Large Scale Pre-Breeding Efforts for Broadening Gene Pool and Genetic Improvement of Wheat

Global Challenges and Urgency for Partnership to Deploy Genetic Resources

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Vision: **Complementing the demand diversity (climate change, demand pattern, diverse cropping/farming system requirements) with GeneBank diversity through pre-breeding.**

Rationale

- Strategic mobilization of useful genetic variation from gene bank into wheat elites
- Yield enhancement under Heat-Drought
- Broadening genetic base of cultivated wheat to address current and future challenges of
  - Stress tolerance
  - Grain nutrition
  - Grain quality

The Approach

- Characterize and mobilize novel diversity to elite germplasm pool
- Connecting upstream and downstream research work for fast track and precision pre breeding
- Strengthening partnership
- Focus on Impact

Addressing multitude of challenges through pre-breeding

Examples: Pre-breeding lines for wheat improvement

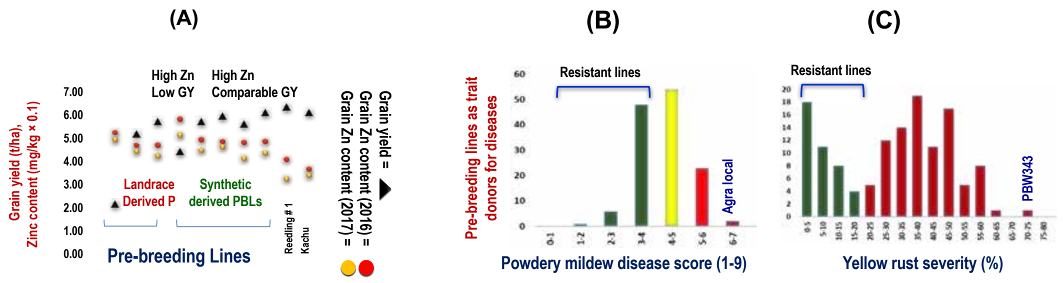
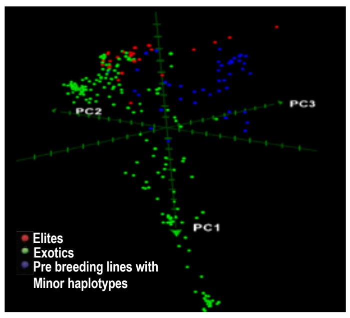


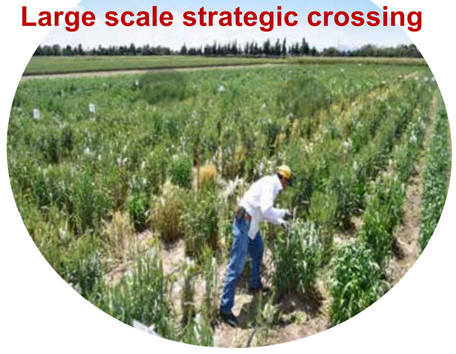
Fig. (A) Y-axis, grain yield (Mg/ha, black triangles) and zinc content [(μg g^{-1} × 0.1), orange (2015) and grey (2016) dots] for 8 PBLs and 2 check lines (X-axis). PBLs 6 and 8 had similar grain yield but significantly higher zinc content as the checks, whereas PBL 4 had very high zinc content (up to 18 μg g^{-1} higher) but low grain yield. LSD for zinc content in 2016 and 2017 was 6.8 and 6.3 μg g^{-1}, respectively, (B) Powdery mildew disease symptom scores (0 = resistant to 9 = susceptible) and (C) Yellow rust severity (%) for 134 PBLs. Green and red bars indicate resistant and susceptible PBLs, respectively.



Pre-breeding lines with Minor haplotypes are genetically diverse from elites & exotics but agronomically more closer to elites i.e. suitable for increasing the genetic base of elite germplasm pool.

Pre-breeding product

Large scale strategic crossing



Pre-breeding lines as donors for heat-drought tolerant

Grain yield under heat

GID	Exotic parent type	2015-16	2016-17
		------ kg ha^{-1}	------
7641495	Synthetic	2261	2346
7644075	Synthetic	2325*	2418**
7645422	Synthetic	2338*	2488**
7645970	Synthetic	2214	2407*
7689940	Landrace	2415*	2362
BAJ #1	Check	2144	2216
VOROBEY	Check	1769	1985
SOKOLL	Check	NA	2023

Grain yield under drought

GID	Exotic parent type	2015-16	2016-17
		------- kg ha^{-1}	--
7643084	Synthetic	3587	4510*
7642492	Synthetic	3480	4574*
7688508	Landrace	3360	4787*
7687479	Synthetic	3167	5198**
7642491	Synthetic	2766	5151**
VOROBEY	Check	3346	4613
BAJ #1	Check	3111	4858
SOKOLL	Check	NA	3968

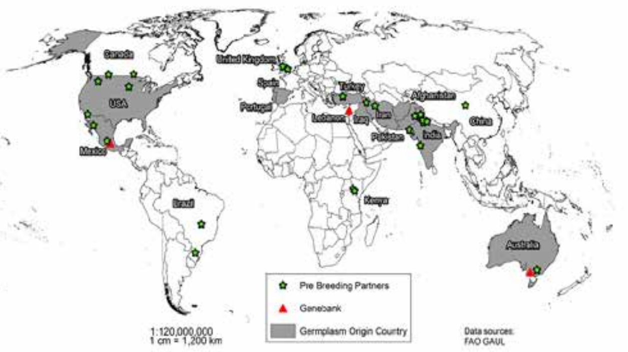


Fig. Information of regions in the world map from where exotic parents obtained and pre-breeding germplasms have been shared.

- 1,000+ exotics mobilized to elite
- 2000+ Advanced Pre Breeding lines
- 1,000+ advanced pre breeding lines evaluated by NARS wheat researches.
- Pre breeding germplasms identified as donors for *drought, heat, rusts, PM crown and root rot, quality, salinity* etc.

Investment: Upstream genomics research channelized via wheat pre-breeding to deliver impact

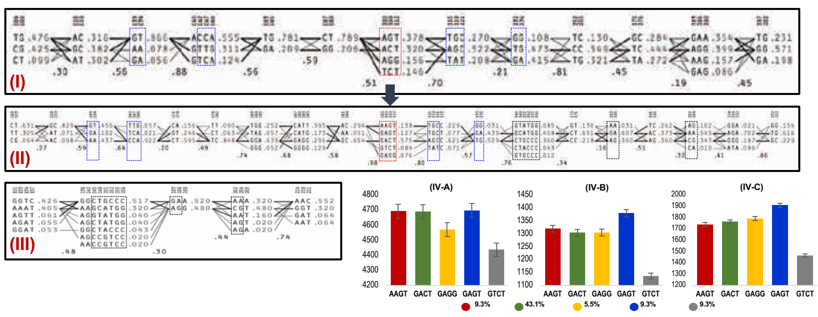


Fig. Haplotype block (HB) map of chromosome 6A in exotic parents (I), pre-breeding lines (PBLs) (II) and elite parents (III). Each haplotype is displayed in a HB with its frequency in population indicated on the right. The value shown below and between HBs represents multi-allelic D', which indicates the level of recombination between the two blocks. HBs partly enclosed in blue or black indicate introgressions from exotic or elite parents into the PBLs, respectively. HBs enclosed in red are from exotic and had significant effects for the trait. (IV) Allelic effects of HB16.10 in the PBLs: haplotype GAGT produced grain yield advantage under heat-stress in 2015 [IV-B] and 2016 [IV-C], with no disadvantage under irrigated conditions [IV-A] at Ciudad Obregon, Mexico. Haplotypes and their frequency (%) among 984 PBLs are plotted on the X-axis

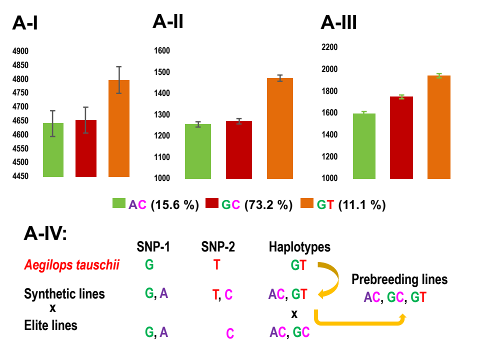


Fig. Average GY (Y-axis) and frequency (%) of PBLs with alleles AC, GC and GT (X-axis) for HB18.1 (6D). PBLs with haplotype GT had highest grain yield across 2016 irrigated (A-I), 2016 heat-stress (A-II); and 2017 heat-stress (A-III) at Ciudad Obregon, Mexico. A-IV: The origin of the yield-increasing haplotype allele, GT, was from synthetics that acquired the 'T' SNP allele from *Aegilops tauschii*. The favorable GT haplotype was present in *Ae. tauschii*, synthetics and PBLs, and was absent in elite parents of the 890 PBLs.

Tangible Outcomes:

- ~100K Gene bank accessions (CIMMYT-ICARDA) characterized by DArT-seq technology.
- Array of more than 2000 advanced Pre Breeding germplasm developed, shared & characterized.
- Novel allele diversity (minor haplotypes, rare alleles) were identified.

Opportunities

Establish large scale wheat Pre-Breeding germplasm resources through bilateral/multilateral projects to expand the impact. Data and germplasm have been shared with organizations in the U.S., Australia, Pakistan, UK, Mexico, Canada, Turkey, Kenya, Brazil, and India. Germplasm and other resources are available to interested researchers on request.

Acknowledgement

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BGRI Borlaug Global Rust Initiative
SAGARPA Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación
HarvestPlus Breeding Crops for Better Nutrition
CIMMYT International Maize and Wheat Improvement Center