the ATA Initiative, the Project is helping to expand the land devoted to wheat production from 70,000 ha to 300,000 ha in the coming five years. The impressive performance of improved varieties of high-yielding, heat-tolerant wheat is generating a policy shift in Nigeria. The SARD-SC Wheat initiative is pursuing similar activities in 11 countries throughout Sub-Saharan Africa.

Africa's rising demand for wheat: Trends, drivers, and policy implications. In this study by WHEAT partners and published in *Development Policy Review*, the authors point to rising incomes, growing populations, and increasing women's labor-force participation as key drivers of the rapidly-growing demand for wheat in Sub-Saharan Africa. Urban wheat-expenditure shares generally exceed rural ones and SSA's demand is met largely by imports and partly through domestic production on large-scale farms. Rising demand may therefore entail few farm/non-farm synergies and minimal prospects to spur broad-based economic development. The article concludes by discussing policy options for African countries to meet their staple food needs while also promoting pro-poor agricultural growth.

More certified seed needed in Pakistan. A study published in the *Journal of Crop Improvement* and involving data from 367 wheat farmers showed that access to certified seed varied by level of education, wealth and income, and access to machinery, and that bank credit and distance from seed stores also played major roles. In any case, farmers with access to certified seed achieved higher crop yields, higher income, and less poverty, and access to certified wheat seed must be increased to feed Pakistan's steadily growing population.

Wheat adoption/seed system survey, Ethiopia. With funding from the Durable Rust Resistance in Wheat (DRRW) initiative led by Cornell University, a 2014 survey conducted in 1,921 wheat-growing households (the same as those surveyed in a 2009/10 study) found widespread, rapid varietal turnover during 2009-2014. This was driven by a 2010/11 stripe rust outbreak and the TKTTF stem rust outbreak of 2013 and ensuing national and international efforts to develop and promote disease resistant varieties. The dominant varieties 'Kubsa' and 'Galema' had been quickly replaced by 'Kakaba', 'Danda'a', and 'Digelu' (the latter sown on 27% of survey area). Adopting new varieties provided farmers with a significant increase in their net incomes: from US $200 to $250/ha, on average, over four years. The survey highlighted that varietal change is indeed possible but that it had become urgent to replace 'Digelu', which features major single-gene resistance and is susceptible to TKTTF (as described in the lead story on Ethiopia, new disease resistant varieties are being developed and seed is being multiplied and distributed). Such impacts are based on a decade of germplasm improvement research and seed multiplication and deployment projects led by ICARDA and CIMMYT and with generous bilateral support. The final report will be published in 2016.

C.3 Progress towards impact (see also Annex 3)

FP1. Restoring cropland productivity and profitability in Northern Ethiopia. In work reported in *Experimental Agriculture*, a long-term experiment (2005-13) to measure the impacts of resource-conserving practices on runoff, soil loss, soil fertility and crop productivity and economic profitability in semi-arid wheat, teff, barley, and grass pea agri-food systems of northern Ethiopia found significant improvements in crop yields, rainwater conservation, and soil fertility, as well as enhanced profitability.

Wheat global impacts 1994-2014. Published by CIMMYT and WHEAT, this report shows that varieties on nearly half the world's wheat lands overall — as well as 70 to 80 percent of all wheat varieties released in our primary target regions (South Asia, Central and West Asia and North Africa) — are CGIAR related. Fully 63 percent of the varieties featured CGIAR genetic contributions, constituting either direct releases of CIMMYT and ICARDA breeding lines or having one of those lines as a parent or more distant ancestor. Yearly economic benefits of CGIAR wheat breeding research ranged from $2.2 to $3.1 billion (in 2010 dollars) and resulted from annual funding of just $30 million, excluding national program costs for wheat evaluation. This represents a benefit-cost ratio of between 73:1 and 103:1, a 'good bargain' international public good. In line with previous wheat impact studies, this report confirms the longstanding role of the global wheat improvement pipeline coordinated by CIMMYT and ICARDA, with support from WHEAT since 2012, as the national breeding programs' main source of new genetic variation for wheat yield increases, adaptation to climate change, and resistance to crop pests and diseases.

Yearly, 300+ partners in public and private breeding programs of nearly 100 countries demand more than 10 tons of seed of experimental lines from CIMMYT and ICARDA for testing and other adaptive research, in return for sharing their field-testing data. This global partnership (IWIN) continues to generate high returns from relatively modest investments, but requires consistent financial support, to continue to benefit wheat farmers and consumers via the partnerships under WHEAT along its impact pathway.

In WHEAT Phase II, DNA fingerprinting and other tools used by WHEAT national partners will improve the frequency and accuracy of adoption assessments. WHEAT, together with AFS-CRPs, will also better address the challenge of showing who along the wheat value chain benefited from adoption and how.

FP3. CGIAR-based wheat seed predominant in Morocco. A comprehensive wheat adoption, impact and seed system analysis in Morocco revealed that 17 INRA/ICARDA/CIMMYT varieties account for the vast majority of improved varieties on farmers' fields, with 82% of all farmers who adopt improved varieties

growing them. Also, their propensity to adopt improved varieties has gone up by 15% in the period under study. But overall, less than half (41%) of Moroccan wheat farmers have used improved varieties, even though those farmers who did have benefitted from higher yields (+49%) and income (+48%).

FP4. Zero-tillage, conservation agriculture, and precision land leveling in South Asia. A study published in *Experimental Agriculture* that examined input costs, net returns, and cost-benefit ratios for wheat production under conventional (CT) vs ZT in Haryana showed that farmers can save approximately US $79/ha and increase net revenues by about US $97/ha using ZT, with an average benefit-cost ratio under ZT of 1.43 vs 1.31 under CT. Finally, shifting to ZT for wheat reduced GHG emission by 1.5 Mg CO^2-eq /ha/ season. Adding evidence to the above in a study in conjunction with the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and reported in the *Journal of Integrative Agriculture*, research in the Indo-Gangetic Plains of India (a largely rice-wheat cropping zone) found that conservation agriculture systems (CA) substantially reduced production costs (up to 23%) with equal or superior yields to conventional cropping systems, while increasing profitability, moderating high temperatures (wheat canopy temperatures 1-4°C lower under CA), increasing irrigation water productivity 66–100%, and emitting 10–15% less GHGs. Finally, research reported in *Food Security* showed that a hectare of laser-leveled field in rice-wheat cropping systems (RW) required 754 kWh less electricity for irrigation per year, compared to a traditionally leveled field, and that if 50% of RW area in Haryana and Punjab states were laser leveled, this would provide an additional production of 699 million kg of rice and 987 million kg of wheat, amounting to US $385 million/year.

D. Gender research achievements

D.1 Selected gender research achievements

WHEAT carries on vital legacy of Paula Kantor. A tremendous setback to WHEAT gender initiatives was the tragic death in May 2015 of inspirational gender specialist Paula Kantor, hired just a few months before that to lead ambitious new work aimed at empowering and improving the livelihoods of women, men, and youth in wheat-growing areas of the developing world. Nonetheless, her legacy has gone forward in the broad project GENNOVATE (see A.4), wherein as of late 2015 case studies for wheat had been competed in 48 villages in Afghanistan (4), Bangladesh (6), Ethiopia (4), India (12), Morocco (3), Nepal (3), Pakistan (12), and Uzbekistan (4). Also in 2015, with funding from BMZ, WHEAT began work to explore how the differing roles and rights of women, men, and youth impact on wheat agriculture in Afghanistan, Pakistan and Ethiopia, with the aims of reducing rural poverty and enhancing food security by empowering disadvantaged groups, particularly poor women and youth. GENNOVATE is funded by the Bill & Melinda Gates Foundation, the government of Mexico, Germany's Federal Ministry for Economic Cooperation and Development (BMZ), the World Bank, and the CGIAR Consortium Office.

Farming in India not solely the domain of men. As part of GENNOVATE with funding from WHEAT and of activities in India under a CIMMYT-CCAFS-led project, researchers found that, contrary to commonly-held beliefs, women's participation in agriculture in India is rapidly increasing because of multiple factors, but especially as a result of out-migration of men in search of alternative incomes. The finding comes from a CIMMYT survey covering 1,022 households in Haryana (335), Bihar (357), and Madhya Pradesh (330). According to the study, women's share wheat production labor is lowest in Haryana and highest in Bihar. In Bihar and Madhya Pradesh, women are engaged mainly in seeding and applying fertilizer, while in Haryana and Bihar they take part in weeding and irrigation. Harvesting is an important activity for women in all three states. Findings suggest that extension services need to target entire families and that selection of communication channels to reach women – for example, mobile phone services in local languages – is crucial.

Adding new partners on gender. As part of the activities under the aforementioned BMZ-funded project "Understanding gender in wheat-based livelihoods for enhanced WHEAT R4D impact in Afghanistan, Pakistan and Ethiopia," partners have established collaboration with alternative R4D partners focusing on participatory gender and social research and development and strengthened the qualitative comparative research capacity of 43 local researchers (16 men and 27 women). Training for the latter covered the GENNOVATE methodology, which combines key informant interviews, sex-specific semi-structured focus group discussions, semi-structured individual innovation trajectory interviews, and life story interviews with women and men of different social groups and ages. The new partners include the Afghanistan Research and Evaluation Unit (AREU); Pakistan's Sustainable Development Policy Institute (SDPI) and Balochistan University of Information Technology, Engineering and Management Sciences (BUITEMS); and an International Development and Social Change Specialist in Ethiopia – strengthening WHEAT gender research capacity.

A revised version of the WHEAT gender strategy was endorsed by WHEAT-MC in December 2014 and approved by the Consortium Office in May 2015. Lessons learnt during Phase I and how they will be applied during Phase II are shown in the WHEAT Phase II Proposal on pp.19-22 and 132-134.

Gender performance self-assessment as per Annex 1, p.26: remains at "Approaching requirements."

E. Partnership building achievements

The WHEAT-MC manages a dedicated Partner Budget (see previous Annual Reports) to fund commissioned and competitive grants to non-CGIAR partners. It is a critical resource for innovation in partnerships, but also for inter-CRP/non-CGIAR initiatives such as BNI. Due to repeated W1&2 cuts, Partner Budget declined from 2.8 M (2014) to 1.12 M (2015), whilst having to sustain multi-year commitments.

E.1. Selected partnership-building achievements

USAID via CSISA rebuilding livelihoods: CIMMYT helps Nepal farmers recover from earthquake. In response to the April's devastating 7.6 magnitude earthquake, estimated to have affected 8 million people and particularly smallholder farmers in isolated hill regions, USAID-Nepal provided CSISA-Nepal with US $1 million for a 13-month Earthquake Recovery Support Program. Among other things, the initiative is providing damaged farm communities with 50,000 grain storage bags, 30 cocoons for community grain storage, 400 mini-tillers and other modern agriculture power tools, 800 sets of small agricultural hand tools, and 20,000 posters on better-bet agronomic practices.

FP1. Looking forward on wheat farming through "foresight." As part of WHEAT's participation in the Global Futures and Strategic Foresight (GFSF) project of the CGIAR Research Program on Policies, Institutions and Markets (PIM), a WHEAT Foresight Specialist has contributed to important partnerships. In work under the Partnership for Economic Policy (PEP), a grant from WHEAT, MAIZE, and PIM is supporting studies that use results from crop growth and general equilibrium models to assess the equilibrium effects of improvements in maize and wheat varieties in Kenya. With Wageningen University, a farm-level model for the economic and environmental effects of technology change was adapted and researchers are also using the Modular Applied GeNeral Equilibrium Tool (MAGNET) to model global impacts of wheat productivity improvements. Finally, by way of the Agricultural Model Intercomparison and Improvement Project (AgMIP), GFSF is collaborating with economic modeling groups worldwide.

FP3. Enhancing nutrient use efficiency in wheat. As part of the Wheat Initiative, researchers from CIMMYT, Rothamsted-UK, and INRA-France are coordinating the Expert Working Group on Nutrient Use Efficiency, which began in 2015 and includes the participation of scientists from Australia, China, France,

Germany, Italy, Mexico, Spain and the UK to evaluate and improve wheat physiological traits and management practices that affect the uptake and use of nitrogen and other soil nutrients.

FP4: USAID-funded CSISA-MI and EU-supported ANEP Bangladesh. The USAID-funded Cereal Systems Initiative for South Asia-Mechanisation and Irrigation (CSISA-MI) and the EU-supported Agriculture, Nutrition and Extension Project (ANEP) in Bangladesh produced five new farmer-focused videos in 2015 on efficient irrigation technologies, machine-aided line sowing, strip tillage, bed planting and mechanized harvesters. The videos contain comical but educational dramas with farmers as actors; they focus on practical messages on how to calibrate, use and maintain the machines, which are drawn by two-wheeled tractors, and describe how machinery service providers can make money by selling machine planting and harvesting services to farmers at a low cost.

Has setting up a CRP affected scientists' networks? The ILAC survey-based study of scientists' networks shows that CIMMYT (35) and ICARDA (11) scientists' (22% female) networks are quite diverse and quite intense (frequency of interaction): 432 links (collaborations) involve 407 individual collaborators from 228 distinct organizations, with a focus on Asia (40%), globally (27%) and Africa (23%). WHEAT collaborations have a clear, though not exclusive, research focus: most scientists' interactions were multi-purpose; e.g., for research, development (R4D), capacity development, advocacy and other goals. About a third of the collaborations were CRP-enabled.

Nearly 90% of interactions involved other CGIAR Center colleagues, ARI scientists and national programs, which fits the WHEAT impact pathway and theory of change. Under collaborations for capacity development, the second-strongest category is "facilitation of innovation platforms, research networks or multi-stakeholder dialogues," indicating that WHEAT invests important efforts in strengthening its impact pathway.

It was found that WHEAT features a very diverse research portfolio but with a limited range of partner types. More than half of all collaborations focus on breeding or pre-breeding research and genetic resource conservation. At the same time, the report found that WHEAT has stimulated a shift in collaboration towards biotechnology, plant sciences, seed systems, social science (including gender), and value chains. The study also noted the WHEAT-induced strengthening of links to other Centers and with downstream partners, as well as an increase in the number of intra-CGIAR collaborations, particularly that of ICARDA-CIMMYT. Over two-thirds of WHEAT collaborations are characterized by low or intermediate transaction costs with high or very high benefits, particularly those among CGIAR researchers. A few WHEAT-induced collaborations have high transaction costs with a greater share of high/very high benefits.

E.2 Strategic partnerships

One global CGIAR wheat program (CIMMYT-ICARDA). Based on the milestone plan approved by both Centers' Boards of Trustees, progress has been made in molecular marker collaboration and genotyping of ICARDA genebank accessions, as well as joint contributions to developing the Phase II proposal and joint engagement with Iran. Greater integration efforts are needed with regard to joint work planning as common practice and greater coordination of bilateral project development.

IWYP (International Wheat Yield Partnership) continued. The Science and Impact Executive Board of the International Wheat Yield Partnership (IWYP) selected the first set of research projects to recommend to its Funders for grant awards resulting from IWYP's First Competitive Call. Funders have committed to provide resources for eight selected projects to find and employ traits and genes to increase photosynthesis; genes to boost spike development; reducing respiration and thereby enhancing photosynthetic efficiency; optimizing canopy architecture to increase carbon capture and conserve nitrogen; using selected genes to increase biomass and yield; and optimizing phenology

leading to increased harvest index. Work will involve institutions and research teams from the United Kingdom, Australia, United States of America, Mexico, India, Argentina and Spain. The total value of the funded research is around US$20 million. Funding agencies include the Biotechnology and Biological Sciences Research Council of the UK (BBSRC), Grains Research and Development Corporation of Australia (GRDC), United States Agency for International Development (USAID), United States Department of Agriculture - Agricultural Research Service (USDA-ARS), Department of Biotechnology of India (DBT), Mexico's Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)and CGIAR through CIMMYT.

JIRCAS-CRPs: BNI Consortium. The Japan International Research Center for Agricultural Sciences (JIRCAS) JIRCAS hired a project manager for a consortium to research and develop wheat with biological nitrification inhibition (BNI), using genes for this trait from the perennial grass *Leymus racemosus.* The CRPs CCAFS, WHEAT, and Livestock and Fish are participating. WHEAT co-funds technical lab assistants on wheat-related research performed by JIRCAS. Backcrossing of *L. racemosus* x wheat synthetics is underway and translocation lines are being field testing. Other sources of BNI are being sought.

E.3 Interactions with other CRPs

CSISA Phase III relies on inter-CRP collaboration (see above), as does GENNOVATE (see sections A.4, D.1) and the BNI Consortium (above). Collaboration with the Dryland Systems CRP took place in Afghanistan, Pakistan (see p.8), and Central Asia.

F. Capacity building

Women in Triticum award winners reflect diversity and talent. Each year the Borlaug Global Rust Initiative recognizes early-career female scientists doing exemplary work to advance agricultural development in wheat with the "Jeanie Borlaug Laube Women in Triticum (WIT) Early Career Award." This year the award was presented to Philomin Juliana, India; Shideh Mojerlou, Iran; and Kerri Neugebauer and Kathryn Turner, USA. The award is aimed at encouraging the professional development of women in the early stages of their career. The WIT winners will attend training with CIMMYT wheat breeders in Ciudad Obregón, Mexico in 2016.

2015 Basic Wheat Improvement Course. The Basic Wheat Improvement Course is a three-month intensive program at the Campo Experimental Norman E. Borlaug in Ciudad Obregón, Sonora, Mexico that 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. During the 2015 Global Wheat Program Visitor's week, the six female trainees participated in a "Women in Agriculture" discussion with women from all departments of CIMMYT, led by Jeannie Borlaug-Laube, daughter of late Norman Borlaug. "Where I am from in Egypt, there are many women working in agriculture; they harvest, cook and grow," said 2015 BWIC trainee, Hoda Moustafa El Gharabawy during the Women in Agriculture discussion. "The women work so hard but, more times than not, men are preferred. That is why I wanted to participate in this training, to make a change for the women in agriculture."

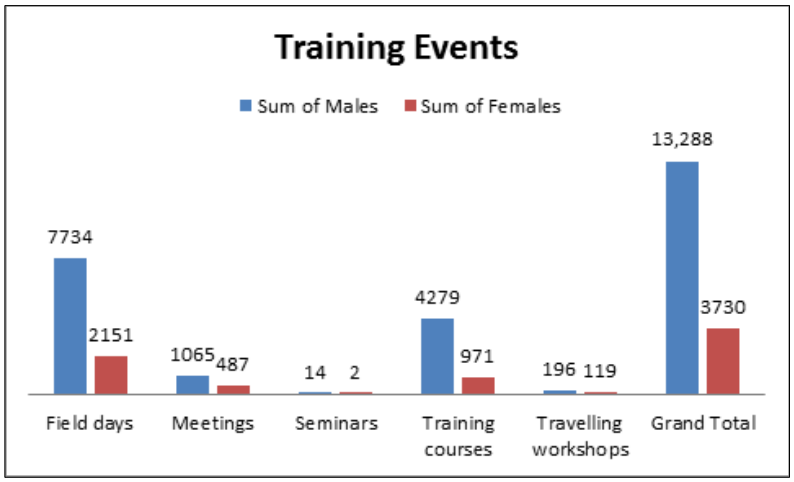
Capacity development, ICARDA. ICARDA hosted 168 trainees in 2015 who attended regional training courses and amongst them 48 were women (29%). Regional courses ranged from scientific management of field experiments to molecular breeding, crop improvement, rust resistant wheat varieties and seed technology, improving water productivity and gender mainstreaming amongst others involving more than 23 different nationalities. In addition to group courses, ICARDA held national training courses involving more than 1,230 trainees of which 759 (62%) were women, as well as on-site farm workshops,

study missions for students and individual non-degree training. A total of 39 students are enrolled under ICARDA co-supervision; 36 are PhD students and 5 MSc students, of which 54% are women.

Degree students and WHEAT overall. Over the years, a clear increase in training is evident as well as support for advanced degree students (see table below), a trend partially attributable to WHEAT investments in learning and capacity development in developing countries. As shown, 2015 was a peak year for training, a trend expected to continue in 2016 and subsequent years during WHEAT Phase II.

MSc and PhD Students trained (from developing countries, as listed)																			
		Year / Total																	
		2010	2010 Total	2014	2014 Total	2015		2015 Total	2016		2016 Total	2017		2017 Total	2018	2018 Total	2019	2019 Total	Grand Total
Country	Gender	Male		Male		Female	Male		Female	Male		Female	Male		Female		Female		
BANGLADESH									1		1								1
CHINA						4	1	5							1	1			6
COLOMBIA						1		1											1
ETHIOPIA						2		2					1	1					3
INDIA		1	1			2	3	5											6
IRAN							6	6		1	1								7
KENYA									1	1	2						1	1	3
MEXICO				1	1	2	4	6	2	3	5		1	1	1	1			14
TURKEY						1		1	1		1	1	1	2					4
Grand Total		**1**	**1**	**1**	**1**	**12**	**14**	**26**	**5**	**5**	**10**	**1**	**3**	**4**	**2**	**2**	**1**	**1**	**45**

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



G. Risk management

The WHEAT risk matrix identifies 10 CRP-specific risks under: Compliance (obligations to Consortium; partners don't deliver what they agreed to deliver), General Management (reputational), Change Management (high transaction costs intra-CGIAR), Financial (late payout of W1&2, need to pre-finance), Technology (loss of CRP-specific data).

With respect to the three major risks: (1) to address delayed transfer of W1&2 funds, which directly affects CRP research and development operations, WHEAT-MC opted for the worst case scenario 2015 budget, with a lowered Partner Budget; (2) in response to non-fulfilled obligations by the partners for commissioned and competitive grants, the CRP-PMU granted several no-cost extensions to ongoing grantees; and (3) owing to the lack of a systematic and integrated approach for monitoring and evaluation at the outcome level, the WHEAT Monitoring, Evaluation, and Learning (MEL) function has co-led inter-CRP efforts (MEL CoP) to address this challenge and improved CIMMYT and ICARDA internal tracking of scientists' outputs, through a Key Performance Indicator system.

H. Lessons learned (including monitoring CRP progress)

The need to increase the quality of project management and of monitoring and evaluation at both project and program levels was identified as a lesson learnt. CIMMYT will set up a dedicated project management cycle team in early 2016 and will initiate collaboration with ICARDA (WHEAT) and IITA (MAIZE) on aligning or harmonizing methodologies and tools.

Most scientists involved greatly appreciated the participatory approach to developing impact pathways and theories of change per FP. They noted that it raised their awareness of how research outputs, including international public goods, need to be developed with an impact pathway in mind and that a number research outcomes go undocumented. The challenge in 2016 is to develop methods to verify assumptions and better monitor progress towards the research and development (subIDO) outcomes that researchers identified. Inter-CRP and R&D partner collaboration would help enormously here.

Despite having to invest more time and effort than planned in influencing Phase II requirements and reviewing Phase II pre-proposal development, in its last two meetings (December 2014 and September 2015), the WHEAT-ISC focused more on strategic direction issues, such as the definition and scope of systems research and the linkages between WHEAT and the Genebanks Platform during Phase II, as well as WHEAT scope for taking on nutrition and health issues in developing countries, including obesity. For more detail on discussions and outcomes, see the ISC meeting minutes.

For lessons learnt on partnerships, in terms of WHEAT scientists' networks, please see section E.1.

H.1 Level of confidence of the response to the key performance indicators

The information reported in Annex 1 is obtained from detailed data found in a variety of sources, including project technical reports and institutional databases. WHEAT is confident about the quality of the indicator information, but will continue to improve the systematic approach to collecting quantitative evidence and other types of performance or progress data across the WHEAT project portfolio, to improve the process and time required to collect and analyze the information.

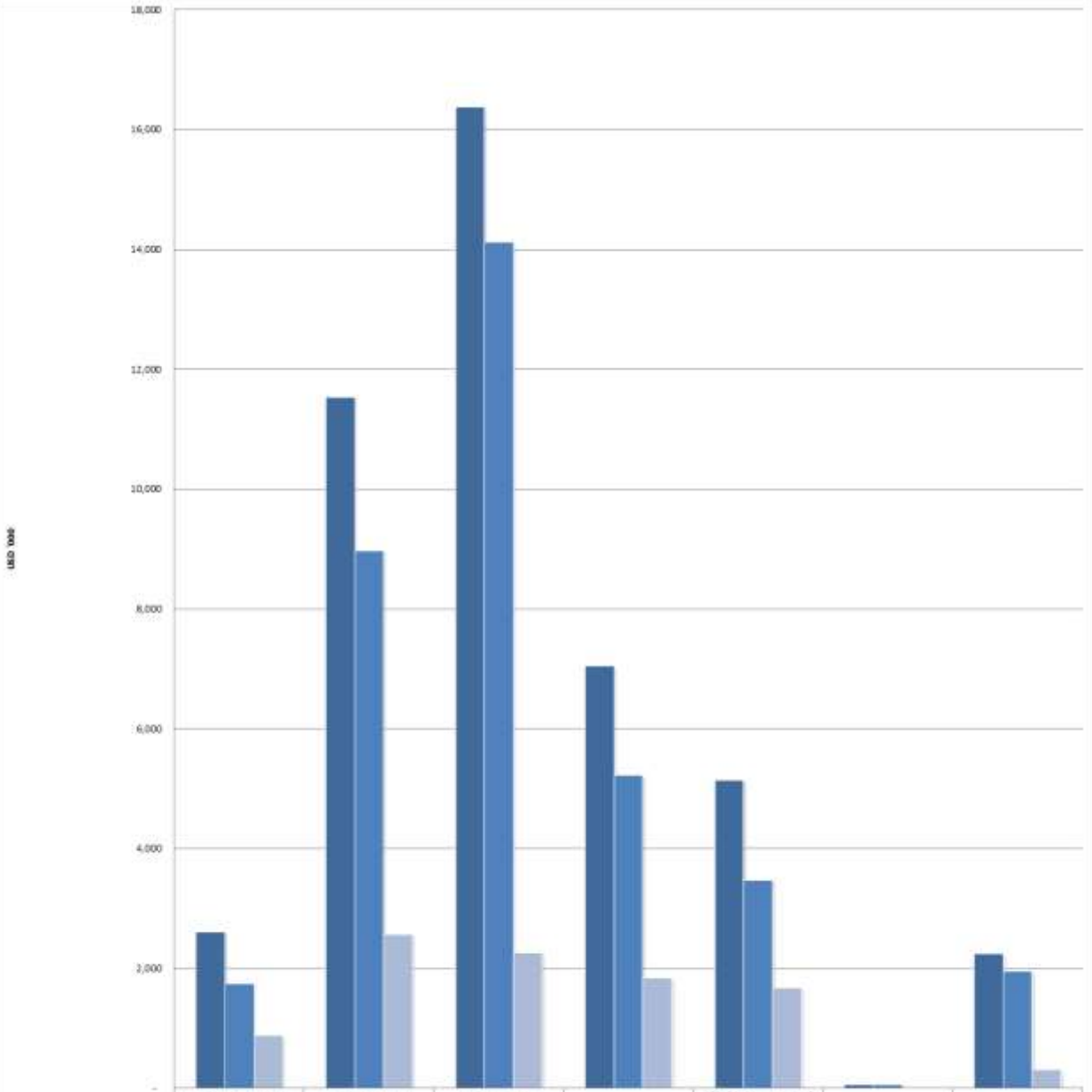
WHEAT has contributed to and actively continues to support inter-CRP efforts to develop a harmonized approach for monitoring development outcomes (IDOs, sub-IDOs). Progress has been slow because of a lack of dedicated resources, the voluntary nature of the activity, the complexity of the task, and competing CRP priorities.

H.2 Unintended results and innovative initiatives

There were no unintended results.

Part II: Financial report

Figure 1. Summary report by Flagship Project, 2015 (US $ 000).



	Flagship 1 - Maximizing value for money, social inclusivity thru prioritizing WHEAT R4D investments	Flagship 2 - Novel diversity and tools to adapt to climate change and resource constraints	Flagship 3 - Global partnership to accelerate genetic gain in farmers field	Flagship 4 - Sustainable intensification of wheat-based cropping systems	Flagship 5 - Human and institutional capacities for seed systems and scaling-out; a new generation of wheat scientists	Infrastructure Budget (ICARDA)	CRP Management/Coordination
POWB Approved	2,594	11,515	16,360	7,035	5,122	54	2,233
Current Year Actual Expenditures	1,730	8,956	14,108	5,207	3,465	54	1,942
Unspent Budget	864	2,559	2,252	1,828	1,657	-	291

Figure 2. Financial summary by natural classification (US $ 000).

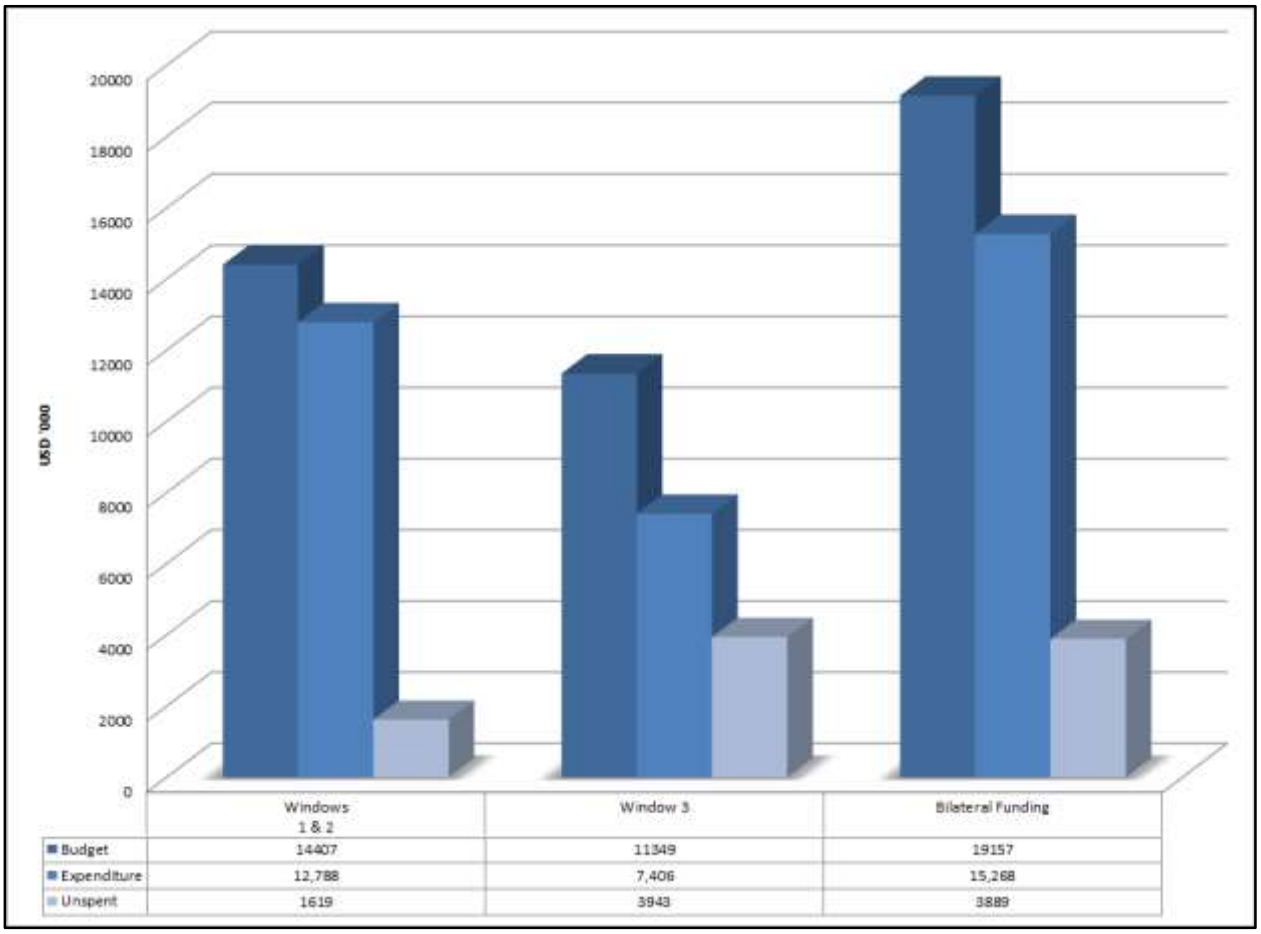
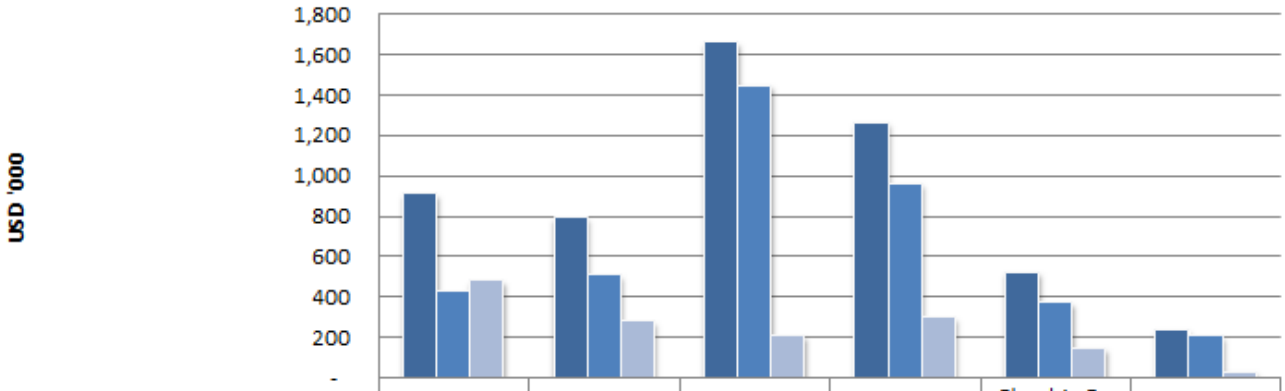


Figure 3. Gender summary by Flagship Project, 2015 (US $ 000; counts funding for gender components in all projects**).**



	Flagship 1 - Maximizing value for money, social inclusivity thru prioritizing WHEAT R4D investments	Flagship 2 - Novel diversity and tools to adapt to climate change and resource constraints	Flagship 3 - Global partnership to accelerate genetic gain in farmers field	Flagship 4 - Sustainable intensification of wheat-based cropping systems	Flagship 5 - Human and institutional capacities for seed systems and scaling-out; a new generation of wheat scientists	CRP Management/Coordination
POWB Approved	914	796	1,665	1,268	528	243
Current Year Actual Expenditures	431	512	1,452	965	377	209
Unspent Budget	483	284	213	303	151	34

Figure 4. Top ten WHEAT donors.

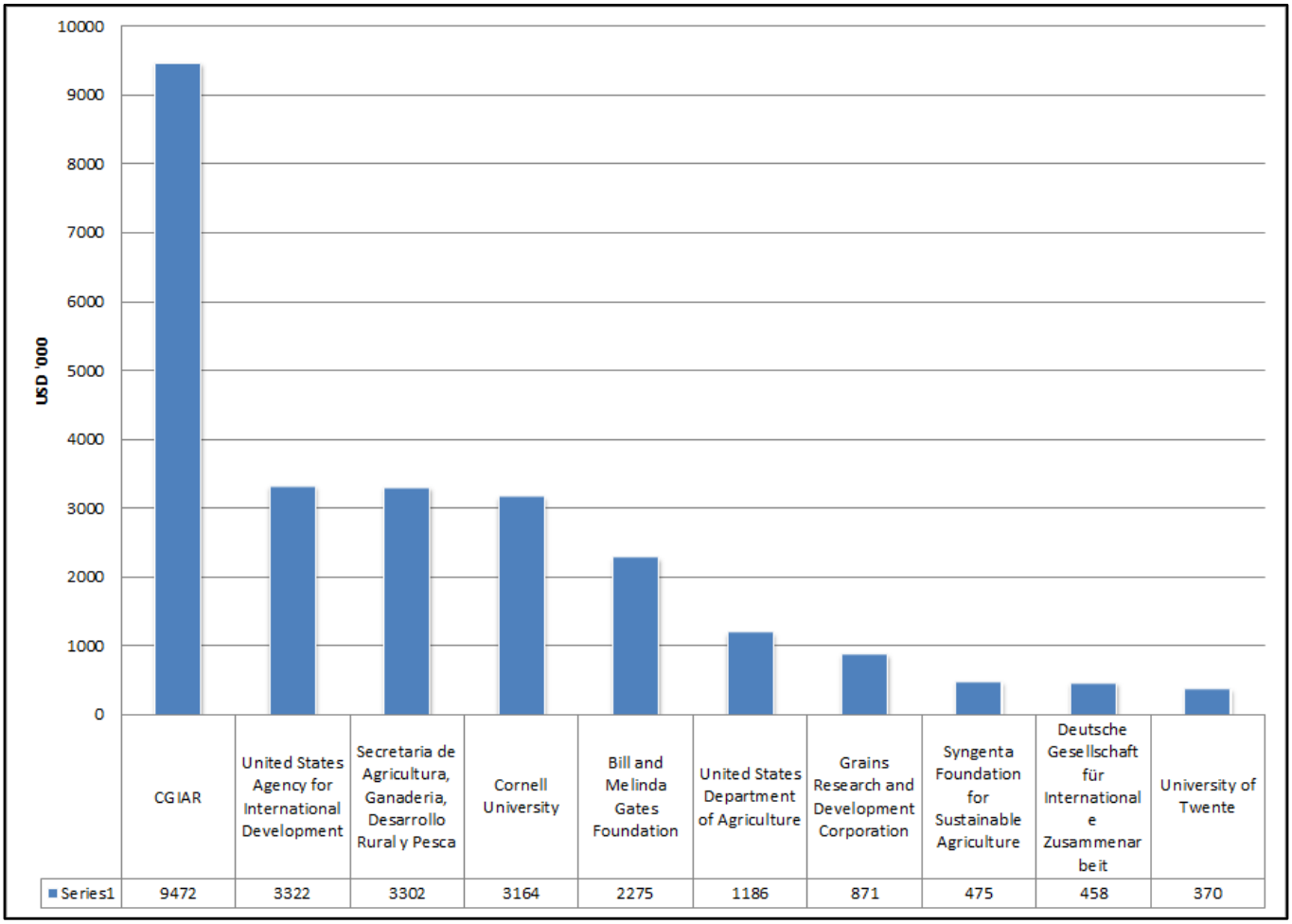


Table 1. WHEAT partnership report, 2015 (actual expenses, US $ 000).

Institute Name	Country	Windows 1 & 2	Window 3	Bilateral	TOTAL
INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS	ARAB REPUBLIC	-	-	-	-
INTERNATIONAL RICE RESEARCH INSTITUTE	PHILIPPINES	-	1,005	-	**1,005**
ETHIOPIAN INSTITUTE OF AGRICULTURAL RESEARCH (EIAR)	ETHIOPIA	-	709	27	**736**
INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE	USA	-	405	-	**405**
Others	Others	304	14	40	**358**
PAKISTAN AGRICULTURE RESEARCH CENTER	PAKISTAN	-	-	214	**214**
UNIVERSITY OF FLORIDA	USA	170	-	-	**170**
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE	KENYA	-	135	-	**135**
DIRECTORATE OF WHEAT RESEARCH (SECRETARY ICAR)	NULL	-	-	129	**129**
UT BATELLE LLC	USA	-	120	-	**120**
World Resources Institute	USA	-	-	111	**111**
INSTITUTO NACIONAL DE INVESTIGACIONES FORESTALES, AGRICOLAS Y PECUARIAS	Mexico	33	-	71	**104**
Wharton Private Equity Partners	USA	-	-	97	**97**
Nepal Agricutural Research Council	Nepal	-	-	77	**77**
INSTITUT DE RECERCA I TECNOLOGIA AGROALIMENTARIES	SPAIN	-	66	-	**66**
TAGEM	TURKEY	-	62	-	**62**
CIRAD	Mexico	60	-	-	**60**
UNIVERSIDAD AUSTRAL DE CHILE	Mexico	-	-	55	**55**
		52	184	429	**665**
Agricultural Research Center	Sudan		14	229	**243**
Ethiopian Institute Of Agricultural Research	Ethiopia			113	**113**
Lake Chad Research Institute	Nigeria			75	**75**
National Institute of Biotechnology & Genetic Engineering	Pakistan			70	**70**
The National Institute for of Agricultural Research	Morocco		21	48	**69**
		58	175	577	**810**
		677	**2,910**	**2,362**	**5,949**

Annex 1. Indicators of progress in 2015.

The Traffic Light Indication sums up the progress achieved of projects under WHEAT, per Flagship Project in 2015, regardless of their funding (Windows 1/2/3 or bilaterally funded). It monitors the progress per Cluster of Activity, per Flagship Project, and for the CRP as a whole. (Please note per-CoA completion is not specifically referenced here due to structural shifts in 2015.)

Flagship Projects (as of 2015 – *note 2016 recent changes***)**	**SI Performance** (aggregation of progress towards all CoAs/FPs – weighted average)
FP1 Maximizing value for money, social inclusivity	**82.1 %**
FP2 Novel diversity and tools	**87.1 %**
FP3 Global partnership to accelerate genetic gain	**86.7 %**
FP4 Sustainable intensification	**87.0 %**
FP5 Human and institutional capacities	**88.5 %**
CoAs 2./3.6 & 2./3.7 (forming part of FPs 2 & 3)	**84.1 %**
Total weighted average - CRP performance	**85.9 %**

CRP indicators of progress, with glossary and targets.

#	CRPs concerned by this indicator	Indicators	Glossary & Comments	Deviation narrative (if actual is more than 10% away from target)	2012		2013		2014		2015			
					Target	Actual	Target	Actual	Target	TOTAL	Target	CIMMYT Actual	ICARDA Actual	TOTAL
KNOWLEDGE, TOOLS, DATA														
1	All	1. Number of flagship "products" produced by CRP	Glossary: These are frameworks and concepts ... they should be likely to change the way stakeholders along the impact pathway allocate resources and/or implement activities .. change the way these stakeholders think and act. For the CRP WHEAT, each Flagship Project is a flagship "product.	Following a standardization of CRP structures, the WHEAT strategy was reorganized around five Flagship Projects (FPs) in 2014, encompassing the nine Strategic Initiatives of the original WHEAT proposal		10	10	10	5	5	5			5
2	All	2. % of flagship products produced that have explicit target of women farmers/NRM managers	Included in FPs: FP1 - Maximizing value for money, social inclusivity through prioritizing WHEAT R4D FP3 - Partnership to accelerate genetic gain in farmers field FP4 - Sustainable intensification FP5 - Human and institutional capacities, scaling out and up	Following a standardization of CRP structures, the WHEAT strategy was reorganized around five Flagship Projects (FPs) in 2014, encompassing the nine Strategic Initiatives of the original WHEAT proposal		3	3	4	4	4	4			5
3	All	3. % of flagship products produced that have been assessed for likely gender-disaggregated impact	Included in FPs: FP1 - Maximizing value for money, social inclusivity through prioritizing WHEAT R4D FP3 - Partnership to accelerate genetic gain in farmers field FP4 - Sustainable intensification FP5 - Human and institutional capacities, scaling out and up	Following a standardization of CRP structures, the WHEAT strategy was reorganized around five Flagship Projects (FPs) in 2014, encompassing the nine Strategic Initiatives of the original WHEAT proposal			10	10 of which 2 more in-depth	4	4	4			5
4	All	4. Number of "tools" produced by CRP	Glossary: These are significant decision-support tools, guidelines, training manuals, software, and/or videos; significant in that they should be likely to change the way stakeholders along the impact pathway allocate resources and/or implement activities	Given that the scope for "tools" includes CIMMYT book chapters, figures are significantly higher than last year		327 (16 co-developed with other CRPs)	522 changed to 25	23 (17 co-developed with other CRPs)	20	39	25	151	11	162
5	All	5. % of tools with explicit target of women farmers	Tools target men and women users equally											
6	All	6. % of tools assessed for likely gender-disaggregated impact	Tools are not assessed individually but at flagship product level											
7	All	7. Number of open access databases maintained by CRP	Wheat Doctor, Wheat Atlas, Rusttracker, IWYP.org, Germinate Wheat, GRIS Wheatpedigree.net, Cereal Knowledge Bank, Institutional Multimedia Publications Repository, Institutional Research Data and Software Repository			5	5	8	To be reviewed	11	5	9	1	10
8	All	8. Total number of users of these open access databases	Unique visitors					124,450	54,767	119,832	125,000	112,278	117	112393
9	All	9. Number of publications in ISI journals produced by CRP				121 (18 with other CRPs)	121	121 (23 jointly with other CRPs)		107	120	153	14	167
10	1,2,3, 4, 6	10. Number of strategic value chains analyzed by CRP				5	5	4	2	10	5	8	2	10
11	1,3,6,7	11. Number of targeted agro-ecosystems analysed/characterised by CRP												
12	1,3,6,7	12. Estimated population of above-mentioned agro-ecosystems												

CRP indicators of progress, with glossary and targets (cont'd).

#	CRPs concerned by this indicator	Indicators	Glossary & Comments	Deviation narrative (if actual is more than 10% away from target)	2012		2013		2014		2015			
					Target	Actual	Target	Actual	Target	TOTAL	Target	CIMMYT Actual	ICARDA Actual	TOTAL
CAPACITY ENHANCEMENT AND INNOVATION PLATFORMS														
13	All	13. Number of trainees in short-term programs facilitated by CRP (male)	From CIMMYT Training database, plus Competitive Partner Grants and ICARDA Short-term = < 90 days			18,220 (14,144 shared with ther CRPs)	16,415	14,232 (171 with other CRPs)	17,000	4,088	3,000	42,337	3,051	45,388
14	All	14. Number of trainees in short-term programs facilitated by CRP (female)	From CIMMYT Training database, plus Competitive Partner Grants and ICARDA Short-term = < 90 days			4,888	5,226	1,068 (73 with other CRPs)	To be reviewed	1,069	1,000	13,237	385	13,622
15	All	15. Number of trainees in long-term programs facilitated by CRP (male)	From CIMMYT Training database, plus Competitive Partner Grants and ICARDA Long-term = > 90 days			30	40	121 (7 with other CRPs)	To be reviewed	44	24	78	10	88
16	All	16.Number of trainees in long-term programs facilitated by CRP (female)	From CIMMYT Training database, plus Competitive Partner Grants and ICARDA Long-term = >90 days			19	23	85 (4 with other CRPs)	To be reviewed	36	24	45	12	57
17	1,5,6,7	17. Number of multi-stakeholder R4D innovation platforms established for the targeted agro-ecosystems by the CRPs	LA-8, SA-42, Af-31			38	43	45	50	50	45	101		101
TECHNOLOGIES/PRACTICES IN VARIOUS STAGES OF DEVELOPMENT														
18	All	18. Number of technologies/NRM practices under research in the CRP (Phase I)				265,730	260,000	124,517		200,005	120,000	271,177	51,392	322569
19	All	19. % of technologies under research that have an explicit target of women farmers												
20	All	20. % of technologies under research that have been assessed for likely gender-disaggregated impact												
21	1,5,6,7	21 Number of agro-ecosystems for which CRP has identified feasible approaches for improving ecosystem services and for establishing positive incentives for farmers to improve ecosystem functions as per CRP's recommends												
22	1,5,6,7	22. Number of people who will potentially benefit from plans, once finalised, for the scaling up of strategies												
23	All, except 2	23. Number of technologies /NRM practices field tested (phase II)				34,850	2,600	2600		2151	1,000	1,873	1,726	3,599
24	1,5,6,7	24. Number of agro-ecosystems for which innovations (technologies, policies, practices, integrative approaches) and options for improvement at system level have been developed and are being field tested (Phase II)												
25	1,5,6,7	25. % of above innovations/approaches/ options targeted at decreasing inequality between men and women												
26	1,5,6,7	26. Number of published research outputs from CRP utilised in targeted agro-ecosystems												
27	All, except 2	27.Number of technologies/NRM practices released by public and private sector partners globally (phase III)				50	50	46	50	24	50	59	14	73

CRP indicators of progress, with glossary and targets (cont'd).

#	CRPs concerned by this indicator	Indicators	Glossary & Comments	Deviation narrative (if actual is more than 10% away from target)	2012		2013		2014		2015			
					Target	Actual	Target	Actual	Target	TOTAL	Target	CIMMYT Actual	ICARDA Actual	TOTAL
POLICIES IN VARIOUS STAGES OF DEVELOPMENT														
28	All	28. Numbers of Policies/ Regulations/ Administrative Procedures Analyzed (Stage 1)				3	2	6	2	8	2	2	7	9
29	All	29. Number of policies / regulations / administrative procedures drafted and presented for public/stakeholder consultation (Stage 2)				3	1			3	1	3	3	6
30	All	30. Number of policies / regulations / administrative procedures presented for legislation (Stage 3)				0	0	1	1	1	1	2	1	3
31	All	31. Number of policies / regulations / administrative procedures prepared passed/approved (Stage 4)								1	1	2	1	3
32	All	32. Number of policies / regulations / administrative procedures passed for which implementation has begun (Stage 5)								0	1	3	1	4
OUTCOMES ON THE GROUND														
33	All	33. Number of hectares under improved technologies or management practices as a result of CRP research	WHEAT is the main provider for wheat germplasm in developing countries. Documenting annual impacts from the CRP is difficult because varieties are released continuously. Using data from 44 countries that together produce 99% of the developing world's wheat, a global study on impacts from the adoption and use of CGIAR WHEAT germplasm during 1994-2014 (Lantican et al. 2016) showed that 50% of all varieties released are CGIAR-derived and that these are grown on around 70 M ha in developing countries, with significant spillover in developed countries, with yearly economic benefits conservatively estimated at between US $2.4 and 3.2 billion [1970]. Given significant differences among countries for variety replacement rates and using an average replacement rate of 10 years and a total of 70 M farm households that benefit (average farm size of 1 ha), the average number of farmers using new varieties is 7 M. Many of these farmers have also adopted improved agronomy technologies or mechanized production; the number who benefit from those technologies is aggregated into the number of germplasm beneficiaries to avoid double counting. Data on beneficiaries of specific technologies by country are available from WHEAT.			1,500,000	1,650,000	1,650,000		4,845,000	1,815,000	6,250,000	750,000	7,000,000
34	All	34. Number of farmers and others who have applied new technologies or management practices as a result of CRP research	[See also explanation in the cell above] In the primary WHEAT target regions (Asia, N-Africa, SSA, Mexico), more than 50% of all varieties released are CGIAR introductions and a further 25% have a CGIAR parent. The figures provided here refer to adoption of recently released (2011-13) varieties, which are still in the scaling-up phase. Data are based on information from Afghanistan, Algeria, Armenia, Azerbaijan, Bangladesh, Bhutan, China, Egypt, Ethiopia, Georgia, India, Iran, Kazakhstan, Kenya, Kyrgyzstan, Mexico, Morocco, Nepal, Nigeria, Pakistan, Rwanda, Sudan, Tajikistan, Tunisia, Turkey, and Uzbekistan, and combine impact from varieties and management practices and refer to adoption of technologies during 2011-15, greatly underestimating total impact.			1,650,000	2,802,000	2,802,000		10,310,000	3,082,200	6,250,000	750,000	7,000,000

Performance Indicator	CRP performance approaches requirements	CRP performance meets requirements	CRP performance exceeds requirements
1. Gender inequality targets defined	Sex-disaggregated social data is being collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations	Sex-disaggregated social data collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations And The CRP has defined and collected baseline data on the main dimensions of gender inequality in the CRP's main target populations relevant to its expected outcomes (IDOs)	Sex-disaggregated social data collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations And The CRP has defined and collected baseline data on the main dimensions of gender inequality in the CRP's main target populations relevant to its expected outcomes (IDOs) And CRP targets changes in levels of gender inequality to which the CRP is or plans to contribute, with related numbers of men and women beneficiaries in main target populations
2. Institutional architecture for integration of gender is in place	- CRP scientists and managers with responsibility for gender in the CRP's outputs are appointed, have written TORS. - Procedures defined to report use of available diagnostic or baseline knowledge on gender routinely for assessment of the gender equality implications of the CRP's flagship research products as per the Gender Strategy -CRP M&E system has protocol for tracking progress on integration of gender in research	- CRP scientists and managers with responsibility for gender in the CRP's outputs are appointed, have written TORS and funds allocated to support their interaction. - Procedures defined to report use of available diagnostic or baseline knowledge on gender routinely for assessment of the gender equality implications of the CRP's flagship research products as per the Gender Strategy -CRP M&E system has protocol for tracking progress on integration of gender in research And A CRP plan approved for capacity development in gender analysis	CRP scientists and managers with responsibility for gender in the CRP's outputs are appointed, have written TORS and funds allocated to support their interaction. - Procedures defined to report use of available diagnostic or baseline knowledge on gender routinely for assessment of the gender equality implications of the CRP's flagship research products as per the Gender Strategy -CRP M&E system has protocol for tracking progress on integration of gender in research And A CRP plan approved for capacity development in gender analysis And The CRP uses feedback provided by its M&E system to improve its integration of gender into research

Annex 2: Varieties released by national authorities, in 2015, based on CGIAR lines

Total varieties released	73
Countries in developing world	20
CIMMYT	56
ICARDA	12
TCI	5
Bread wheat	54
Durum wheat	18
TCL	1

TCL 1

Country	Origin	NAME OF CULTIVAR	SPS	PEDIGREE/PARENTAGE
Afghanistan	CIM	Afghan-15	T. aestivum	WHEAR//2*PRL/2*PASTOR
Afghanistan	CIM	Bahar-15	T. aestivum	CAL/NH//567.71/3/SWRI/4/CAL/NH//. . .
Afghanistan	CIM	Elhaam-15	T. aestivum	STARSHINA
Afghanistan	CIM	Lalmi-15	T. aestivum	MTRWA92.161/PRINIA/5/SERI*3….
Afghanistan	CIM	Wafer-15	T. aestivum	BABAX/LR42//BABAX*2/3/TUKURU
Afghanistan	CIM	Wahdat-15	T. aestivum	KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ
Algeria	ICA	Beni Mestina	T. durum	LAHN/CHAM12003
Algeria	ICA	SIGUS	T. durum	TER1/3/STJ3//BCR/LKS4
Azerbaijan	CIM	Gunashli	T. aestivum	NEE/SUB//SAANINE/ALD
Bhutan	CIM	Bumthang Kaa Drukchu	T. aestivum	Danphe#1
China	CIM	Chuanmai 104	T. aestivum	Chuanmai 104/B2183,
China	CIM	Chuanmai 68,	T. aestivum	99-1572/98-266/01-3570
China	CIM	Chuanmai 81	T. aestivum	SW8019/99-1572//99-1572,
China	CIM	Chuanmai 92,	T. aestivum	Neimai 8/Jian 3//Chuanmai 42,
China	CIM	Demai 8	T. aestivum	Yinxuan 11-12/882-191//Demai 3,
China	CIM	Guohaomai 3	T. aestivum	1227-185/99-1522//99-1572
China	CIM	Mianmai 285	T. aestivum	1275-1/99-1522,
China	CIM	Wenmai 14	T. aestivum	Yunmai 39/Yunmai 42,
Ethiopia	ICA	Amibara (Doukkala-4)	T. aestivum	SHUHA-8/DUCULA
Ethiopia	ICA	Dambal	T. aestivum	AGUILAL/3/PYN/BAU//MILAN= AGUILAL/FLAG-3
Ethiopia	ICA	Fentale (Moontij-3)	T. aestivum	FERROUG-2/FOW-2

Ethiopia	CIM	Kingbird	T. aestivum	TAM-200/TUI/6/PAVON-76//CAR-422/ANAHUAC-75/5/BOBWHITE/CROW//BUCKBUCK/PAVON-76/3/YECORA-70/4/TRAP-1
Ethiopia	ICA	Obora	T. aestivum	UTIQUE96/FLAG-1
Ethiopia	ICA	UTUBA	T. durum	Omruf1/Stojocri2/3/1718/BeadWheat24//Karim
India	CIM	DBW 107	T. aestivum	TUKURU/INQLAB
India	CIM	DBW 110	T. aestivum	KIRITAT/4/2*SERI*2/3/KAUZ*2/BOW//KAUZ
India	CIM	DBW 93	T. aestivum	WHEAR/TUKURU/WHEAR
India	CIM	HD 4728	T. durum	
India	CIM	Pusa Kiran (HS 542)	T. aestivum	MILAN/KAUZ//PRINIA/3/BABAX
India	CIM	Pusa Vatsala (HD 3118)	T. aestivum	ATTILA*2/PBW65//WBLL1*2/TUKUR
India	CIM	UAS 347	T. aestivum	(TOB/ERA/TOB/CNO67/#/PLO/$/VEE#5/5/KAUZ/6/FRET2)/DWR162
India	CIM	WH 1142	T. aestivum	CHENAEGILOPS SQUARROSA(TAUS)//FCT/3/2*WEAVER
Iran	CIM	Baharan	T. aestivum	KAUZ/PASTOR//PBW343
Iran	CIM	Mehrgan	T. aestivum	OASIS/SKAUZ//4*BCN/3/2*PASTOR
Iran	ICA	Shush	T. Durum	CBRD-3/STORK X DICOCCOIDES
Kenya	CIM	R1271	T. aestivum	PBW343*2/KUKUNA*2//YANAC
Kenya	CIM	R1306	T. aestivum	KSW/5/2*ALTAR 84/AE.SQUARROSA (221)//3*BORL95/3/URES/JUN//KAUZ/4/WBLL1
Kenya	CIM	R1310	T. aestivum	KFA/5/REH/HARE//2*BCN/3/CROC_1/AE.SQUARROSA (213)//PGO/4/HUITES/6/REH/HARE//2*BCN/3/CROC_1/AE.SQUARROSA (213)//PGO/4/HUITES
Kyrgyzstan	TCI	Azhara	T. aestivum	VORONA/TR810200=Kalyoz 19
Mexico	CIM	BACOREHUIS F2015	T. aestivum	ROLF07*2/5/REH/HARE//2*BCN/3/CROC1/AE.SQUARROSA(213)//PGO/4/HUITES
Mexico	CIM	BAROBAMPO C2015	T. durum	TRN//21563/AA/3/BD2080/4/BD2339/5/RASCON_37/TARRO_2//RASCON_37/6/AUK/GUIL//GREEN
Mexico	CIM	CONASIST C2015	T. durum	GODRIN/GUTROS//DUKEM/3/THKNEE_11/4/DUKEM_1//PATKA_7/YAZI_1/3/PATKA_7/YAZI_1/5/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/3/ADAMAR
Mexico	CIM	CONATRIGO F2015	T. aestivum	THELIN/2*WBLL1
Nepal	CIM	Danphe	T. aestivum	KRITATI//2*PBW 65/2*SERI.1B (Ug99 Res.)
Nepal	CIM	Tilottima	T. aestivum	WAXING*2/ VIVITSI (Ug99 Res.)
Nigeria	ICA	LACRIWHIT-7	T. aestivum	CROW'S'/BOW'S'-3-1994/95//TEVEE'S'/TADINIA

Nigeria	ICA	LACRIWHIT-8	T. aestivum	REYNA-15 = CHAM4/SHUHA'S'/6/2*SAKER/5/RBS/ANZA/3/KVZ/HYS//YMH/TOB/4/BOW'S"
Pakistan	CIM	Pakhtunkhwa-15	T. aestivum	WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ
Pakistan	CIM	Pirsabak-15	T. aestivum	MILAN/S87230//BABAX
Pakistan	ICA	Shalkot-14*	T. aestivum	Babagha-10=TRACHA'S'//CMH76-252/PVN'S'
Pakistan	CIM	Ujala-2016	T. aestivum	KIRITATI/4/2*WEAVER/TSC//WEAVER/3/WEAVER
South Africa	CIM	SSD8113	T. durum	
S Africa	CIM	SSD8124	T. durum	
S Africa	CIM	SSD8133	T. durum	
S Africa	CIM	SSD8143	T. durum	
S Africa	CIM	SSD8154	T. durum	
Spain	CIM	DON ORTEGA	T. durum	
Spain	CIM	VICTORIOSO	TCL	
SUDAN	ICA	Berghouata1	T. durum	Ter1//Mrf1/Stj2
Tajikistan	TCI	Faizbakhsh	T. aestivum	TAM200/KAUZ
Tajikistan	CIM	Isfara	T. aestivum	SW89.5181/KAUZ
Tajikistan	CIM	IZ-80	T. aestivum	KAUZ/CHEN//BEN/3/MILAN
Tajikistan	TCI	Mohi nav	T. aestivum	Selection from Atay
Tajikistan	TCI	Shokiri	T. aestivum	SHARK/F4105W2.1
Tajikistan	CIM	Vahdat	T. aestivum	VORONA SN079
Tunisia	CIM	INRAT 100	T. durum	MÂALI/8/GREEN_2/HIMAN_12//SHIP_1/7/ECO/CMH76A.722//BIT/3/ALTAR 84/4/AJAIA_2/5/KJOVE_1/6/MALMUK_1/SERRATOR_1/9/SELIM/5/SULA/AAZ_5//CHEN/ALTAR 84/3/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1
Turkey	CIM	Altınöz	T. aestivum	OASIS/SKAUZ//4*BCN/3/2*PASTOR
Turkey	CIM	AYZER	T. durum	BCRIS/BICUM//LLARETA INIA/3/DUKEM_12/2*RASCON_21
Turkey	CIM	Candidate-12	T. aestivum	SAUAL/YANAC//SAUAL
Turkey	CIM	EKER	T. durum	TRN//21563/AA/3/BD2080/4/BD2339/5/RASCON_37/TARRO_2//RASCON_37/6/AUK/GUIL//GREEN
Turkey	CIM	HASANBEY	T. durum	AVILLO_1/SNITAN
Turkey	TCI	METIN	T. aestivum	HATUSHA/MTG//TX81V6614
Turkey	CIM	Nusrat	T. aestivum	MILAN/6/KAUZ*2/4/CAR//KAL/BB/3/NAC/5/KAUZ

Annex 3: Further 2015 outputs- and outcomes-related stories with links to further information

Outputs

FP1. Socioeconomics support to CSISA. Findings from a study by the International Food Policy Research Institute (IFPRI), in collaboration with the CIMMYT-led multi-CRP Cereal Systems Initiative for South Asia (CSISA), regarding the economic and environmental trade-offs associated with subsidies for laser land levelers in eastern Uttar Pradesh, have provided state and local governments with alternative strategies for improving the efficiency and impact of subsidies.

FP2. Scientists harness genetics to develop more "solar"- and structurally-productive wheat. The International Wheat Yield Partnership (IWYP) recommended about US $20 million in grants from funders for 8 research projects by leading institutes, to increase wheat's photosynthetic and energy-use efficiency and to harness the genetics behind key components of yield. In early outcomes, IWYP partners are finding evidence that higher biomass drives improvements in photosynthetic capacity and efficiency. Combined with improved plant architecture, this can make wheat more productive. The Partnership aims to raise the genetic yield potential by up to 50% over the next 20 years.

First study of synthetic wheat performance under heat stress. A study published in *Crop Science* showed for the first time that, under three different temperature scenarios in the field (non-stress, heat-stress, and late- or extreme heat), lines derived from synthetic hexaploid wheat out-yielded their synthetic derivative parent by an average 13% under extreme heat conditions and 5% under non-stress conditions, underlining the value of synthetics as a source of heat tolerance traits such as higher crop growth rate, increased water-soluble carbohydrate storage in stems, cooler canopy temperature, optimal pigment composition, photo-protective mechanisms, and radiation use efficiency.

Surveys/collections, wheat landraces: Turkey, Tajikistan, Uzbekistan. Surveys and collecting of landraces in collaboration with FAO were completed and final reports will be published by FAO in early 2016. A genomic diversity study for Turkey bread wheat landraces was carried out and a core subset established; an association mapping study is pending. A core subset for durum wheat landraces will be created in 2016/17. Characterization and genomic diversity analyses for all collections are scheduled for 2016, in part through a project contracted with the International Treaty on Plant Genetic Resources for Food and Agriculture. Among other things, outcomes of this work will drive on-farm wheat diversity and will be applied in a new project to help farm communities adapt to climate change.

FP3. Inheritance study and fine mapping of a bread wheat spot blotch disease resistance QTL. (Study published in *Molecular Breeding)*. The wheat QTL QSb.bhu-5B, which determines resistance to spot blotch, was mapped to an interval of 0.62 cM on chromosome arm 5BL via the analysis of a recombinant inbred line population bred from a cross between 'YS116' and 'Sonalika.' Lines tested from F_3 to F_5 were inoculated in the field with *Bipolaris sorokiniana* over three consecutive seasons and disease responses recorded. In the present population, QSb.bhu-5B, which is flanked by the SSR loci Xgwm639 (0.28 cM) and Xgwm1043, behaved as a single Mendelian gene designated as *Sb2,* and Xgwm1043 and Xgwm639 were shown to serve as effective markers. This research was funded by a WHEAT Partner budget competitive grant.

A genomic selection index applied to simulated and real data. In this paper in *G3-Genes-Genomes-Genetics*, WHEAT scientists developed the theory of a genomic selection index (GSI) and applied it to two simulated and four real data sets with four traits. They numerically compared its efficiency with that of the phenotypic selection index (PSI) by using the ratio of the GSI response over the PSI response, and the PSI and GSI expected genetic gain per selection cycle for observed and unobserved traits, respectively. In addition, they used the Technow inequality to compare GSI vs. PSI efficiency. Results from the simulated data were confirmed by the real data, indicating that GSI was more efficient than PSI per unit of time.

FP4. Spurring a Transformation for Agriculture through Remote Sensing (STARS) progress. STARS is a research project led by the University of Twente in the Netherlands to look for ways to use remote sensing technology to improve agricultural practices in Sub-Saharan Africa and South Asia. Through a multi-partnership of private and public institutions, regional experiment cases are executed on the ground by ICRISAT, UMD and CIMMYT, while overarching research is being done at CSIRO. Challenges such as unproductive soil, plant diseases, pests and drought, have forced STARS to look at the problems on a national level and help the countries and national programs to address these issues. CIMMYT also ran on-farm experiments in northwestern Mexico on precision agriculture and remote sensing for yield and grain quality spatial variability, to improve crop management and remote sensing to schedule irrigation. Technology includes hyperspectral and thermal sensors onboard a manned aircraft as well as a GreenSeeker sensor connected to a GPS and mounted on a motorbike.

Capacity building in Pakistan. International training courses were held across the globe on a wide variety of subjects in 2015. In Pakistan, CIMMYT organized a one-day training session and on-farm demonstration in March on participatory wheat variety selection, during which nine newly released, high yielding, rust resistant wheat varieties were introduced to smallholders in the 13 districts of Baluchistan Province, Pakistan. The training sessions allowed 30 farmers, wheat breeders, seed companies and federal seed inspectors to interact and evaluate their roles in the wheat seed value chain. In addition, the Wheat Productivity Enhancement Program (WPEP) in Pakistan, led by CIMMYT and funded by USDA, held the first Wheat Improvement Training Course in Pakistan for 20 early- and mid-career scientists and Ph.D. scholars from across the country.

Outcomes

Making the case for conservation agriculture in Iraq. Funded by the Australian Government through the Australian Center for International Agricultural Research (ACIAR) until the end of 2014, ICARDA researchers educated farmers in Iraq about the benefits of CA. Perceptions of the values of traditional farming were challenged through demonstrations on research stations and on farmer fields. Seminars, short-term courses, six-month research fellowships, on-the-job training and study tours were delivered to over 700 Iraqi scientists and extension specialists. Through their efforts, CA area now exceeds 15,000 ha in Iraq and Iraqi farmers achieved average yield increases of 160 kg/ha and earned an additional US $100/ha.

Kenya wheat breeders win the 2015 BGRI Gene Stewardship Award. Plant pathologist, Ruth Wanyera and wheat breeders, Godwin Macharia and Peter Njau of the Kenya Agriculture and Livestock Research Organization (KALRO) received the 2015 Gene Stewardship Award at the Borlaug Global Rust Initiative Workshop (BGRI) in Sydney, Australia for their contribution to the fight against Ug99. The team has facilitated the testing of wheat lines from all over the world, screening close to 400,000 accessions since the project started in 2008. Through the work of the KALRO team, 7 new varieties that yield 30-40% more, contributing to an increase average wheat yields in Kenya from 2.4 to 3.0 t/ha have been released in the last 5 years.

Impacts

FP3. Genome-wide association for grain yield in historical Pakistan wheat cultivars. Most modern Pakistan wheat cultivars come from CIMMYT breeding lines and during 1961-2013 average wheat yields in Pakistan rose nearly 500% from 0.8 to 3.8 tons per hectare thanks largely to wheat breeding research. Genome-wide association studies using 123 historical wheat cultivars of Pakistan under rain-fed conditions found higher frequencies of alleles for the yield-related traits of earlier maturity, shorter plants, and larger grain---as well as for grain yield overall---in cultivars released after 2000. Involving researchers from Pakistan, China, and CIMMYT, the study included 10 cultivars that pre-dated the Green Revolution, 23 Green Revolution releases (1960-79), 45 releases from 1980-2000, and 45 cultivars released during 2000-14. Among other things, the results will facilitate molecular-marker-assisted

breeding for the favorable alleles identified, as well as eventual cloning and use of specific yield-related genes.

FP4. Zero-till wheat raises farmers' incomes in Eastern India and Syria. In a study published in *Food Security*, WHEAT researchers reported that wheat farmer's total annual income increased by 6% on average with the introduction of zero tillage (ZT) in Bihar, a state characterized by high population density, resource-poor farmers vulnerable to climate change risks, and the lowest average wheat yields in the Indo-Gangetic Plains (2.14 tons per hectare). Findings showed that the prevailing zero-tillage practice, even without full residue retention, has led to an average yield gain of 498 kilograms per hectare (19%) over conventional tillage wheat. For more detail and accounts of other studies on zero tillage and conservation agriculture in South Asia, see section C.3. In Syria, research reported in the *Journal of Agricultural Economics* showed that ZT adoption drove net crop income gains and greater wheat consumption per person.

RESEARCH
PROGRAM ON
Wheat