Study #4031

**Contributing Projects:**
- P1223 - Delivering Genetic Gains in Wheat (DGGW)
- P1367 - Evaluate and characterize high yield potential lines at key NARS
- P1335 - Wheat variety adoption and impacts in central Asia
- P1366 - Deliver International Nurseries to co-operators
- P1317 - Improving Heat Tolerance of Wheat
- P1358 - Developing of analytical and decision tools to help breeders in the standarization of methods and to do breeding more efficiently.

**Part I: Public communications**

**Type:** OICR: Outcome Impact Case Report

**Status:** On-going

**Year:** 2020

**Title:** Significant genetic gains in grain yield delivered by breeding research: A constant flow of high-yielding, disease-resistant germplasm provided to National Agricultural Research System partners

**Short outcome/impact statement:**
The CGIAR Research Program on Wheat (WHEAT) bread wheat breeding program at CIMMYT delivered significant genetic gains to National Agricultural Research System (NARS) partners by developing high-yielding, disease-resistant wheat germplasm. Analysis of historical data showed grain yield gains of 46.6 (irrigated), 57.7 (drought), 65.1 (high rainfall) kg/ha/yea, or 0.5-1% p.a. On-station trials of selected varieties/germplasm delivered similar estimates. These genetic gains in grain yield impact an estimated 61 million hectares of the 215 million hectares of the global wheat area.
Outcome story for communications use:
Demand for food around the world is increasing, driven by population increase and dietary changes. Simultaneously, the consequences of climate change pose a series of stresses on cropping systems that will severely endanger food production. Increasing the rate of genetic gain (GG) is a paramount contribution to meet future wheat demand; and assessing such a rate is critical to determine the performance of breeding programs.

Using a set of previous studies, the performance of bread wheat-breeding germplasm developed by the Global Wheat Program (GWP) at CIMMYT was assessed through the extensive analysis of international data sets (Crespo-Herrera et al., 2018, 2017; Gerard et al., 2020). The results derived from such analysis indicate genetic gains ranging from 0.5-1% per annum, which on average represents 46.6 kg/ha/year. For a more controlled assessment of the genetic gains, the CIMMYT-GWP team evaluated a selection of internationally distributed lines from 2004-2017 in the Elite Spring Wheat Yield Trial (ESWYT) and Semi-Arid Wheat Yield Trial (SAWYT). Over two years-worth of evaluations indicate a genetic gain of 0.7% in optimally irrigated (47 kg/ha/year) and drought stressed environments (25 kg/ha/year), respectively. Biomass accumulation in optimal environments is the variable (0.87) most correlated with yield.

In another long-term, on-station experiment, a set of historical varieties representing 50 years of wheat breeding again evaluated under optimally irrigated and drought environments, estimated genetic gains ranged between 24.7-35.3 kg/ha/year and 18.1-25.6 kg/ha/year, respectively (Mondal et al., 2020). CIMMYT’s bread wheat breeding program continues to deliver superior germplasm to target environments. In 2020, these efforts led directly to the release of 39 varieties in 10 countries by national partners (Afghanistan, Algeria, Bangladesh, Ethiopia, India, Iran, Kenya, Nepal, Pakistan, Peru and Turkey).

While genetic gains continue to be delivered, the wheat breeding program is testing faster recycling approaches to further reduce time for generation advancement from the current 5-6 years to 3-4 years, thereby accelerating the genetic gain. A field-based Rapid Bulk Generation Advancement Scheme (RBGA) has been designed for faster recycling at CIMMYT. This scheme will be initiated in the newly-established screenhouse facility at CIMMYT’s research station in Toluca, Mexico, growing wheat year-round. With an expected cycle time of 3 months, the facility will allow 4 crop cycles in a year, a massive improvement when compared to the current 2 crop cycles in-field. This approach will also follow early-yield testing of developed germplasm at targeted locations, thus accelerating germplasm availability for national partners.

Links to any communications materials relating to this outcome:
- https://tinyurl.com/yjbjuwt8
- https://tinyurl.com/ye7nxq77
- https://doi.org/10.2135/cropsci2011.12.0634
- https://tinyurl.com/ygh4thfz

Part II: CGIAR system level reporting
Link to Common Results Reporting Indicator of Policies: No
Stage of maturity of change reported: Stage 3
Links to the Strategic Results Framework:
Sub-IDOs:
- Adoption of CGIAR materials with enhanced genetic gains
- Increased capacity for innovations in partner research organizations

Is this OICR linked to some SRF 2022/2030 target?: Yes

SRF 2022/2030 targets:
- # of more farm households have adopted improved varieties, breeds or trees

Description of activity / study: <Not Defined>

Geographic scope:
- Global
- Regional

Region(s):
- Latin America and the Caribbean
- Sub-Saharan Africa
- Southern Asia

Comments: breeding program elite lines (different trials and nurseries) reach collaborators in 60+ countries every year.

Key Contributors:
Contributing CRPs/Platforms:
- EiB - Excellence in Breeding Platform
- Wheat - Wheat

Contributing Flagships:
- FP3: Better varieties reach farmers faster

Contributing Regional programs: <Not Defined>
Contributing external partners: <Not Defined>

CGIAR innovation(s) or findings that have resulted in this outcome or impact:
1. Assessment of the genetic gains of grain yield of wheat germplasm developed by the CIMMYT-GWP.
2. Implementation of new technologies for rapid generation advancement of breeding materials to enhance the rate of genetic gain.

Innovations: <Not Defined>
Elaboration of Outcome/Impact Statement:
The CIMMYT germplasm that constitutes the international yield trials, such as ESWYT and SAWYT, are
the final products of the bread wheat breeding program. These trials are distributed annually to more
than about 140 collaborators within the International Wheat Improvement Network (IWIN). Various
studies indicate that CIMMYT continues to deliver superior germplasm to target environments in
South and Central Asia, East and North Africa and Latin America. However, since the international trials
are conducted in a series of sites that may have heterogeneous characteristics -- namely soil, climate,
and management -- the bread wheat breeding team re-assessed the performance of the breeding
program under more controlled conditions that allow the measurement of the GG. To this end, the
team selected 60 genotypes each from the ESWYT and SAWYT from the 2004-2017 distribution years
based on their global performance. They were evaluated at the main CIMMYT testing site in Ciudad
Obregon under two optimally irrigated (ESWYT) and three drought (SAWYT) environments. The results
indicate that in optimally irrigated environments, the realized genetic gain (GG) was 47 kg/ha/year,
equivalent to 0.7% per annum (p < 0.001, rsq = 0.66), whereas in drought related environments, the
realized genetic gain (GG) was 25 kg/ha/year or 0.7% (p < 0.001, rsq = 0.55).

References cited:
Singh, R.P.P., 2018. Genetic gains for grain yield in CIMMYT’s semi-arid wheat yield trials grown in
Crespo-Herrera, L.A., Crossa, J., Huerta-Espino, J., Autrique, E., Mondal, S., Velu, G., Vargas, M., Braun,
https://doi.org/10.2135/cropsci2016.06.0553
physiological related traits for CIMMYT’s High Rainfall Wheat Screening Nursery tested across
semi-dwarf spring wheat breeding at CIMMYT: Grain yield progress in optimum, drought and heat

Quantification:

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<td>Unit</td>
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Gender, Youth, Capacity Development and Climate Change:

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<td>Suchismita Mondal, GWP CIMMYT, <a href="mailto:s.mondal@cgiar.org">s.mondal@cgiar.org</a></td>
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<td>Leonardo Crespo, GWP CIMMYT, <a href="mailto:l.crespo@cgiar.org">l.crespo@cgiar.org</a></td>
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