Evidences

Study #3284

Projects:<Not Defined>

Part I: Public communications

Type: OICR: Outcome Impact Case Report

Status: New

Year: 2019

Tagged as: New Outcome/Impact Case

Title: The CGIAR Research Program on Wheat’s (WHEAT) synthetic wheat breeding strategy, which successfully transfers valuable diversity from wild goat grass to modern wheat, is providing farmers with climate-resilient, pest and disease-resistant wheat.

Short outcome/impact statement:
The breeding practice of using "synthetic hexaploid wheat" to incorporate genetic diversity from wild wheat relatives into modern varieties benefits the world's farmers through climate resilient and pest-resistant wheat. A 2019 study validated this practice, finding that 20% of the wheat lines in CIMMYT?s global spring bread wheat breeding program contain an average of 15% of the genome segments from the wild wheat relative Aegilops tauschii.

Outcome story for communications use:
More than 4.5 billion people obtain 21% of their calories and 20% of their protein from wheat. Demand is predicted to double by 2050 and wheat production cannot currently keep up. Production faces serious pressure from climate change-associated drought and heat, as well as diseases and insect pathogens.

Genetic diversity in wheat is crucial to combat threats to wheat productivity. Wild relatives of wheat are especially valuable sources of resistance to pests and diseases, tolerance to abiotic stresses, and yield-related traits (1, 2).

Since the early 1980s, scientists at the International Maize and Wheat Improvement Center (CIMMYT), including WHEAT scientists, have sought to broaden wheat's genetic diversity through the development and use of synthetic hexaploid wheat: a cross of a wild wheat relative – Aegilops tauschii, or goat grass – with durum wheat (1). Breeding synthetic wheat with modern bread wheat successfully transfers valuable diversity from wild goat grass to modern bread wheat (3). Between 1988 and 2010, CIMMYT used approximately 900 Aegilops tauschii accessions maintained in genebank collections to produce approximately 1300 primary synthetic wheat lines for developing varieties with improved traits.

A 2019 analysis (4) used state-of-the-art molecular technology to measure the effect of these efforts, and found that 20% of the wheat lines in CIMMYT's global spring bread wheat breeding program contain an average of 15% of the genome segments from the wild wheat relative Aegilops tauschii.

Because CIMMYT contributions are present in nearly half of the wheat sown worldwide, this means many of the over 2.5 billion people in 89 countries who consume wheat – over 1.2 billion of whom live on less than USD 2 a day and depend on wheat as their primary staple food – are benefiting from the diversity and resilience derived from ancient wheat relatives, thanks to the synthetic wheat breeding approach. The study findings validate and make a strong case for continuing and scaling up the synthetic wheat breeding strategy to meet the urgent global demand for climate-resilient, disease- and pest-resistant, high-yielding wheat.

Links to any communications materials relating to this outcome:

- https://tinyurl.com/y9arrmbm
- https://acsess.onlinelibrary.wiley.com/doi/full/10.2135/cropsci2018.01.0017
- https://tinyurl.com/y949puyf
- https://doi.org/10.1038/s41598-019-47936-5

Part II: CGIAR system level reporting

Link to Common Results Reporting Indicator of Policies : No

Level of maturity of change reported: Level 3

Links to the Strategic Results Framework:
Sub-IDOs:

- Adoption of CGIAR materials with enhanced genetic gains
- Increased conservation and use of genetic resources
- Closed yield gaps through improved agronomic and animal husbandry practices

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

Comment: Cultivars derived from synthetic wheat currently grown on over 2 million hectares in southwest China (34% of total wheat area) and on 10% of the wheat area in India. (4)
Reported yield potential of these varieties ranges from 2.7 to 9 tonnes/ha, depending on the environment and growing conditions. The variety Chuanmai 42, released in 2003, reached a record yield of 10.7 t/ha in 2010 ? 30% higher than the previous provincial record for a wheat variety. (12)
In addition to high yield, these new varieties supply crucial traits (tolerance to drought and heat, disease/pest resistance).

Geographic scope:

- Global

Comments: <Not Defined>

Key Contributors:
Contributing CRPs/Platforms:

- Genebank - Genebank Platform

Contributing Flagships:

- FP3: Better varieties reach farmers faster
- FP2: Novel diversity and tools for improving genetic gains and breeding efficiency

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

- KSU - Kansas State University

CGIAR innovation(s) or findings that have resulted in this outcome or impact:
Improved germplasm, elite lines distributed via the International Wheat Improvement Network

Innovations:

- 465 - Elite winter wheat lines.
- 463 - Improvement of wheat landraces, collected from farmers, through evaluation and selection.
- 282 - 28 new pre-breeding wheat lines with high yield potential and climate resilience for Mexico's growing regions.

Elaboration of Outcome/Impact Statement:
More than 4.5 billion people obtain 21% of their calories and 20% of their protein from wheat. Demand is predicted to double by 2050 and wheat production cannot currently keep up. In some regions, wheat yields are now reaching a plateau, assumed to be due to lack of genetic variation (4). In addition, production faces dire threats from climate change-associated drought and heat, as well as diseases and insect pathogens.

One of the best sources of genetic diversity for high-yielding, climate-resilience and stress-tolerant wheat is from its wild relatives. (2, 5). Since the 1980s, CIMMYT has produced synthetic hexaploid wheat ? the result of crossing the wheat relative goat grass (Aegilops tauschii) with durum wheat -- to create a genetic ?bridge? to bring desired traits from wild wheat relatives to bread wheat. Between 1988 and 2010, CIMMYT used approximately 900 Aegilops tauschii accessions maintained in genebank collections to produce approximately 1300 primary synthetic wheat lines for developing varieties with improved traits.

A 2019 study by CIMMYT wheat scientist Umesh Rosyara and colleagues validated the success of this breeding technique, finding that 20% of the wheat lines in CIMMYT?s global spring bread wheat breeding program contain an average of 15% of the genome segments from Aegilops tauschii. These lines represent the result of competitive selection for traits, including high and stable yield potential, durable resistance to major rust diseases, water use-efficiency / drought tolerance, heat tolerance, end-use quality, and enhanced Zn and Fe content for nutrition (13, 14).

For example, the synthetic-derived variety Chuanmai 42, released in 2003, reached a record yield of 10.7 t/ha in 2010 ? 30% higher than the previous provincial record for a wheat variety (12). A survey (4) of users and breeders in China, India, Argentina, Pakistan, Turkey, Kazakhstan and Bolivia found that farmers cited disease and pest resistance, yield potential, and yield stability, as the top traits they observed in their synthetic wheat derived varieties, with drought-tolerance observed in nearly a third of these varieties.

Because CIMMYT contributions are present in nearly half the wheat sown worldwide, this means many of the over 2.5 billion people in 89 countries, who consume wheat -- over 1.2 billion of whom live on less than US$2 a day and depend on wheat as their primary staple food -- are benefiting from diversity and resilience derived from ancient wheat relatives.

References cited:

1. Aberkane, H., T. Payne, M. Kishi, M. Smale, A. Amri, N. Jamora. 2019. "Transferring diversity of goal grass to farmers' fields through the development of synthetic hexaploid wheat." Genebank Impacts Working Paper No. 2. CGIAR Genebank Platform, CIMMYT, ICARDA, Crop Trust. https://tinyurl.com/y949puyf

2. Crespo-Herrera, L. A., J. Crossa, J. Huerta-Espino, M. Vargas, S. Mondal, G. Velu, T.S. Payne, H. Braun, R.P. Singh. 2018. "Genetic Gains for Grain Yield in CIMMYT's Semi-Arid Wheat Yield Trials Grown in Suboptimal Environments." Crop Science. https://doi.org/10.2135/cropsci2018.01.0017

3. Dreisigacker, S., M. Kishii, J. Lage, M. Warburton. 2008. "Use of synthetic hexaploid wheat to increase diversity for CIMMYT bread wheat improvement." Australian Journal of Agricultural Research. http://hdl.handle.net/10883/1739

4. Rosyara, U., M. Kishii, T. Payne, C. P. Sansaloni, R.P. Singh, H.J. Braun, S. Dreisigacker. 2019. "Genetic Contribution of Synthetic Hexaploid Wheat to CIMMYT's Spring Bread Wheat Breeding Germplasm," Scientific Reports. https://doi.org/10.1038/s41598-019-47936-5

5. Lantican, M.A., H.J. Braun, T.S. Payne, R.P. Singh, K. Sonder, M. Baum, M. van Ginkel, O. Erenstein. 2016. "Impacts of International Wheat Improvement Research, 1994-2014." International Maize and Wheat Improvement Center. https://tinyurl.com/ycdxhf43

6. CGIAR Research Program on Wheat. 2019. ?Extensive use of wild grass-derived 'synthetic hexaploid wheat' adds diversity and resilience to modern bread wheat.? https://tinyurl.com/qk74fwm

7. Aberkane et al. 2019. "Reaching into the past to tackle new challenges: Improving wheat by conserving wild ?goat grass.?" Genebank Impacts Brief No 2. November 2019. https://www.genebanks.org/wp-content/uploads/2019/11/Impact-Brief-2-Aberkane.pdf

8. Aberkane, H. T. Payne, M. Kishi, M. Smale, A. Amri, N. Jamora. 2019. "Transferring diversity of goal grass to farmers? fields through the development of synthetic hexaploid wheat". Genebank Impacts Working Paper No. 2 CGIAR Genebank Platform, CIMMYT, ICARDA, Crop Trust. https://tinyurl.com/y949puyf

9. Ogbonnaya, Francis C., Osman Abdalla, Abdul Mujeeb-Kazi, Alvina G. Kazi, Steven S. Xu, Nick Gosman, Evans S. Lagudah, David Bonnett, Mark E. Sorrells, and Hisashi Tsujimoto. 2013. ?Synthetic Hexaploids: Harnessing Species of the Primary Gene Pool for Wheat Improvement.? Plant Breed. Rev 37: 35?122.

10. Lobell, David B., Wolfram Schlenker, and Justin Costa-Roberts. 2011. ?Climate Trends and Global Crop Production Since 1980.? Science 333 (6042): 616?20. https://doi.org/10.1126/science.1204531.

11. Dempewolf, Hannes, Gregory Baute, Justin Anderson, Benjamin Kilian, Chelsea Smith, and Luigi Guarino. 2017. Past and Future Use of Wild Relatives in Crop Breeding.? Crop Science 57 (3): 1070?1082. https://doi.org/10.2135/cropsci2016.10.0885.

12. Crespo-Herrera et al. 2018 Genetic Gains for Grain Yield in CIMMYT's Semi Arid Wheat Yield Trials Grown in Suboptimal Environments.? Crop Science. doi.org/10.2135/cropsci2018.01.0017

Quantification:

Type of quantification: a) Actual counts or estimates from a particular study (please provide reference)
Number: 2000000.00
Unit: ha
Comments: Cultivars derived from synthetic wheat are currently grown on over 2 million hectares in southwest China (34% of total wheat area) and on 10% of the wheat area in India. (4)

Type of quantification: a) Actual counts or estimates from a particular study (please provide reference)
Number: 20.00
Unit: synthetics, as a % of elite lines in CIMMYT spring wheat breeding program
Comments: Measure of genetic contribution of synthetic hexaploid wheat to CIMMYT's global spring bread wheat breeding program and a proxy measure for maintaining agro-biodiversity in the context of wheat breeding. Results show importance of synthetics in maintaining and enhancing genetic diversity and genetic gain over years & can guide a more targeted introgression strategy. https://doi.org/10.1038/s41598-019-47936-5

Type of quantification: a) Actual counts or estimates from a particular study (please provide reference)
Number: 1402.00
Unit: synthetic hexaploid wheat lines
Comments: In the past 32 years, CIMMYT has generated more than 1,401 spring type SH wheat and over two thousand crosses made between the most promising SH wheat and elite bread wheat lines. https://doi.org/10.1038/s41598-019-47936-5

Gender, Youth, Capacity Development and Climate Change:
Gender relevance: 0 - Not Targeted
Youth relevance: 0 - Not Targeted
CapDev relevance: 0 - Not Targeted
Climate Change relevance: 1 - Significant
Describe main achievements with specific **Climate Change** relevance: In addition to high yield, these new varieties supply crucial traits, including tolerance to drought and heat and pest resistance (1, 14, 15) that are urgently needed by farmers around the world. These varieties are especially important to farmers in developing countries who often have little means other than the seed they plant to protect their crop. (4)

Other cross-cutting dimensions: No

Other cross-cutting dimensions description: Agrobiodiversity and genebanks: Synthetics represent a major pathway to making use of crop wild relatives and landraces in breeding and maintaining genetic diversity in elite breeding material.

Outcome Impact Case Report link: Study #3284

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