2017 Delivering Genetic Gain in Wheat Annual Report

Progress and Results

ADVOCACY

We made good progress communicating DGGW outputs and impacts to internal and external audiences, partnering more closely with 1) CIMMYT to promote activities in breeding and surveillance and the new threat of wheat blast in Bangladesh, 2) Sathguru to promote the seed systems initiative in Nepal, and 3) DFID to announce their $10.5M support of the DGGW initiative in Jan 2017. For the DFID announcement, we updated 10 social media cards highlighting impact, branded with DFID and BMGF logos, that were then used by DFID on their social media channels, and project leaders Coffman and Acevedo in PowerPoint presentations to audiences around the globe. We responded to BMGF and DFID needs for impact metrics. We produced 20 videos, available on YouTube, (a complete list is in Appendix C). We put the SAARC course online in a Canvas course, and, in partnership with EIAR, helped format and provide photos for Getaneh Woldeab's (Ethiopia) "Protocols for Wheat Stem Rust Race Analysis" publication, which will be posted online with video in 2018. In 2015, we worked with a science documentary film crew based in Berlin, Hoppenhaus & Grunze Media, to direct them to contacts for a documentary on Ug99. In 2017, their six-part *Food Fight* series examining the scourge of Ug99 was released in Germany, and will be released for an English-speaking audience on the online UNDARK magazine, in 2018. In Nov 2017, we covered a meeting in Ethiopia with wheat leaders from CIMMYT, ICARDA and DGGW to evaluate progress, increase efficiencies and eliminate redundancies; more stories / video from that trip are being produced by C. Knight and L. McCandless, using footage generated by a Reuters-Ethiopia videographer from Addis that we hired for the occasion. We got the most media mileage/global coverage [see complete list in Appendix C] out of surveillance stories about rust outbreaks in Sicily, Italy, Morocco, Scandinavian countries, Germany and Yemen, largely generated by Dave Hodson through his Rusttracker web portal. Over 20 media stories resulted, and significant engagement was made with various journalists resulting in news coverage, including high profile media such as Nature, Reuters and Nature Middle East. By hiring S.Hautea in IP-CALS in Aug 2016 and using some % of her time to do social media across all projects, we have been able to leverage content and increase ROI across all IP-CALS Gates/DFID projects (see #2, below). We generated Wheat is Science and Take it to the Farmer hashtag campaigns in conjunction with the international "March for Science" on April 22, 2017, co-promoted with Alliance for Science, and will look for more opportunities for social media campaigns in 2018. The fact that we are truly a global initiative is reflected by the geographies of our audiences on our social media platforms; in Facebook, our top 5 are India, USA, Kenya, Bhutan and Pakistan; in YouTube, the top 5 are India, USA, Pakistan, Canada & UK.

SURVEILLANCE

There was continued expansion and strengthening of the Global Rust Monitoring System during the reporting period. With 30,629 published geo-referenced survey records, the Wheat Rust Toolbox database increasingly represents one of the most comprehensive and valuable data resources for crop diseases. Survey teams from 20 countries, including (new this year) Italy, Ecuador and Russian Federation, have contributed standardized survey data. The SAARC survey app and tool box were updated for recording wheat blast.

To maintain and enhance the information platform and core databases for tracking and monitoring key wheat diseases, an Open Data Kit (ODK) based survey tool was developed and tested and used in Turkey, Kenya, Ethiopia, and Tanzania. Data were transferred automatically into the Kobotoolbox platform and then transferred in the Wheat Rust Toolbox within 2-3 days of survey. In Ethiopia, data were collected in real-time and monitored while the survey team was still in the field.

A new DataBase (DB) structure has been implemented enabling the management and display of dead (D) sample data. New tools, maps and charts are now available for the display of yellow rust genetic lineages and races on separate maps and charts. Similar DB and tools are ready for stem rust D samples from USDA-CDL. Preview of surveillance, genotypic and race data on maps and charts in draft version now available within the Toolbox based on experiences from the MLN Toolbox. Common upload procedures have been developed and automatic upload of survey, race and genetic data is now possible.

The RustTracker web portal was used to published significant caution updates around the risk of stem rust in the Mediterranean Basin, the re-emergence of stem rust in Sweden and the detection of a new significant race (RRTTF) in Ecuador. Over 20 media stories relating to rust issues were included in the Rustracker web portal. Significant engagement was made with journalists from different media outlets. This resulted in news coverage picked up by several media outlets, including *Nature*, Reuters and *Nature Middle East.*

A fully functional, generic rust survey app has been developed using ODK. This has been incorporated into training events and was used successfully in Tanzania and Ethiopia. In South Asia the Rust Survey App developed by Sathguru was successfully deployed and used in Bangladesh, Bhutan, India and Nepal.

Direct in-country technical support and training was provided in Ethiopia, Kenya, Nepal, India, Turkey and Russian Federation. In addition financial survey support was given to Bhutan, Nepal, Kenya, Tanzania, Morocco, Georgia, Azerbaijan, Iraq, Uzbekistan. In all countries, surveys were completed successfully and data incorporated into the Wheat Rust Toolbox / RustTracker.

Barberry Surveillance Monitoring and sampling of barberry bushes was conducted in Kenya and Ethiopia, Kyrgyzstan, and Kazakhstan. Samples were shipped to USDA-MN for characterization. All samples will be genotyped (viable or not). Race typing will be performed for viable samples in year 3. The USDA-ARS Cereal Disease Lab (CDL) derived about 20 isolates from 2014 aecial collections from Ethiopia. Confirmed phenotypic tests were carried out on 12 isolates in two winter seasons (2015-16, and 2016-17) and obtained 10 races. CDL will continue characterizing other isolates during this season. *B. thunbergii* reference genome was scaffolded. Genetic linkage maps completed for both parental species (using GBS markers. PGT resistance mapped in a population of F1 hybrids. A transcriptome was assembled for *B. thunbergii* from a library of 13 tissues, and annotation of the contigs in the QTL region is currently underway to identify candidate genes. Diagnostic markers to distinguish two barberry species and their hybrid were successfully developed via a low-cost, reference-independent GBS pipeline.

Pathogen characterization. A total of 335 wheat stem rust samples collected in 2016 from five countries were analyzed at the Cereal Disease Laboratory in winter 2017. Kenya sent 99 samples to AAFC in October of 2016. There were 23 viable isolates typed to race. Eritrea sent 52 samples to Agriculture & Agri Food Canada (AAFC) in October of 2017, and Kenya sent 72 samples to AAFC in November of 2017. Race pathotyping of isolates from Kenya and Eritrea is in progress at the Morden lab. A total of 238 wheat stem rust samples were received at the Aarhus Rust Reference Center from 10 countries in Africa and Asia. 199 of these were recovered and generally sub-cultured for single pustule development, spore multiplication and race typing. By date of reporting, race typing has been completed for 139 isolates, while results for 26 are awaiting final confirmation. In addition, 250 wheat yellow rust samples were received from 12 countries in Africa and Asia. By date of reporting, a total of 98 were genotyped and a subset of 19 of these were additionally race typed.

Cereal Rust Biosafety Laboratory at Regional Cereal Rust Research in Izmir, Turkey, became operational and the testing phase was completed using the local wheat rust samples from Turkey. A glasshouse was constructed for race typing of local races outside the biocontainment facilities and evaluation of seedling resistance in wheat and barley germplasms using local races. During the 2017 rust survey in the Aegean region of Turkey, 70 yellow rust samples were collected from 8 sites in Aegean region, Adana, and Eskisehir of which 40 samples were recovered and used to inoculate yellow rust differential sets.

Collections of *Puccinia triticina* (wheat leaf rust pathogen) from Hungary and Morocco from 2017 were sent to the USDA-ARS CDL for race identification. Viability of the collections from both countries was poor. Single uredinial isolates from each collection are currently being increased, and then will be tested on a host differential of 24 near-isogenic lines of Thatcher wheat that differ for single leaf rust resistance genes. Collections of leaf rust from Ethiopia, North Africa, and the Middle East were solicited, however collections from these countries and regions were not sent in 2017. Collections from Kazakhstan from 2017 will be also typed for race identification in 2018. In Turkey, preliminary results showed high level of pathogenic diversity among 40 leaf rust samples collected during the rust survey. Remaining rust samples will be used for race typing.

A total of 426 stem rust samples were received by EIAR, Ambo PPRC during the 2016/17 cropping season. A total of 279 stem rust samples were collected in 2017 main cropping season from Oromia, Tigray and Amhara regions. Of these 18 samples are analyzed so far.

Stem rust race analysis in Ethiopia. Twenty young researchers from 10 centers were trained on phenotyping of wheat and race analysis of stripe, leaf and stem rusts. Capacity for leaf rust race analysis is being developed at Debre Zeit with technical backstopping and support from CIMMYT. More than 20 leaf rust isolates maintained in the greenhouse at Debre Zeit. Additional field collections were undertaken on main season surveys. Capacity for yellow rust race analysis is being developed at Kulumsa with technical backstopping and support from CIMMYT. More than 30 yellow rust isolates (representing varietal and regional diversity) maintained in the greenhouse at Kulumsa.

Stem rust molecular diagnostics. Molecular analysis of D samples continued. Given the increased importance of non-Ug99 RG (clade I) analysis, a core SNP assay is now used for analysis of all D-samples. This core SNP assay is able to distinguish between the major clades and sub-clades currently found in Africa, Central Asia, Europe and North America. A new Database structure, management and display tools are now ready for upload of D samples from USDA-CDL. It is expected that data will be available before 31/12 2017.

Advanced warning of vulnerability to emerging rust races. CIMMYT breeding lines (250 durum and 300 bread wheat) were assessed at the seedling stage with multiple races of the stem rust pathogen. A total of 703 and 232 advanced wheat breeding lines from KALRO and EIAR, respectively, were assessed with six virulent Pgt races at the seedling stage. For 206 of the breeding lines from Kenya and all lines from Ethiopia, seedling tests were supplemented with molecular marker assays linked to stem rust resistance genes including *Sr2*, *Sr57* (*Lr34*), Sr24, *Sr25*, *Sr26*, *Sr31*, *Sr38*, and *Sr1RSamigo*. The phenotypic and genotypic data informed gene postulations for the material. These data are useful for advancing wheat lines that possess adult plant resistance (field resistant, but not seedling resistant) OR wheat lines that possess combinations of major stem rust resistance genes (very few lines identified). The work highlighted the broad-spectrum susceptibility of Kenyan and Ethiopian germplasm to race TTKTT (Ug99 +*Sr24* virulence + *SrTmp* virulence). Seventy-one released varieties from Ethiopia were sent to CDL for molecular marker screens and seedling testing.

BREEDING PIPELINE

Spring Wheat. We maintained large-scale breeding activities, above the target, in Mexico and Kenya during the reporting period. Phenotyping for resistance to diseases and end-use quality analysis for 1474 lines, retained from 1st year yield trials, conducted during the reporting period. Seed multiplication at Mexicali 2016-17 season and El Batan 2017 seasons of elite candidate lines for inclusion in various international nurseries and trials. Quality analysis for the 2nd year for 568 elite wheat lines promoted to international nurseries 51stIBWSN and 36thSAWSN in El Batan 2017 season. Preparation of all international trials and screening nurseries for worldwide growing seasons 2017-18 and 2018 completed and seed shipped/under shipment to collaborators. Seed preparation and completion of sowing of breeding materials at various stages of development in Obregon and Mexicali for 2017-18 crop seasons.

Yield trials**.** Using the 3-year performance data for grain yield in diverse environments and various other traits, 45 entries were selected with expected superior performance in irrigated environments. These entries and checks were used in preparing 180 sets of the international yield trials 38thESWYT. Distribution is underway for growing at >170 sites in 2017-2018 and 2018 wheat seasons by multiple partners in over 30 countries. Entries showing superior performance are retained by National partners for further testing and some are likely to be released as varieties in the future. A total of 45 entries with expected superior performance were also selected for

semi-arid environments. These entries and checks were used in preparing 160 sets of 25thSAWYT and distribution is underway for growing at >150 sites in 2017-2018 and 2018 wheat seasons by multiple partners in over 30 countries. A total of 45 entries with expected superior performance in heat stressed environments were selected. These entries and checks were used in preparing 140 sets of international yield trial 16thHTWYT and distribution is underway for growing at >130 sites in 2017-2018 wheat seasons by multiple partners in over 30 countries. Using two years multi-environment grain yield, agronomic, disease resistance and end-use quality data, 45 entries with red grains were selected to form 90 sets of international yield trial 26thHRWYT. These are the only trials that have red grain entries and serve partners in areas where wheat matures with possibility of rains (red grains are resistant to sprouting). Distribution for 25thHRWYT completed for growing at >70 sites in 2017 and 2017-2018 wheat seasons by multiple partners in over 25 countries and the distribution of 26thHRWYT for countries planting wheat during March-June will initiate in January 2018. 50thIBWSN (283 entries), 35thSAWSN (277 entries) and 28thHRWSN (157 entries) distributed/distribution underway for growing at >140, 120 and 80 field sites, respectively by NARS partners in over 40 countries. The international screening nurseries also include entries included in the corresponding year's international yield trials and are grown by the partners as small plots to screen them under diseases and other stresses to select the best performing lines. Entries showing superior performance are retained by National partners for further testing and some are likely to be released as varieties in the future.

Data and Molecular Markers. All data are in open access and can be downloaded through the CIMMYT web through IWIN. Electronic data capture was implemented in 2016 for recording grain yield and other traits using tablets with the Field app developed by KSU. Molecular markers for effective stem rust resistance genes validated/optimized and used in developing backcross derivatives of important current and potential varieties with combinations of at least two resistance genes. The target genes (19) with their respective markers were: *Fhb1,Lr67 Sr2 Sr22,Sr25, Sr26 Sr32,Sr47, Sr50,SrND643,Yr39 ,Yr41,Yr15, Yr51,Yr52, Yr57, Yr59, Yr60 and Yrkk.*

Durum Wheat*.* A total of 1,425 new crosses were generated, including 715 simple and 710 top crosses. Some 17% of all crosses involved parents with a molecularly-marked gene that can be selected subsequently for using MAS. Selection in segregating populations was conducted in conditions allowing optimal plant development and under high epidemics of durum wheat leaf rust (Obregon, Toluca, El Batan) and yellow rust (Toluca) resulting in effective generational advancement of selected plants/families. A new race of leaf rust appeared in Mexico in Feb. 2017 which was characterized, purified and multiplied for use in the summer cycle on all our segregating material. MAS was performed during the entire segregating phase in most crosses were it could be applied effectively. A total of 35,565 marker data points were generated from 19,564 plants sampled for MAS. An additional 9,904 marker data points were generated for gene-linked marker characterization of parental lines. Yield testing activities included the full agronomic, yield and quality evaluation under full irrigation and drip-simulated drought of 3,519 new lines, representing 460 crosses, in Preliminary Yield Trials (PYTs, augmented design with repeated checks), and of 1,398 lines, representing 540 crosses, in replicated Advanced Yield Trials (AYTs, 2-3 reps, lines in 2nd or 3rd year of testing). In addition, the most advanced 606 lines from the latter group were also tested under heat using a March sowing. A total of 19,328 yield trial plots were sown, evaluated and harvested as part of this overall effort. Of those, 6,498 from the trials grown under full irrigation were analyzed for the main quality attributes globally relevant to durum wheat. All new and advanced lines (4,917 in total) were also tested as head-rows under intense epidemics of leaf rust and yellow rust. Breeder's data were collected by hand-held tablets using the KSU app "FieldBook" and technicians were trained to do the same. Data from IWIN made available on CIMMYT's IWIN site as datasets come in and were compiled. Data from Mexico-based operation were stored in backup servers at CIMMYT as the central database for breeding programs in developed countries and made available as requested.

Yield trials. The 49th IDYN (45 new lines + 4 checks + 1 slot for local check), was distributed to partners in 32 countries as 2-rep yield trials requested to be evaluated at 90 field sites/environments during the 2016-17 season. The IDSN 49th comprised of about 100 additional high yielding lines and 5 checks tested annually at over 30 field sites by NARS partners. The 49th IDSN (119 new lines + 4 checks + 1 slot for local check), was distributed to partners in 37 countries as a 1-rep observation nursery requested to be screened at over 101 field sites/environments in 2016-17 season.

Winter/Facultative Wheat. The project is implemented within the framework of International Winter Wheat Improvement Program (IWWIP) (Turkey-CIMMYT-ICARDA) with established framework of testing sites at research institutes and stations in Turkey. Overall the progress towards achieving the project outputs is on schedule. The 2017 winter wheat season was very favorable in Turkey allowing evaluation for yield potential as well as for moisture stress tolerance depending on the site. Overall excellent evaluation was done for rusts and a number of lines were identified possessing multiple resistant combined with good adaptation.

Grain quality evaluation was done at three institutes in Turkey plus at CIMMYT-Mexico and detailed results were used for selection of good bread-making quality germplasm. End-use quality has become more important and has been a high priority in the crossing and selection process. Testing advanced lines in Turkey is complimented by trials in Uzbekistan and Iran which are very important collaborators and provide useful information. For the first time, the project achieved acceleration of two generations per year (Izmir greenhouse and early spring field planting in Erzurum). Acceleration generation facility construction was started in December, 2017 and will be used in 2018. Adoption of IWWIP germplasm is progressing well. In 2017 two varieties were released in Turkey, with the total number of IWWIP originated released varieties brought to 74.

Bread wheat varieties adapted for Kenya. The targets for Period 2 were in general achieved both in gemplasm screening and identification of elite lines as well as in seed bulking and distribution of improved varieties. While order of new breeder seed from Kenya Seed company (KSC) was not furnished, the company marketed certified seed of improved KALRO varieties from breeder seed acquired 3 years ago. Moreover, KSC also markets varieties emanating from its own breeding program.

Wheat varieties adapted for Ethiopia. The Ethiopian wheat breeding program in collaboration with CIMMYT-Ethiopia is developing high yielding rust resistant bread and durum wheat varieties for the different agro-ecologies of the country. For this purpose, every year several genotypes are evaluated in variety testing schemes at research centers/stations representing the various wheat growing agro-ecologies. Of the 14 different bread wheat nurseries consisting of 1647 entries tested, 798 entries were selected at Kulumsa. The data for other centers will be compiled soon. In addition, three nurseries consisting of 464 entries were evaluated at Debre Zeit, and 25 lines were selected. Besides introductions, crossing blocks and segregating populations, the national variety testing scheme consists of Observation Nurseries (ONs), Preliminary Variety Trials (PVTs), National Variety Trials (NVTs) and Variety Verification Trials (VVTs). A few stable high yielding lines that are disease resistant and superior in quality will finally be put into VVTs and evaluated by national variety release committee on farmers' fields at six target environments for release. In 2017, the national bread wheat breeding program

had two sets of observation nurseries consisting of 507 entries (396 lines from CIMMYT) entries, five sets of pre-national variety trials consisting of 140 entries (119 lines from CIMMYT), four sets of national variety trials consisting of 82 lines (65 entries from CIMMYT) and two sets of variety verification trials consisting of three new varieties (two from CIMMYT) were conducted at different locations. The final result of the bread wheat VVTs is still pending. Similarly, the durum wheat breeding program also planted one set of observation nursery consisting of 53 entries (18 from CIMMYT), four sets of pre-national variety trials consisting of 50 entries (44 from CIMMYT) and seven sets of national variety trials consisting of 57 entries (51 entries from CIMMYT), and two sets of variety verification trials consisting of four new varieties (one from CIMMYT). Three durum wheat varieties were released (one from CIMMYT). For 2017, three candidate bread wheat varieties (two from CIMMYT) and three durum wheat varieties (two from CIMMYT) were under VVTs. Seeds of elite lines in advanced stage of testing are also multiplied on larger plots. In addition breeder, pre-basic and basic seeds of new and existing improved varieties are under multiplication to provide initial quality seeds to seed producers and farmers to realize the genetic gain expected on farmers' fields.

GS & HTP: Genomic Selection and High Throughput Phenotyping

Development and implementation of improved approaches for yield prediction and selection using genomics and high-throughput phenotyping proceeded on track during the reporting period.

We further tested and evaluated different classes of models for combined analysis of GS and HTP data in the CIMMYT program. Tested models were in agreement with initial findings that inclusion of HTP data leads to significant advancements of model accuracy. (See publication by Sun et. al. 2017.)

Improved processing pipelines for UAV based imaged data were developed. Fully-automated analysis to plot-level data is now possible. Initial testing of pipelines on field trial image data from Kansas State University (KSU), USA and BISA (Ludhiana), India were successful and fully-automated analysis achieved.

Improved algorithms for defining field plot coordinates needed for extraction of plot-level data were developed. Initial testing and implementation in 2017-18 CIMMYT Obregon cycle nurseries is underway.

Field-based imaging of 2016-17 CIMMYT Obregon cycle nurseries was completed for multispectral and thermal imaging. Complete nurseries and multiple time points for imaging were completed for PCs (50K small plots), YT (20K plots), EYT-bed-irrigation (3K plots), EYT-heat (3K plots), and EYT-flats (3K plots) were assayed at three to five time points.

Special trial of replicated small plots to large plots was completed for 1000 entries of the 2016-17 PCs that advanced to 2016-17 YTs. Ongoing analysis of prediction accuracy with initial results of 0.4 prediction accuracy from small plots to large plots and calculated gain of 2x over current levels of phenotypic selection.

Improved statistical methodology for spatial correction of field-trials using geospatial information. Benchmark against current auto-regressive row / columns (AR1 x AR1) models showed consistent improvement for geographically weighted regression approach using physical distance parameters extracted from plot coordinates used for HTP. (See publication by Haghighattalab et al. 2017.)

PHENOTYPING PLATFORMS

Kenya. A total of 19,870 spring wheat lines were tested in main season 2016 in Kenya. The 2016 main season nursery also accommodated 3,800 winter wheat nurseries. Data were recorded both for yellow rust and stem rust on at least two occasions and shared with partners. The International stem, rust phenotyping platform accommodated over 37,627 wheat and barley accessions from 15 different countries and research institutions globally for evaluation against the Ug99 race group at KALRO, Njoro in 2017. A total of 21,479 spring wheat lines were tested in offseason and 16,148 lines were tested in main season in 2017 in Kenya. The 2017 main season nursery also accommodated 4,624 winter wheat nurseries from USDA, Turkey, Iran, Hungary and Canada. Fee for service implemented for USDA and AAFC projects accounted for 20% of fees recovered for the entire screening operations for a year. Participating countries testing advanced lines and breeding materials include those from CIMMYT, USA, Canada, UK, Iran, Turkey, Uruguay, Nepal, Bangladesh, Afghanistan, India, Pakistan, Ethiopia, Hungary, South Africa and research partners from advanced research institutes. Evaluation and screening data for 2017 main and off seasons have been distributed to collaborators and shared in a centralized database A total of 10,650 advanced lines or (PC) from 1st year yield trials were introduced in offseason 2017 against stem rust races of the Ug99 race group and selected. 1,530 lines were planted in the main season and 1,170 of the Elite PC (EPC) were evaluated in both seasons. Pedigree information was available along with the phenotypic data for stem and yellow rusts for the year 2017 and data shared with partners. A total of 300 lines were phenotyped at existing greenhouse from KSRON (Kenya Stem Rust Observation Nursery) as a part of the masters research. A new greenhouse was under construction.

USDA-MN. 206 breeding lines and selections from KSRON nurseries were evaluated at USDA-MN-CDL using stem rust races TTKSK, TRTTF, TKTTF, TTKST TTKTT. Results enabled us to discriminate and postulate the lines that carried seedling/ race specific genes and APR based on field response. Two mapping populations developed at CIMMYT were evaluated for stem rust response in off-season 2017.One hundred resistant superior performing lines in both off-season and main-season 2017 are shared with EIAR and smaller sets shared with other East African partnering countries.

Ethiopia. A total of 6,654 lines were evaluated at Debre Zeit, EIAR in the year 2017, 5,691 lines were evaluated against stem rust pathotypes in the main season 2017, and 963 lines were tested in the off-season 2017. The sources are mainly CIMMYT, USDA, India, North Dakota State University (NDSU) and regional programs from EIAR. Stem rust data were distributed to collaborators on at least two occasions. Five virulent stem rust races were multiplied at Ambo PPRC and supplied to Kulumsa and Debre Zeit for field screening of wheat germplasms at single race nurseries and international wheat nurseries both in 2016 and 2017 main cropping seasons. Collaborative studies on mapping new genes wherein mapping populations were evaluated in Debre Zeit, promising resistant bread wheat and durum wheat lines in CIMMYT, ICARDA nurseries were identified. Fifteen CIMMYT plus 5 ICARDA nurseries with total of 2100 lines were tested at Kulumsa and some nurseries at Holeta, Adet, Melkassa, Debre Zeit, and Sinana during 2017 main-season. 563 lines (34.3%) from CIMMYT nurseries and 256 (55.6%) from ICARDA nurseries were advanced. In bread wheat observation nursery, 510 genotypes were evaluated in two sets, of which 135 lines were advanced for differential sets of PVTs. Also, out of 5 sets of PVTs, with total of 150 lines, about 1/3 are expected to be advanced to differential sets of NVTs. From 4 sets of BW NVTs, 15 elite lines

have been advanced for possible VVTs in 2018. The 2017 VVT result for 3 candidate varieties is expected in April 2018. ETBW 7956 (ICARDA source) is for the highlands; ETBW 9042 and ETBW 7638 (both from CIMMYT) are for midland and lowland respectively. 310 quintals of breeder seed of 7 varieties produced for supply to seed producers.

Holeta Septoria Platform. During the 2017 main-season, 1195 BW entries were used for Septoria phenotyping at Holeta Res. Center, a septoria hot spot. These included 261 from ICARDA, 434 KLDN & 500 elite lines from National Wheat Res. Program. Septoria leaf blotch tritici was recorded using double digit (00-99). Also, morphological data were taken on 5 random plants for each entry. Data will be shared after recording seed parameters.

INNOVATIVE SEED SYSTEMS

The seed processing equipment was successfully installed in January 2017 in Nepal. The semi-automatic seed processing facility commissioned at Agriculture Forestry University (AFU) is capable of processing wheat and maize with capacity of 1 ton/hour for wheat and 0.5t ton/hour for paddy (for major cereals). Currently, the line has seed dryer, pre-cleaner, cleaner gravity separator and seed treater in the processing section. Seed-testing equipment capable of performing tests for germination, purity, viability, moisture, vigor for all seeds was installed successfully. Production of certified wheat seed on 20 ha of land at AFU was initiated. However, due to erratic rains and first time experience of certified wheat seed production by the team, yield recorded was below the national average, resulting in a total production of 10MT of seeds, which were processed at the newly installed seed processing facility.

Sixty-five farmers outside AFU, in nearby villages, were for the first time mobilized to multiply certified wheat seed for the Dec 2017-April 2018 wheat season. Total area covered was ~30 ha, focusing on farmers having a minimum of 0.5 ha or more. Additionally, 20 hectares of AFU's own land were sown with wheat foundation seeds. Focusing on multiplication and promotion of resistant and stress tolerant wheat varieties, foundation seeds of NL 3063, popularly known as Gautam, were distributed to all the farmers outside AFU. Another popular wheat variety, BL 3063, was sown on 20 ha of AFU land. BL 3063 is believed to have terminal heat tolerance and performs exceedingly well under zero tillage.

After installation of the seed testing lab equipment, the lab was inspected by officials from Seed Quality Control Unit (SQCC) for licensing and accreditation. Their recommendations were applied and the lab will secure its accreditation by December 2017 to start its testing services from this season for private sector and research related work by students. In addition to catering the private sector with quality seed testing services at affordable rates, the seed testing lab once functional from this season will be an additional source of revenue generation for the university (AFU).

DATA MANAGEMENT

All the goals for this period were met for the Data Management Objective. A CIMMYT-led multi-party evaluation process was created for Data Management for the Wheat and Maize program which resulted in the decision to utilize B4R (Breeding for Research a IRRI developed platform) and associated additional systems as the mechanism for data management going forward. Most recently, KSU project gave CIMMYT a copy of their database with all of the raw phenotypic data values through the end of the 2017 evaluation season in Obregon – and very importantly, this database came populated with trial and occurrence numeric IDs that will make it much easier to migrate these data into B4R and to merge them with the trial metadata coming from IWIS2.

TALENT PIPELINE

During the reporting period we increased the number of Ph.D. students from developing countries researching with national and international wheat researchers: two Ethiopian students at the University of Minnesota Plant Pathology Department, and one Ethiopian student at Cornell University for a Ph.D. program in Plant Breeding and Genetics. All three students completed their first semester satisfactorily. Five MSc students enrolled in Ethiopian universities are doing thesis research with DGGW collaborators in Ethiopia; five Kenyan MSc students are working with researchers at KALRO and CIMMYT in Kenya. Two postdoctoral positions at CIMMYT were filled. A third postdoctoral position was created to work in collaboration with the University of MN and USDA rust pathologists on research related to Ethiopian rust pathogens and the deployment of rust resistance genes in wheat varieties.

The 6th "SAARC Wheat Rust Monitoring and Disease Management Course," conducted in Nepal in February 2017, was attended by 24 participants from India, Nepal, Bangladesh, Bhutan, Pakistan and Afghanistan, of whom 5 were women. The 9th training course, "Standardization of stem rust note taking and evaluation of germplasm with emphasis on emerging threats of yellow rust and leaf rust," was conducted at KALRO Njoro in September and was attended by 32 participants from 13 countries. In February, a training on wheat blast was conducted jointly by DGGW and CIMMYT in Bangladesh with 4 participants from Nepal and India. The surveillance and SAARC trainings were recorded for use at future trainings. Wheat pathology and breeding trainings for Ethiopian junior scientists were held in 2017 at the EIAR research centers with 40 researches participating. For 2016-17 season, pre-season surveillance trainings were conducted in Nepal, Bhutan and Bangladesh with 55 participants. Pre-season (in advance of 2017-18 season) surveillance was recently conducted in India at two centers with 25 participants, including 6 females. During 2016-17 season, 2 in-season surveillance trainings were conducted. In Nepal, the training course was conducted on disease surveillance and monitoring with 24 participants of which 5 were women, from India, Nepal, Bangladesh, Bhutan, Pakistan and Afghanistan.

In Nepal, two trainings on seed-processing machine handling and maintenance were held for the AFU project team, including operators, technicians and senior seed-technology students. Personnel responsible for handling the seed processing facility were given an exposure-visit to India to gain real-time experience. With support from the Nepal Agricultural Research Council (NARC), a training in certified wheat seed production was held for wheat seed growers/farmers and 29 extension professionals from public-private sector (National Seed Company, Universal Seed Company) and AFU. NARC, with continual support to the AFU, played a leading role in developing the training modules for the wheat seed growers. In December, an initial training, "Seed production, Agronomy and Value Chain" was held at AFU for wheat seed farmers.

Online videos from trainings, including the SAARC course and the wheat blast training course, were made available. In collaboration with EIAR, we created a rust research protocol manual based on the Ethiopian experience and infrastructure available in-country. We have also joined forces with CIMMYT Academia to increase the visibility of the training material available from CIMMYT.

Five early-career women scientists were recognized as Women in Triticum awardees at the CIMMYT field day in March 2017. Five additional WIT awardees were selected in December 2017. Silvia Germán was selected for the 2017 WIT mentor award; the 2018 awardee was identified but is not yet announced. Additionally, to increase the number of scientists with gender-aware leadership skills through specialized training, three DGGW teams, one from Ethiopia and two from Kenya, participated in specialized training for gender-aware leadership skills offered through the Gender-responsive Researchers Eqiupped for Agricultural Transformation (GREAT) program, which took place in Kampala, Uganda, August 2017.

To better measure and evaluate impact, we created a database system, which will incorporate all identified scientists from Talent Pipeline objective. A baseline survey has been generated, and it will be sent out to all participants of training, sponsored students and postdoctoral fellows and to WIT awardees.

PROJECT MANAGEMENT

All subcontractors provided their progress reports on time and met expectations for Period 2. In the few instances that adjustments needed to be made, a sound explanation was provided. A new sub-contract is currently being established with Cambridge University to support pathogen surveillance activities in collaboration with CIMMYT-Ethiopia activities.

EPAC members for DGGW were identified and the Terms of Reference were updated to increase their input opportunities. Multiple virtual meetings with objective leaders were held and notes from meetings were recorded and shared with the participants. The Cornell project management team visited seven different subcontractors including EIAR, CIMMYT, KALRO, Aarhus University, Kansas State University, and the USDA-MN, Nepal Agriculture And Forestry University Seed system. We met with Sathguru twice at Cornell during this period.

Special initiatives were supported including applying for funding for blast mitigation, which has been evaluated but no opportunities have been identified, and developing a concept note for a proposal to Green Climate Fund through Ethiopian partners. Acevedo and Coffman participated in the CIMMYT wheat breeding program assessment (March 2017). Similarly, ad hoc objective-special workshops were identified and supported. In collaboration with CIMMYT and the Bangladesh Agricultural Research Institute (BARI), DGGW sponsored a wheat blast training for South Asia region in Bangladesh in January 2017. A wheat rust surveillance side meeting was held at the International Wheat Initiative Conference in Austria in 2017. A convening of UK and CIMMYT wheat scientists was sponsored and coordinated by the BMGF and DGGW to help develop new collaborations and seek potential future funding opportunities. We also participated in the Whole Grain Summit 2017 and an alternate host session at 2018 APS meeting was proposed and accepted.

To improve and facilitate knowledge sharing among DGGW objectives, the DGGW proposal summary and progress report were published on the web. Additionally, frequent weekly communications meetings were held at IP- CALS, and multiple virtual meeting were held with CIMMYT communications team (quarterly) and with GREAT (weekly, now monthly) and Alliance for Science (monthly). A meeting was held in Ethiopia in November 2017, involving CIMMYT, EIAR, and ICARDA wheat breeders to develop a collaborative plan for increasing genetic gain.

Project Adjustments

Advocacy

Because no technical workshop was held in 2017, we delayed some activities/expenditures which we are picking up again for the 2018 BGRI Technical Workshop in Morocco, in April. We were not able to convene key stakeholders about what constitutes responsible gene stewardship, but feel that is perhaps best done through the EPAC meeting at the workshop in April 2018, and through the 2018 Gene Stewardship Award. We did not create a long-form documentary of the project, instead putting our resources into 20 short (3-5 min each) videos which are listed with live links in Appendix C. As for the 2.1.1 indicator, we had a total of 35 posts, but fell somewhat short of our goal to cross-post 10 blog posts/quarter from our partners. Going forward, we are adjusting those expectations to 5 crossposts/quarter. But, since the DGGW covers genetic gain for heat tolerant and drought-resistant wheat, we are able to piggyback/crosspost more stories related to climate change and the need for “climate resilient” crops — including wheat.

Surveillance

For stem rust samples collected in East Africa and shipped to North America, it was noted that samples that were collected more than 30 days prior to shipping were almost always dead. We need to ensure that samples collected during the summer (June-August) are increased and stored in a freezer prior to shipping for race pathotyping.

Further promotion and hands-on training with the ODK survey tool is needed to encourage wider use and uptake in more countries.

Regional analysis of rust samples at the ICARDA Regional Cereal Rust Research Center (RCRRC): Race typing of foreign rust samples could not be implemented due to lack of authorization of importing rust samples from outside Turkey. However, in June 2017, agreement between ICARDA and General Directorate of Agricultural Research and Policies of Republic of Turkey was signed and following this agreement and fine tuning of the biosafety facility, the Cereal Rust Biosafety Laboratory in Izmir has received the first official authorization of importing 15 yellow rust races from INRA-France on December 13, 2017. This is a great achievement and will enable the RCRRC to undertake regional race analysis of cereal rusts (wheat and barley) in 2018.

Ambo PPRC has managed to successfully implement all planned activities, but greenhouse facilities are becoming a critical issue. Greenhouse infrastructure is ageing and is in need of urgent repair. Not all chambers are functional and this severely limits capacity.

Breeding Pipeline

Output/Outcome 4: Instead of three, we submitted four lines for NPT 2017 after data analyses and consideration.

Given the challenges (machinery, transport, warehousing and drying facilities) at the KALRO Seed Unit, the program has made a proposal to The World Bank though the new “East and Central Africa Agricultural Transformation Project” for support in acquiring critical units. This will greatly increase the footprint of the seed unit in delivering genetic gain wheat to Kenya and regional farmers. Moreover, the seed unit is in the processing of adopting seed distribution through wholesale and retail establishments, which is expected to increase volumes of improved seeds delivered to farmers.

GS & HTP

Continued adjustments are being made on data management and database development. We have developed and implemented database structures for geospatial data as needed for management of the field-based HTP data. Institution implementation of an enterprise level database CIMMYT (e.g. BMS) is still pending (this is outside of the funded objectives of GS & HTP project). All project data covering most of the CIMMYT bread wheat breeding program data are being managed and curated on a project database at KSU.

Phenotyping Platforms

Construction of a new greenhouse in Kenya is nearing completion. Suppliers for various equipment and research units for the greenhouse have been identified and we are in the process of finalizing the same. Irrigation system and greenhouse issues are being addressed at EIAR, Debre Zeit and Ambo research stations.

Data management system is in progress to ensure that it is published open access and available to the global wheat community.

For the next reporting period the following is planned:

- Reconstitute Kenya Stem Rust Observation Nursery (KSRON) to include new stem rust APR lines from the CIMMYT nurseries identified from off and main seasons. These collections will be put in the observation nurseries to be established in the off season (planting in January) and main season (planting in July), within the next project reporting period.
- Ship about 200 lines identified from ending year’s KSRON to Cereal Disease Lab for seedling (stem rust) screening and molecular markers.
- Constitute an advanced yield trial (AYT) from the best (plant type, 1000 KWT, disease resistance) to be established in 5 traditional testing sites.
- Explore opportunities for irrigated wheat by engaging with county governments in wheat growing areas.
- Continue bulking breeder seed of improved varieties and pre-released lines (in NPT) while working closely with KALRO Seed Unit to increase production and distribution of pre-basic and certified seed.
- Proactively call for a stakeholders meeting involving seed companies and other players in the wheat value chain to review progress in exploiting genetic gain for wheat in Kenya.
- As the identified “Regional Centre of Excellence” in the new “East and Central Africa Agricultural Transformation Project” for wheat in the region except Ethiopia, the Kenya program plans work with CIMMYT to multiply some of the best lines in Kenya Stem Rust Observation Nursery (KSRON) and distribute those as test kits to regional partners.

Data Management

We are working with CIMMYT to develop a data management system, on how to make data accessible to collaborators in a timely manner, and increasing the number of data points collected electronically.

Talent Pipeline

Leadership trainings have been re-scheduled to be held in combination with the BGRI Technical Workshop in April, 2018. Data management systems trainings have been postponed until the system is completed.

To better measure and evaluate impact, we created a database system, which incorporates all identified scientists from the Talent Pipeline objective. A baseline survey has been generated, and it will be sent out to all participants of training, sponsored students and postdoctoral fellows and to WIT awardees.