国际农业大科学计划宣讲研讨会
International Mega Programmes – Lessons to Learn
CAAS, Beijing, China, June 25-28, 2018

Big data driven China-CIMMYT collaboration in genomics and molecular breeding

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CIMMYT-CAAS Joint Research Center for Genomics and Molecular Breeding

Institute of Crop Science, CAAS and CIMMYT-China

Outline

- Big data in maize genomics and plant breeding
- Major advances and achievements in China-CIMMYT maize collaboration (2010-2018)
- Future maize collaboration driven by big data

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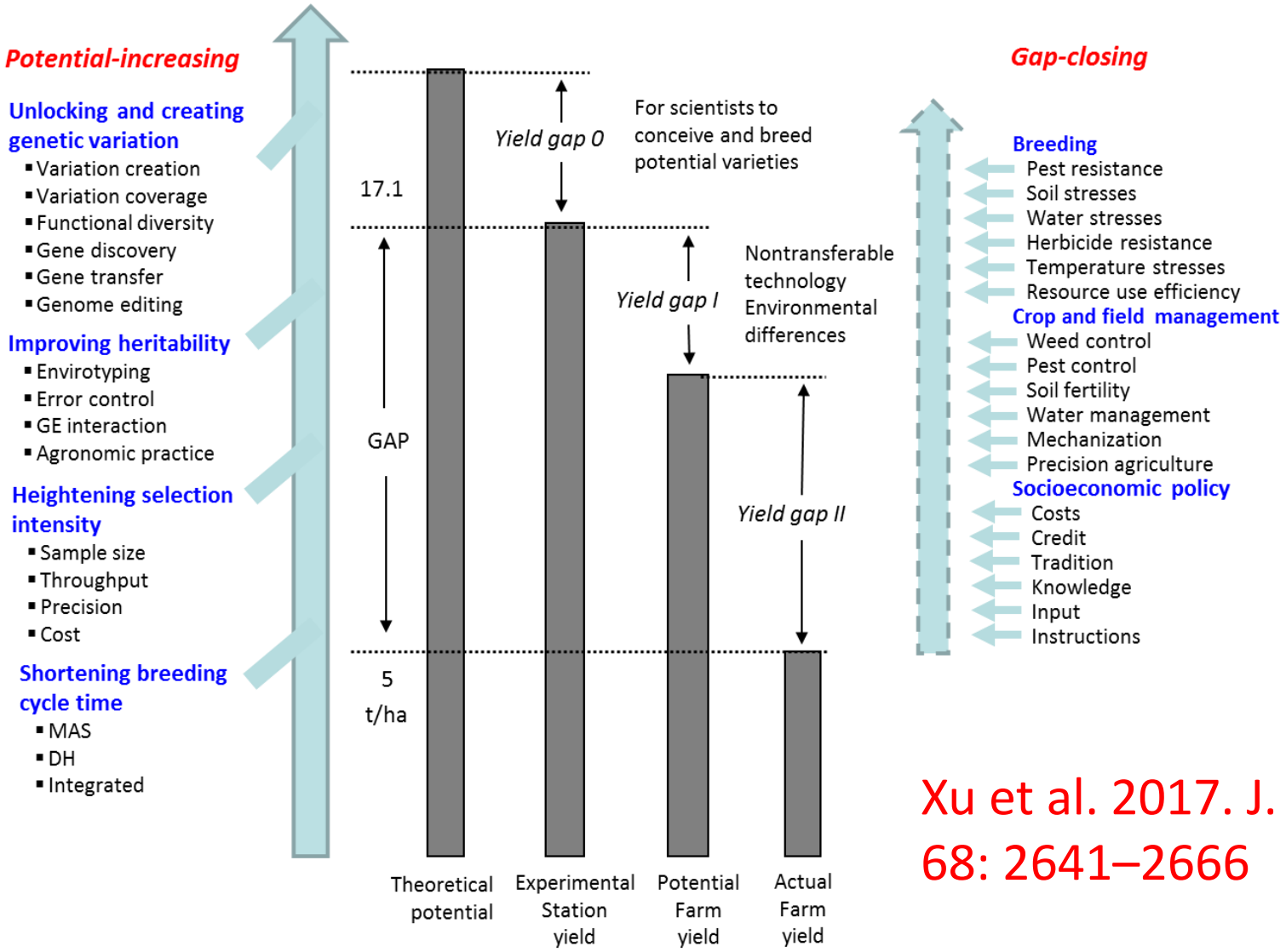
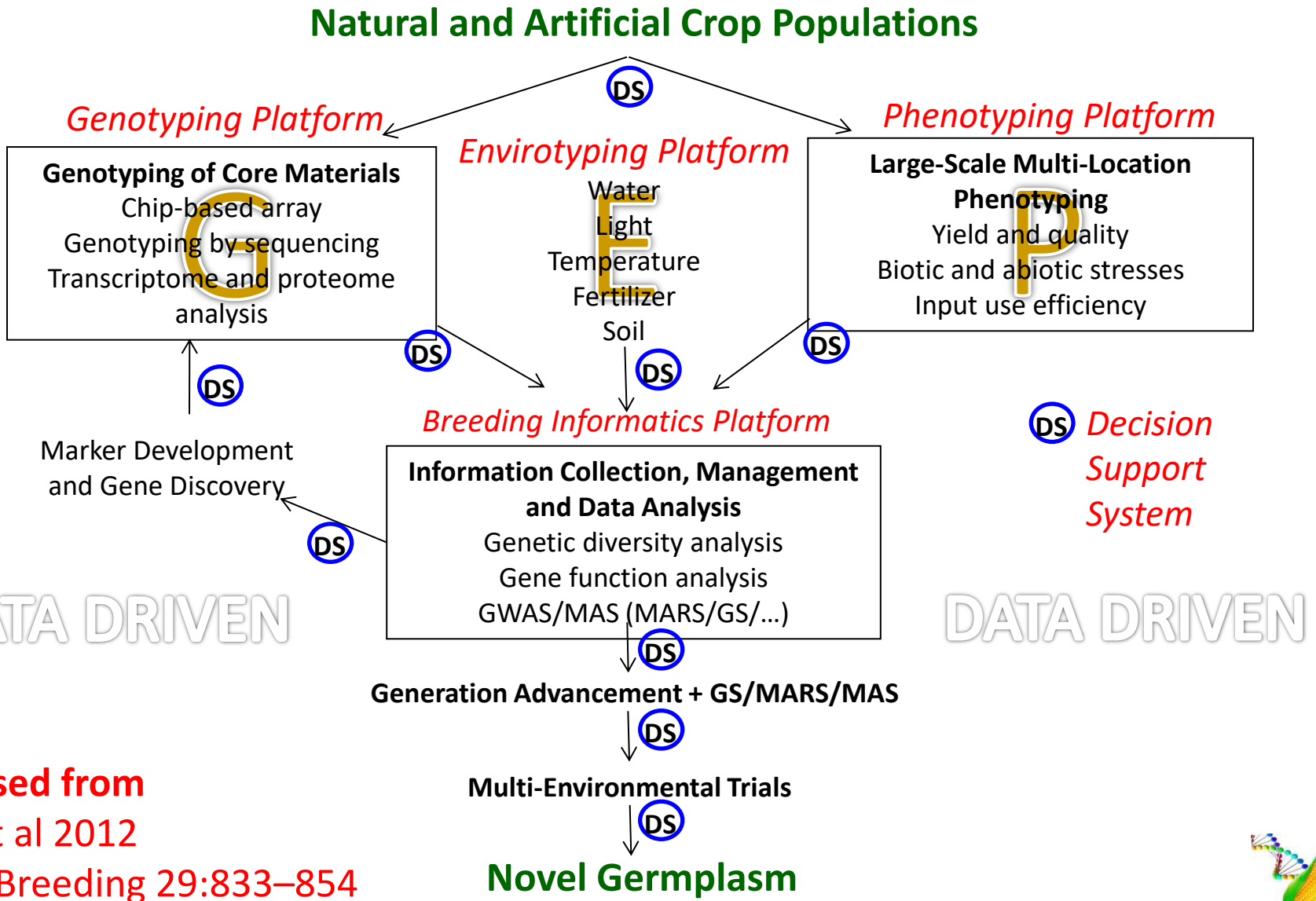
Enhancing genetic gain through potential increasing and gap closing



Xu et al. 2017. J. Exp. Bot. 68: 2641–2666

Big data and support systems in molecular breeding



Revised from
Xu et al 2012
Mol Breeding 29:833–854

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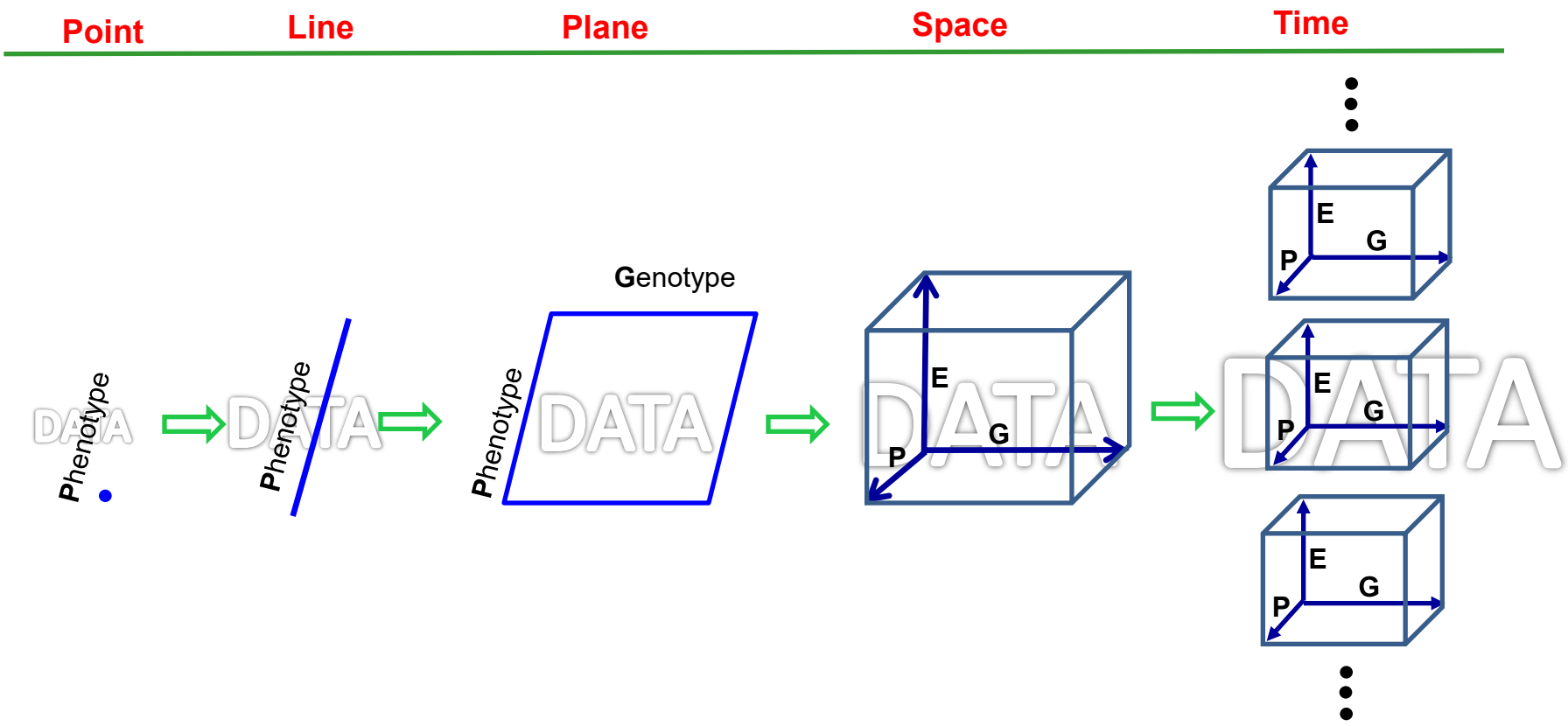
Breeding revolution driven by increasing data collection



Single phenotype	Multiple phenotypes	Multi-phenotypes assisted by genotypes	Multi-phenotypes across environments assisted by genotypes	Multi-phenotypes across environments and time series assisted by genotypes

4-D profile of plant breeding

Xu 2016 Theor Appl Genet 129: 653–673

Data revolution in plant breeding

Media: Notebook ➡ Excel ➡ Database ➡ … …

Scale: 10^3 (K) ➡ 10^6 (M) ➡ 10^9 (B) ➡ 10^{12} (T)

Dimension: One (P) ➡ Two (PXG) ➡ Three (PX GXE) ➡ Four (PXGXEXT)

P: Phenotype; G: Genotype; E: Environment; T: Time

Throughput: 1 ➡ 100 (1X96) ➡ 10,000 (96X96) ➡ 1M (384X3072) ➡ 100M (384X300K)

Precision:

Repeatability	Duplicability	Compatibility
Additivity	Predictability	

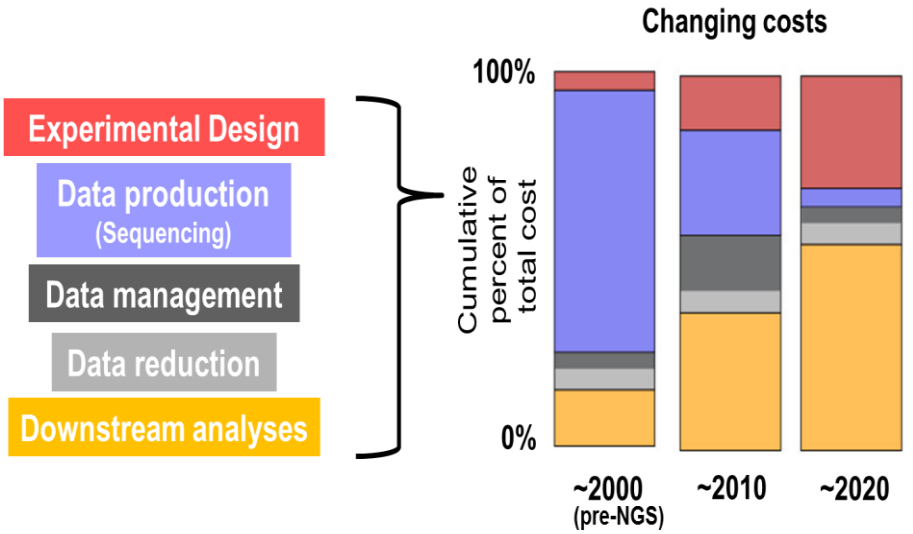
Yunbi Xu (2018) unpublished

Data generation and analysis are costly and time consuming

Genome Biol. 2011 Aug 25;12(8):125. doi: 10.1186/gb-2011-12-8-125.

The real cost of sequencing: higher than you think!

Sboner A, Mu XJ, Greenbaum D, Auerbach RK, Gerstein MB.



Breeding Application

CIMMYT and donors are eager to maximize the use and impact of data

Revised from
Kate Drehe 2013
CIMMYT Science Week

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Milestones of China-CIMMYT collaboration in maize

Oct. 19, 2009 ICS, CAAS
Maize Molecular Breeding Laboratory

1 scientist supported by CIMMYT + local scientists

Oct. 23, 2009 Yunnan Acad. Agri. Sci.
Maize diseases and breeding

1 scientist supported by CIMMYT + local scientists

Jan. 6, 2017 Henan Agri. Univ. (HAU)
CIMMYT-China Maize and wheat Research Center

2 CIMMYT scientists supported by HAU

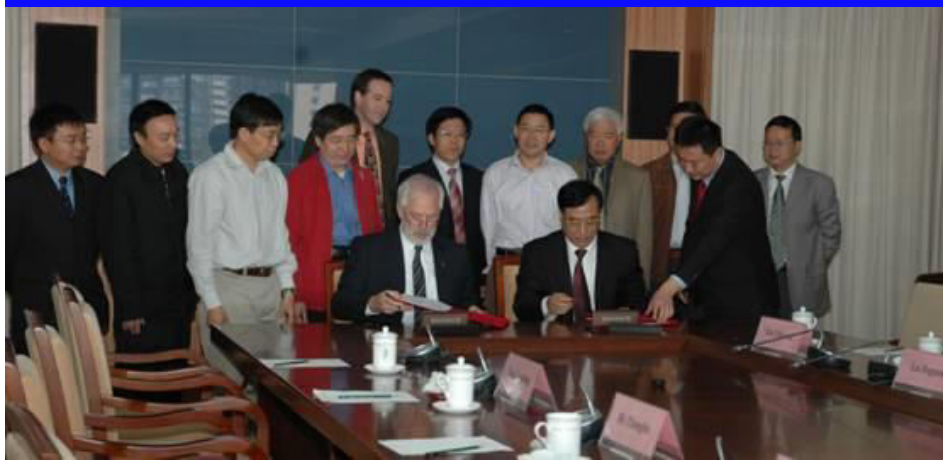
Nov. 30, 2017 Foshan University, Guangdong
CIMMYT-China Tropical Maize Research Center

Adjunct scientists supported by FU

March 30, 2018 Shanghai Acad. Agri. Sci.
CIMMYT-China Specialty Maize Research Center

Adjunct scientists supported by SAAS

MoA was signed on 19 Oct , 2009 for establishment of CIMMYT-CAAS Joint Research Center for Genomics and Molecular Breeding in CAAS



MoU was signed on Yunbi's posting in the Institute of Crop Science, CAAS, Aug. 6, 2010

ccMaize (www.ccmaize.org)

Maize Molecular Breeding Laboratory

CIMMYT-CAAS Joint Research Center for Genomics and Molecular Breeding

Genomics and molecular breeding

CIMMYT managers visiting ccMaize, CAAS, Beijing, May 17, 2012

Major advances in China-CIMMYT collaborative projects (2010-2018)

- **Molecular breeding platforms**
  - Breeding network: informatics and support tools
    - Public research institutions/universities
    - Private seed companies
    - Genotyping service providers
  - Affordable genotyping system
    - 55K SNP chip
    - 1K, 5K, 10K and 20K GBS or multiplexing-PCR markers
  - Concept development
    - Envirotyping to characterize environments
    - Bulked sample analysis to simplify genetic mapping
- **Maize resequencing and hapmap construction**
  - Resequencing 100+ key maize germplasm accessions (40T data)
  - Construction of hapmaps II, III and IV, and maize pangenome
- **Linkage mapping/GWAS and marker development**
  - Multiple biotic and abiotic stresses, yield, and hybrid performance
- **Marker-assisted selection**
  - Gene introgression from tropical to temperate: GLS, TLB, …
  - Genomic selection for complex traits: yield, plant density, DT, …

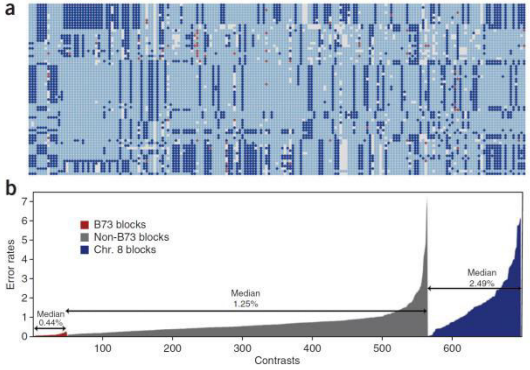
Major achievements in China-CIMMYT collaboration (2010-2018) (1)

Introduction of over 2000 maize accessions

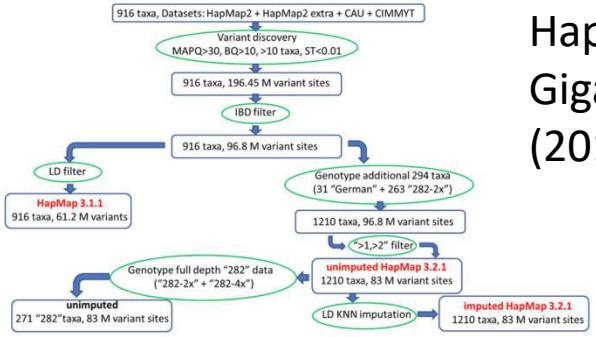
Training over 500+ students, scientists and breeders

Leading scientists, breeders and senior managers

Publication of over 50+ articles through collaboration with partners



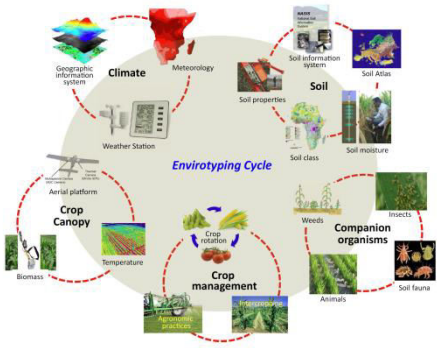
HapMap II
Nat Genet
(2012)



HapMap III
GigaScience
(2018)

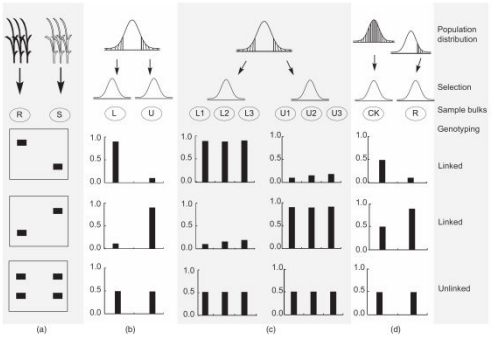
Partners: CIMMYT, CAAS, Cornell, CSHL, BGI, SCAU, CAU, ZJU

Major achievements in China-CIMMYT collaboration (2010-2018) (2)



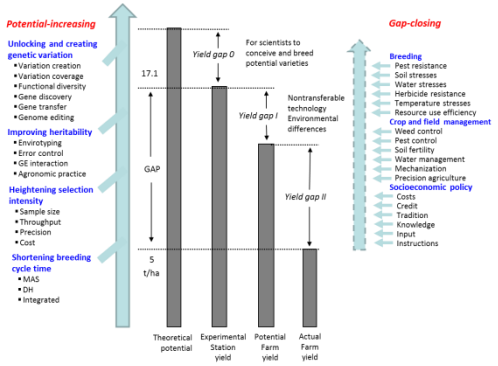
Envirotyping concept

Theor Appl Genet (2016)



Bulked sample analysis

Plant Biotech J (2016)



Genetic gain strategies

J Exp Bot (2017)

National award “Top 100 PhD Dissertations” to a China-CIMMYT joint training student (Yanli Lu, 2012, Sichuan Agri. Univ.)

Magnolia Silver Award (to Yunbi Xu for his outstanding contribution to international collaboration), Shanghai, 2014

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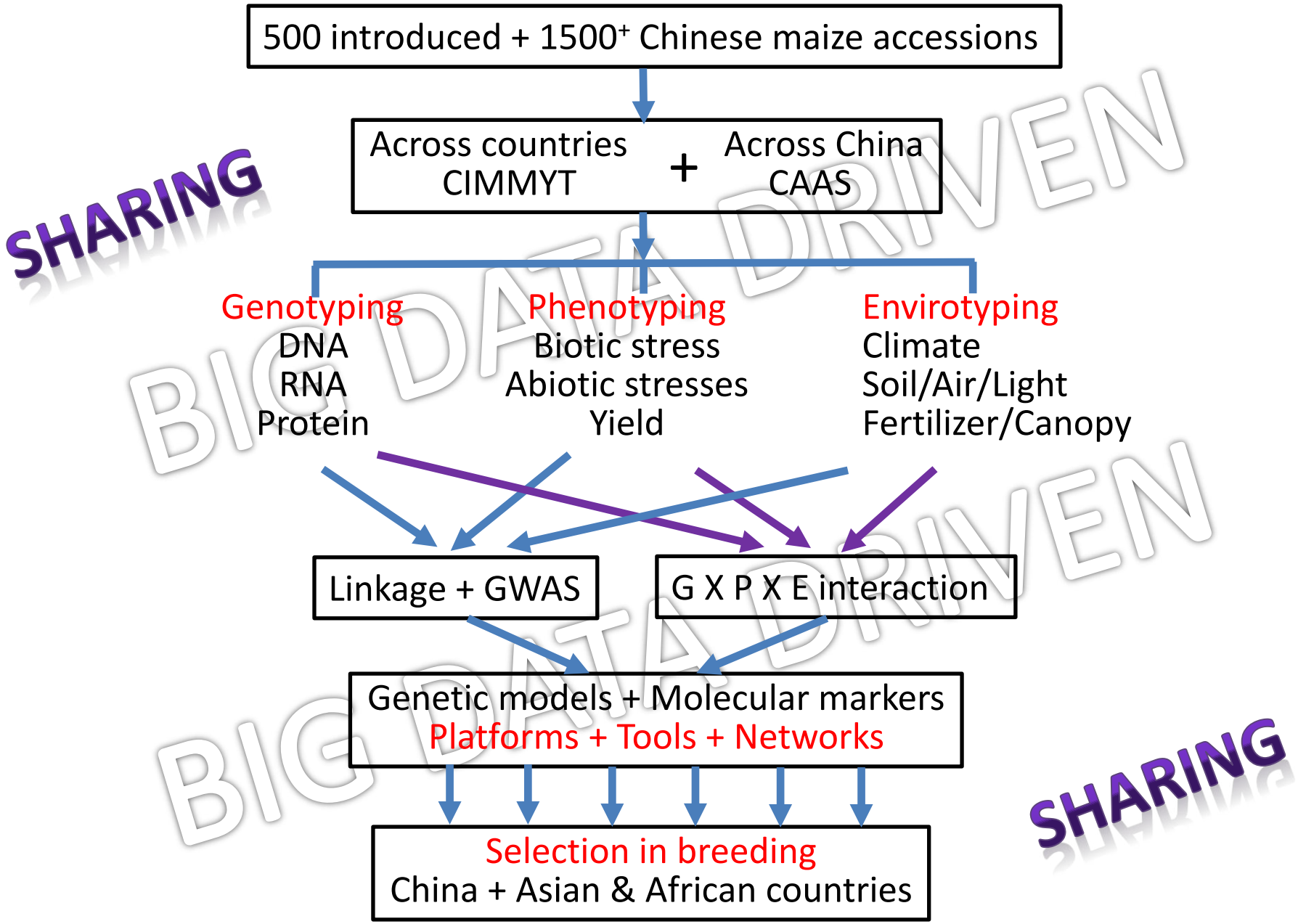
Big data driven China-CIMMYT collaboration

- A comprehensive understanding of the genomic architecture of globally important maize genetic resources to accelerate gains.
- Novel genomics-assisted tropical/temperate maize introgression supported by appropriate phenotyping sites.
- Decision support systems and tools to improve resource use efficiency in maize, improve soil health, reduce erosion and pollution, in support of a greener agriculture in China.
- More collaborative research and scientific exchange programs, involving a greater number of Chinese scientists, and supporting network in CIMMYT-China collaboration across Chinese institutions and universities
- Stronger China-CIMMYT-Asia and China-CIMMYT-Africa partnerships through the Road and Belt Initiative of China.

Objectives in genomics and molecular breeding

- Introduction of 500 maize accessions, including specialty maize, for biotic/abiotic stress tolerance and adaptability;
- High-resolution genotyping and precision phenotyping of 2000^{+} maize accessions for biotic/abiotic stress tolerance in multi-environment trials through China-CIMMYT collaboration;
- Integration of the generated data with the 20K CIMMYT maize accessions genotyped by GBS to build big data for worldwide GWAS, functional marker development, GS model construction and molecular breeding through international partnership supported by China and CIMMYT;
- Development of network and support systems for international maize molecular breeding, by developing and sharing affordable genotyping platforms, available molecular markers, prediction models, and bioinformatics /decision support tools, supported by big data and AI-assisted plant breeding.


500 introduced + 1500+ Chinese maize accessions
Across countries
CIMMYT
+
Across China
CAAS
SHARING
BIG DATA DRIVEN
Genotyping
DNA
RNA
Protein
Phenotyping
Biotic stress
Abiotic stresses
Yield
Envirotyping
Climate
Soil/Air/Light
Fertilizer/Canopy
Linkage + GWAS
G X P X E interaction
Genetic models + Molecular markers
Platforms + Tools + Networks
Selection in breeding
China + Asian & African countries
BIG DATA DRIVEN
SHARING

The roles of CAAS in China-CIMMYT maize collaboration

- Strategic planning and policy development for international collaboration between China and CG centers
- Coordination of CAAS-CIMMYT collaboration involving multiple CAAS institutes including Institute of Crop Science, Institute of Biotechnology, Institute of Plant Protection, Institute of Agricultural Economics and Development, Institute of Agricultural Resources and Regional Planning, and Institute of Environment and Sustainable Development in Agriculture
- Coordination of countrywide China-CIMMYT collaboration, involving both the existing institutions/universities, i.e., Henan Agricultural University, Foshan University, Shanghai and Yunnan Academies of Agricultural Sciences, and future collaborators, e.g., China Agricultural University.
- Coordination of worldwide China-CIMMYT collaboration, involving Asian and African countries
- Working with Chinese government agencies and international organizations/donors to support and strengthen China-CIMMYT collaboration, including fundraising, training and scientific exchange.

Acknowledgements

Partners and collaborators

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Yunnan Acad. Agri. Sci.

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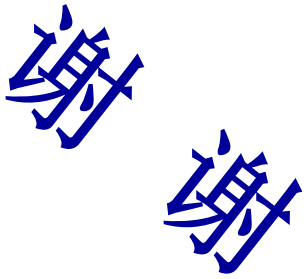
National Natural Science Foundation of China
Ministry of Science and Technology of China
Ministry of Agricultural and Rural Affairs of China
Agriculture S&T Innovation Program, CAAS



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