**Current Period Progress: AGG Year 1 Executive Summary and Impact Report**

The Accelerating Genetic Gains in Maize and Wheat (AGG) project has made strong progress towards all milestones and outcomes. From the lab to the field, AGG stakeholders are grateful to donors for supporting the ambition to improve maize and wheat breeding programs towards faster and better focused products and impacts. To this end, AGG scientists have designed and begun implementing substantial modifications to breeding targets and breeding schemes. AGG is also in a continuous improvement process for the partnership modalities, pursuing co-ownership and co-implementation that truly builds capacities of all involved. The following pages show a selection of highlights - an *Executive Summary* – of AGG's Year 1 achievements.

**Maize – High-value Deliverables and Impacts**

**Optimization of breeding tools and methods to increase rate of genetic gain.**

- The maize breeding pipelines are now aligned with the product profile requirements of stakeholders, based on "must-have" and "nice-to-have" traits.
- The breeding pipelines in eastern and southern Africa (ESA) were costed in detail. Meanwhile, costing is still ongoing in West Africa (WA). This will enable refinements to improve efficiency and reduce costs.
- Forward breeding for maize streak virus (MSV) and maize lethal necrosis (MLN) is routinely applied in four product profiles in ESA, a technique that saved almost US$ 32,000 in 2020.
- Scientists have optimized the fall armyworm (FAW) mass-rearing (in partnership with KALRO, Katumani), artificial infestation, and germplasm rating protocols to identify promising germplasm for the future.

**Climate-resilient, input-responsive maize varieties developed and accessed by partners in SSA.**

- 27 new, multiple-stress-tolerant maize hybrids and open-pollinated varieties (OPVs) were released by small and medium sized enterprises (SMEs) and national agricultural research system (NARS) partners for commercialization in sub-Saharan Africa (SSA) in 2020.
- Three FAW-tolerant improved maize hybrids developed by CIMMYT were announced to partners in Dec 2020. These are undergoing national performance trials (NPTs) in eastern Africa (EA) for release and commercialization; NPTs will follow in southern Africa (SA) in last quarter of 2021.
- In 2020, for the first time, product evaluation and advancement meetings were held with CMMYT and NARS scientists in AGG partner countries. Scientists included socio-economic data from regional on-farm varietal trials to gain a stronger understanding of women and men farmers' trait preferences.
- Implementing genomic selection (GS) using a "test-half-and-predict-half" approach successfully reduced breeding costs by 32%, a major improvement when compared to traditional phenotypic selection.
- Simulations of achievable gains from reducing breeding cycle time predicted that recycling parents after Stage 1 trials, instead of Stage 3 trials, would save two years and increase genetic gain by 17%. With this in mind, scientists began modifying breeding schemes in ESA and WA.
- In 2020, several partners initiated and/or increased the use of doubled haploids (DH) in their breeding pipelines. 338 populations were submitted for DH development by CIMMYT and NARS breeders from 9 SSA countries. 41,552 DH lines were delivered to the breeders.

**Accelerated varietal turnover and adoption of superior maize varieties in SSA.**

- The weighted average age of CIMMYT-related improved maize varieties in ESA has decreased from 14 years in 2014 to 10.2 years in 2020.
- In Nigeria, a DNA-based assessment of varietal turnover found that the weighted-average age of improved maize varieties is around 10 years.
- In 2020, more than 500 regional on-farm trials (ROFTs) were conducted across ESA in collaboration with partners, a five-fold increase. The number of ROFT sites in SA increased from fewer than 20 trials of complete block designs to 410 of incomplete block designs.
- Two examples from Ethiopia indicate large-scale dis-adoption of old stress-susceptible varieties (BH660 and BH540) and a rapid adoption of new, stress-tolerant varieties (BH661 and BH546). With this change, the national average yield increased from 1.7 t/ha in 1993 to 4.2 t/ha in 2019.

- In Benin, 60% of farm households cultivated stress-tolerant maize varieties, which increased their food consumption by 18% and dietary diversity by 2%, while food insecurity fell by 25%.
- Data from 438 households across all maize growing regions in northern Ghana indicate that the adoption of DT maize increased by 38% between 2013 and 2018, increasing yields by 37% and sales of harvested grain by 28%.
- By February 2021, certified seed production of recently released CIMMYT- and IITA-related stress-tolerant maize varieties reached 134,260 t for SSA; thus, the **AGG project reached 9.4 million households with seed of improved maize varieties, covering 5.5 million ha, and benefitting 64.8 million people in 9 countries in ESA and 4 countries of WA.**
- A value chain analysis conducted in Kenya, Tanzania and Uganda on 32 seed companies, 612 agro-dealers, and 466 farmers found challenges to increasing varietal turnover: 1) only 20% of farmers actively seek new varieties; 2) agro-dealers hesitate to invest in the promotion of new varieties and prefer selling varieties they know are demanded by farmers; 3) seed companies focus investments on triggering farmer demand, but invest little in strengthening their retail network; and 4) companies take a big risk when updating their seed portfolio as demand for the new varieties is not guaranteed and they can lose market share when taking out old varieties.

**Capacity of targeted African NARS and SME seed companies strengthened.**

- Following breeding program assessments conducted jointly with the CGIAR Excellence in Breeding Platform (EiB), customized improvement plans were developed with and for KALRO (Kenya), NARO (Uganda), and DR&SS (Zimbabwe) and endorsed by respective management teams.
- Regional Collaborative Maize Breeding and Seed Systems Networks implemented in EA, SA and WA.
- KALRO and NARO are receiving support to adopt the Breeding Management System (BMS) data management system in preparation for the transition to the Enterprise Breeding System (EBS).
- Despite the severe challenges from the COVID-19 pandemic, virtual capacity building activities benefiting 753 participants (565 male and 188 female) were conducted.

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**Wheat – High-value Deliverables and Impacts**

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**Adoption of modernized breeding approaches to deliver accelerated genetic gains.**

- A rapid-generation advancement breeding scheme is underway. New screenhouses will grow four generations per year and reduce the current breeding scheme by one year.
- Researchers are implementing cycle time-reduction using genomic selection (GS) for recycling of parents. Simulation results show increases in genetic gains.
- Speed breeding is operational for rapid trait introgressions. Specific genes and QTLs for disease resistance are being incorporated into elite lines and varietal candidates in the new facility.
- An extensive costing of each breeding stage was conducted and will be used in further optimization of breeding pipelines to maximize predicted genetic gain per unit of cost.
- To increase gender intentionality, CIMMYT breeders and socio-economists are working with Wageningen University and Banaras Hindu University to survey gender-preferred traits in Uttar Pradesh (India). Similar work will be done in Bihar (India) and Ethiopia.

**Characterization of target populations of environments to support enhanced testing networks.**

- Leveraging 16 years of international yield trial data, three major target populations of environments (TPEs) for wheat breeding in India were determined.

- Analyses suggested that greater gains will be achieved by selecting parents for each of the TPE-targeted, re-designed breeding pipelines. AGG has restructured this breeding program accordingly.

**CIMMYT wheat breeding provides genetic gain for grain yield.**

- CIMMYT bread wheat varieties released from 1965 to 2014 showed a significant increasing trend in grain yield of 0.5-0.7%, or 24.7-35.3 kg/ha/year across multiple selection environments at Ciudad Obregon, Mexico under disease-free conditions.
- Analysis of 10 years of international, NARS trial data found annual genetic gains of 1.17 % (65 kg/ha) under high rainfall, and 0.73% (33 kg/ha) under low rainfall environments.

**Breeding and disease screening provide advanced selection candidates in eastern Africa.**

- At the Ethiopian durum wheat stem rust phenotyping platform in Debre Zeit, 6,578 F2-derived F4 lines from CIMMYT were assessed and 1,510 lines were selected by the EIAR team. Researchers evaluated elite lines and identified 68 durum lines for further testing.
- Over **33,000 breeding lines, varietal candidates, and mapping populations from CIMMYT and six partner countries were evaluated for yellow and stem rust resistance** at Njoro, Kenya.
- Selections were made from 44 breeding populations (14 F5 and 30 F6) by KALRO scientists. The resultant lines became part of the Kenya breeding pipeline.

**Wheat rusts tracked and recommendations developed to limit spread of wheat disease.**

- Crucial monitoring activities identified threats: stem rust Ug99 race TTKTT was confirmed for the first time in Iraq. A new stripe rust genotype was detected in Ethiopia.
- Over 1,300 fields were surveyed in Ethiopia and 324 stem rust samples were analyzed. Seven stem rust races were identified; TTKTF was the predominant race, followed by TKKTF.
- New CIMMYT-KALRO greenhouses, with capacity to evaluate wheat germplasm for yellow rust, leaf rust and stem rust diseases will open in 2021 at Njoro.

**Seed production of new varieties to support varietal replacement.**

- In Pakistan, a fast-track seed multiplication program by national partners and governmental agencies is multiplying early-generation seeds and recently-released varieties.
- NARC (Nepal) implemented pre-release seed multiplication of six new varieties in the 2019-20 and are doing the same for four varietal candidates in 2020-21.
- EIAR (Ethiopia) produced 2 t of breeder seed of 3 varieties, 20 t of breeder seeds of recent bread wheat varieties, and 9 t of breeder seed for 7 durum wheat varieties.
- KALRO (Kenya) multiplied 2.5 t of breeder seed for 5 new varieties and completed a license agreement with AgVenture Ltd. to fast track their seed distribution.

**Commitment to capacity development.**

- CIMMYT's wheat training course with 17 participants (5 women) started in February 2020 but was partially suspended in mid-March due to the COVID-19 pandemic.
- The 2021 online course started in January with 68 participants (16 women). Students joined from Ethiopia, Kenya, India, Nepal, and Pakistan, to name a few participating countries.
- Field data management and disease scoring training was provided to Ethiopian researchers and technicians at Holetta, Kulumsa and Debre Zeit. Training on handling stem and yellow rust in the greenhouses, race identification and seedling tests was provided at Ambo and Kulumsa.

**Continued provision of benefits to the global wheat community.**

- In 2020, evaluations of 540 elite lines across India, Pakistan, Bangladesh and Nepal, resulted in **selection of 463 lines for advancement by 41 national partners; 68 lines were selected by 10 or more collaborators for use in their breeding programs.**
- Also in 2020, **36 bread and 7 durum wheat varieties were released by NARS partners in Afghanistan, Algeria, Bangladesh, Ethiopia, India, Iran, Kenya, Mexico, Nepal, Pakistan, Peru and Turkey** from selections made from CIMMYT international trials and nurseries.
- New international trials and nurseries of bread and durum wheat were distributed to more than 180 partners in 78 countries for sowing in the 2020-21 and 2021 crop seasons.
- International trial and nursery data for grain yield, agronomic and disease resistance during the 2019-20 cropping seasons is available through the open-access IWIN database.

**Data management, biometrics, and quantitative genetics.**

- The Enterprise Breeding System (EBS) v.2.1 software tool was tested by maize and wheat champion users in preparation for broad engagement by breeders in 2021.
- Together with EiB, AGG holds regular meetings with IITA maize breeders, preparing the way for planned deployment of EBS during 2021 and into 2022.
- Over 1 million maize and 8 million wheat records were migrated to the EBS. Trial and nursery metadata and entry lists for wheat were migrated from IWIS2 to the EBS.
- Implementation of sparse testing and augmented designs increased for both maize and wheat trials, and programming code was prepared for inclusion of these options in EBS.
- Biometrics support to breeding included use of efficient experimental designs, implementation of genomic selection, application of selection indexes, definition of target populations of environments (TPEs), estimation of genetic trends and design of on-farm testing strategy.
- A manual with guidelines for estimating genetic gain was published in collaboration with EiB and public- and private-sector partners.