

The Application of Genomic Resources in Wheat Breeding



University of Saskatchewan Senate Meeting



UNIVERSITY OF
SASKATCHEWAN

Kirby Nilsen
Durum Wheat Breeding and Genetics Program
Crop Development Centre

The tragic ripples of
an epic fraud p. 437

Insect pest profits from
maize defenses pp. 462 & 494

Photoredox activation
of methane pp. 474 & 488

Science

310
17 AUGUST 2018
science.org

AAAS



- 17 Gb genome
- 42 chromosomes
- 100,000 genes
- Highly repetitive
- Allopolyploid

ROAD MAP FOR WHEAT

Ordered sequence will
speed research pp. 625, 662, & 662



UNIVERSITY OF SASKATCHEWAN

Crop Development Centre

COLLEGE OF AGRICULTURE AND BIORESOURCES
AGBIO.USASK.CA

What Do Genome Sequences Offer?

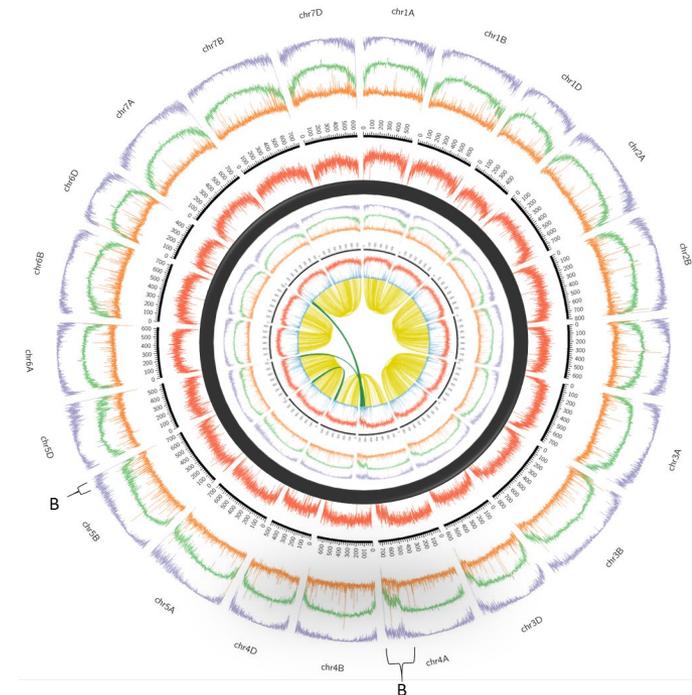
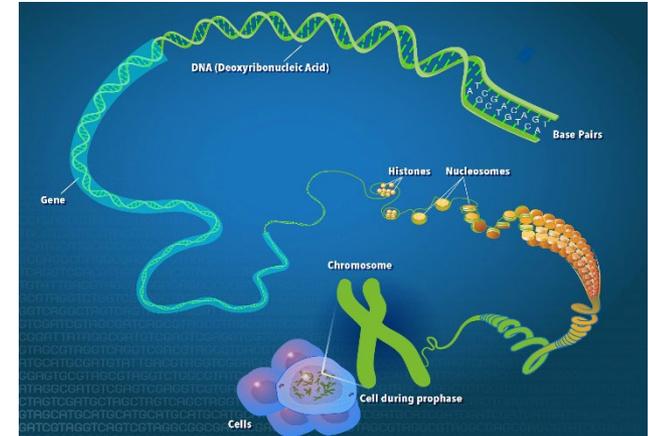
- A resource for reference based mapping
 - Unlimited source of DNA markers for MAS/genomic selection
- Physical intervals for quantitative trait loci
- A roadmap of genes
- Candidate genes for traits = perfect markers
- Discovery and exploitation of new alleles



What is Genomics?

The study of genomes and their function

- **Structural genomics:** Examines the physical nature of genomes
- **Comparative genomics:** Compares the structure of genomes within/between different individuals or species
- **Functional genomics:** Studies expression and function of the genome

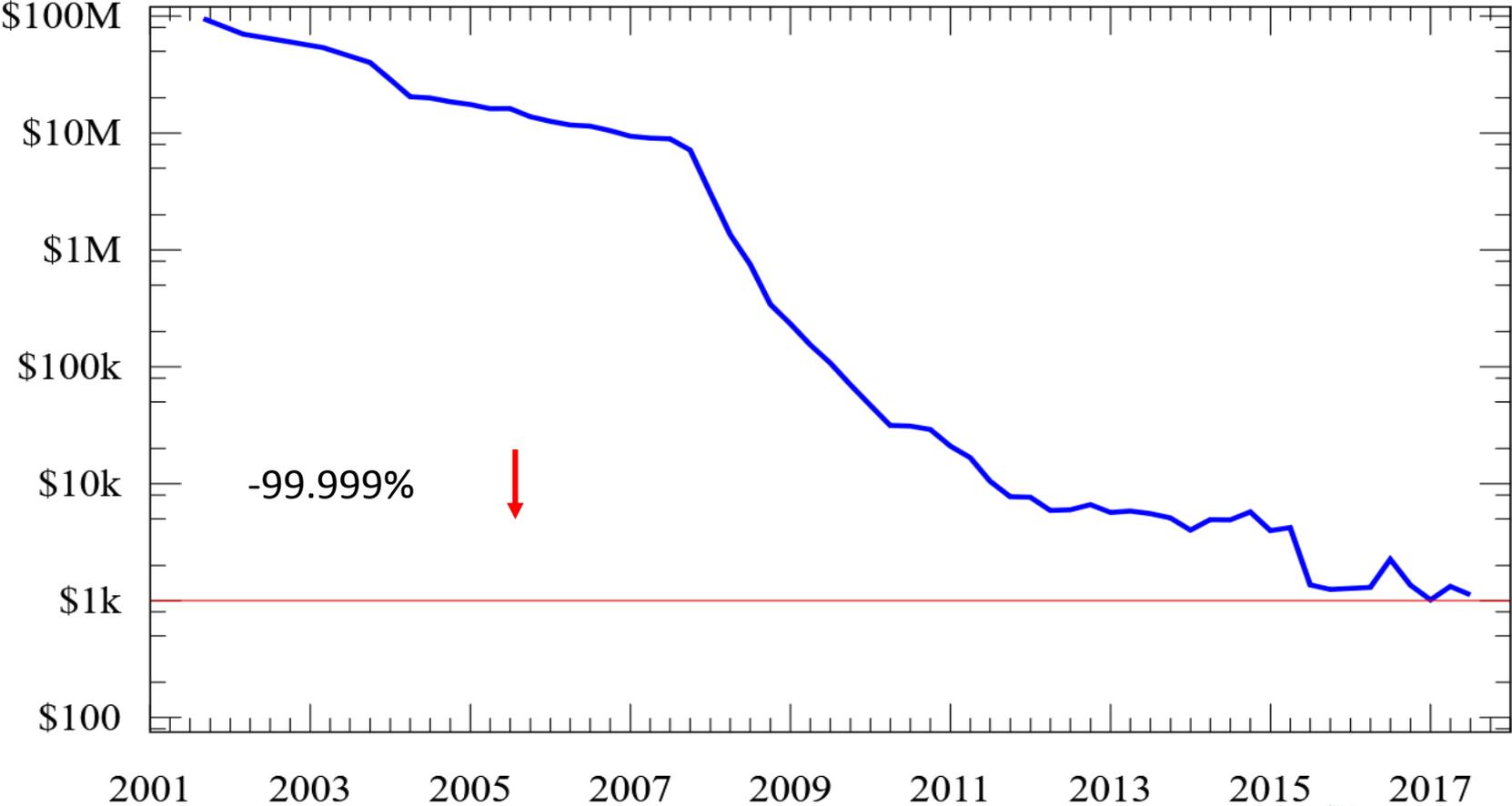


UNIVERSITY OF SASKATCHEWAN

Crop Development Centre

COLLEGE OF AGRICULTURE AND BIORESOURCES
AGBIO.USASK.CA

Cost to Sequence a Human Genome



Roche/454



Illumina



Ion Torrent



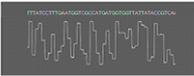
PacBio



10x Genomics



Oxford Nanopore

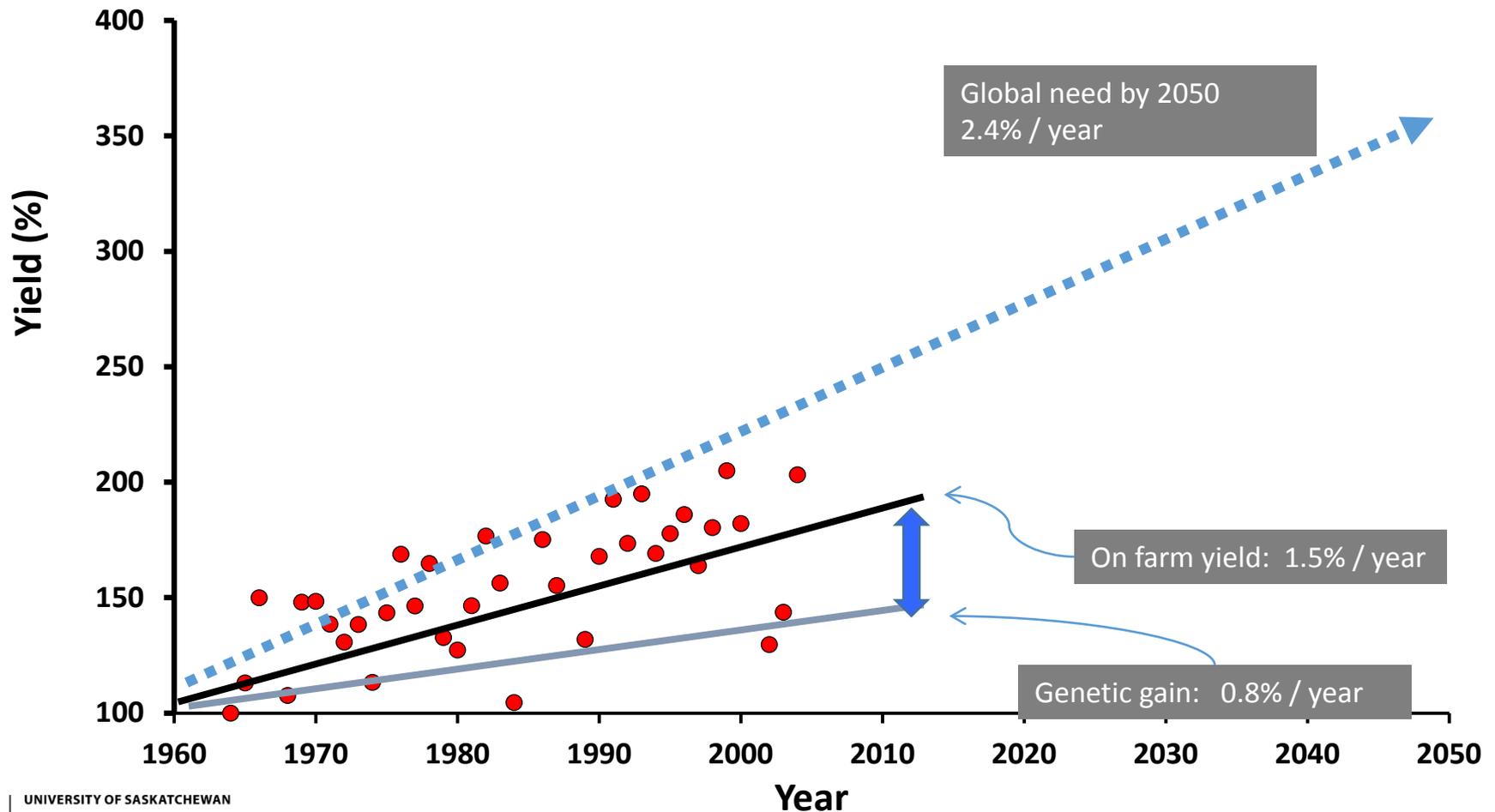


Priorities in Wheat Breeding

- Increase Yields – **Profitability**
- Durable disease and pest resistance – **Yield Stability**
 - Wheat Rusts – new virulence
 - FHB – symptoms/mycotoxins,
 - insect pests (midge, sawfly)
- Abiotic stresses
 - Drought, heat stress
- Nutrient use efficiency
- End-use quality - **Marketability**



Annual Yield Gains Lag Future Demand



Bridging the Yield Gap With Genomics



CTAG²

Canadian Triticum Applied Genomics

WHEAT GENOME SEQUENCE

MODULATING
RECOMBINATION

EPIGENETIC
VARIATION

ASSOCIATION
GENETICS

GENE
DISCOVERY

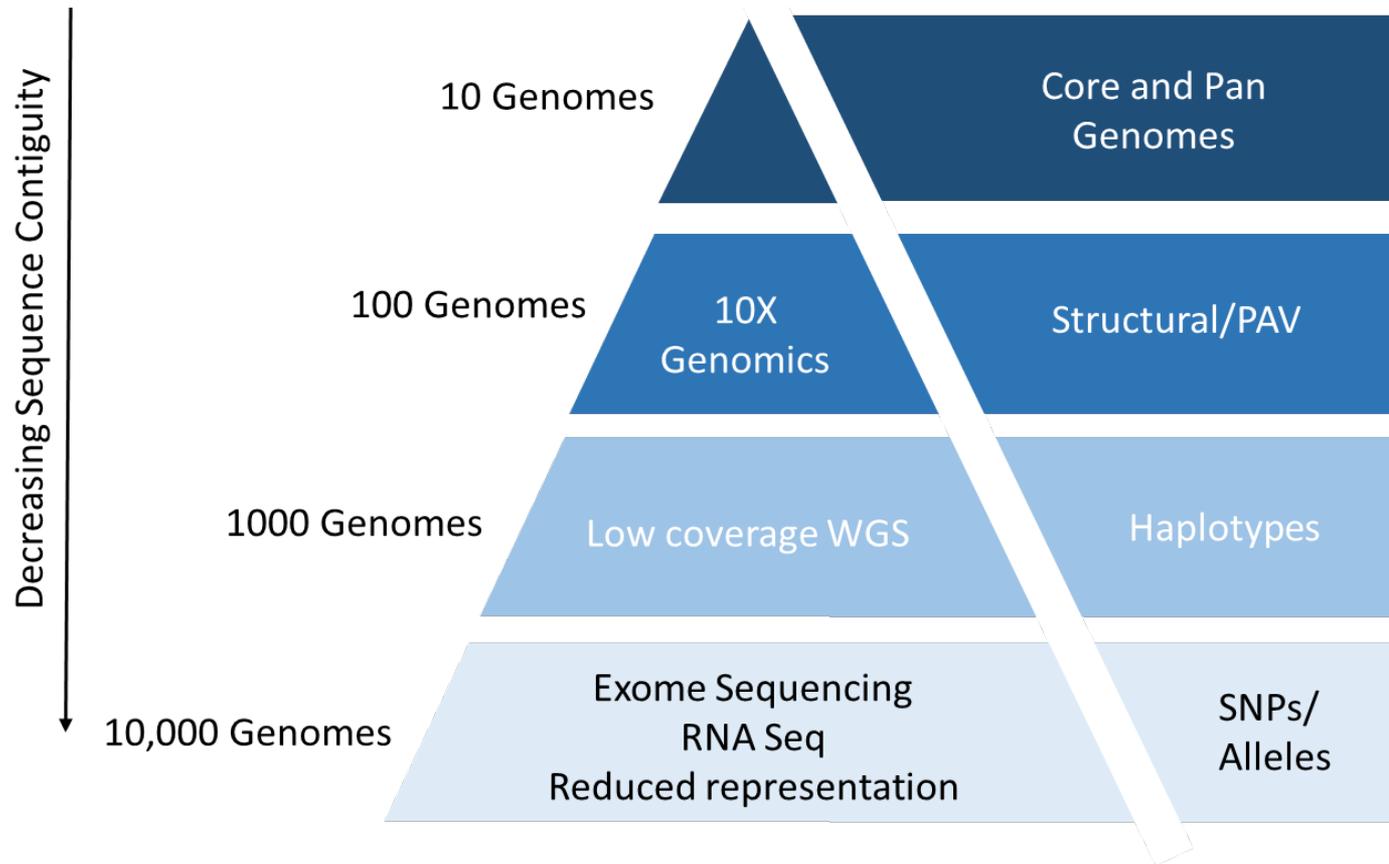
MARKER
DISCOVERY

GENOMIC
SELECTION



Harnessing the Diversity of Wheat

2018 - Chinese Spring Genome



Genotyping

Single Marker:

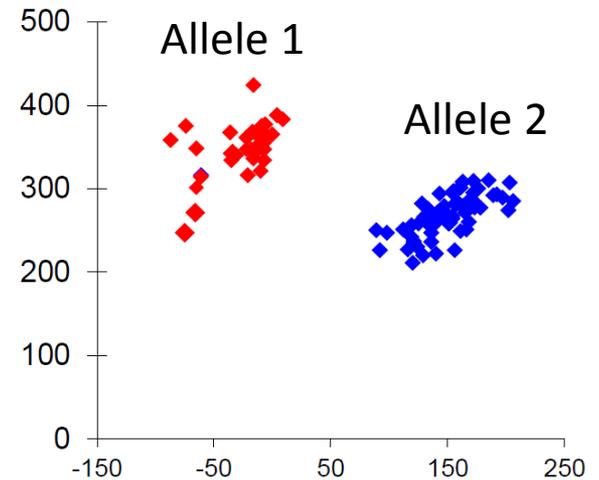
- Agarose Gel
 - SSR (short sequence repeat)
 - CAPS (cleaved amplified polymorphic sequence)
- Fluorescent Dye
 - KASP (kompetative allele specific PCR)

Marker Arrays:

- 9K SNP array (Illumina)
- 90k SNP iSelect array (Illumina)
- 820k SNP array (Axiom)
- Breeder array

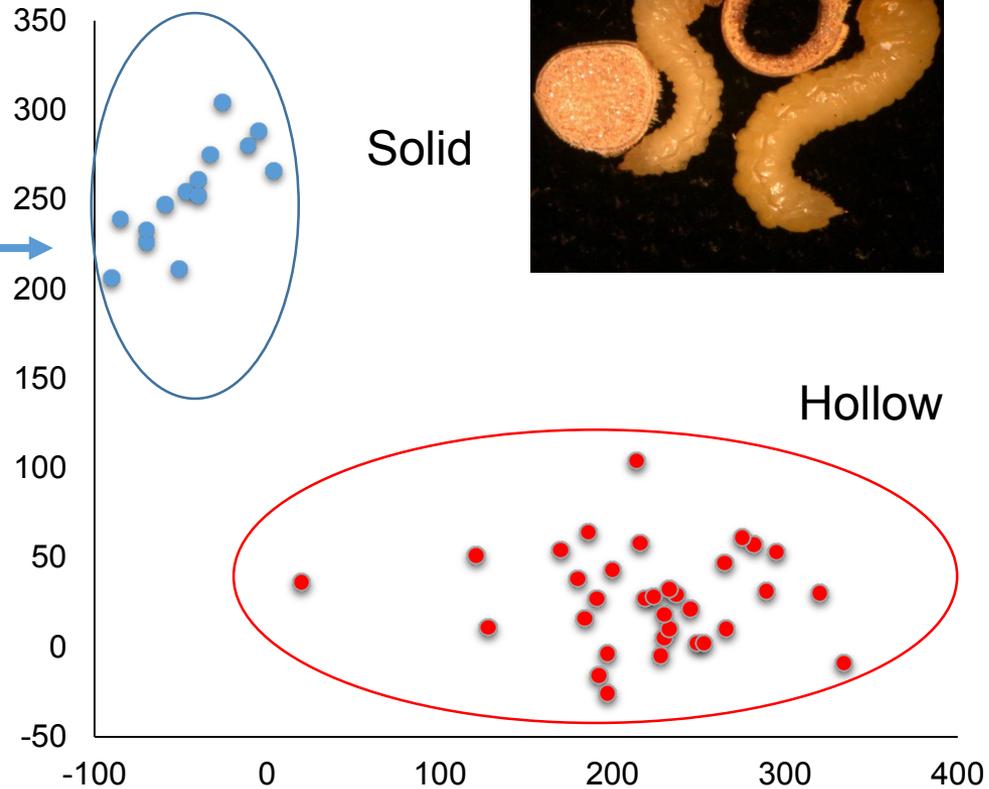
Sequencing:

- GBS (genotype by sequencing)
- Exome (gene space from genomic DNA)
- RNAseq (gene space from mRNA)



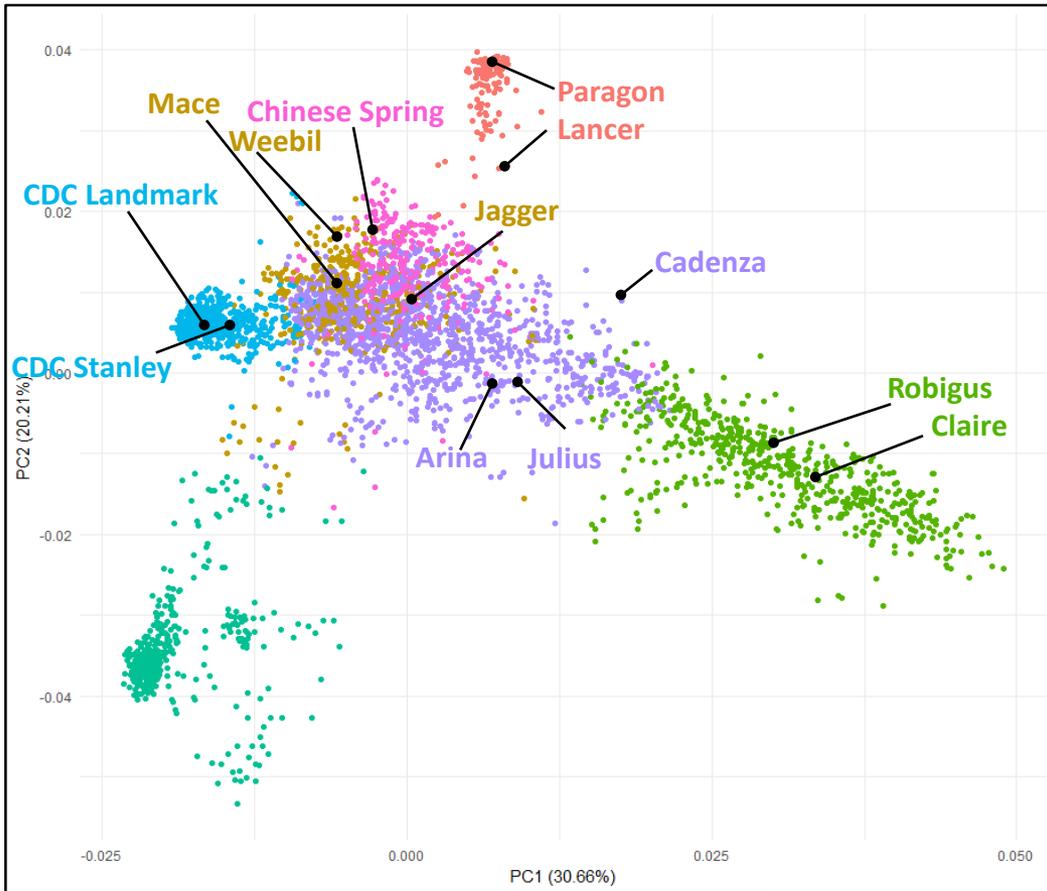
Marker Assisted Selection

3BL

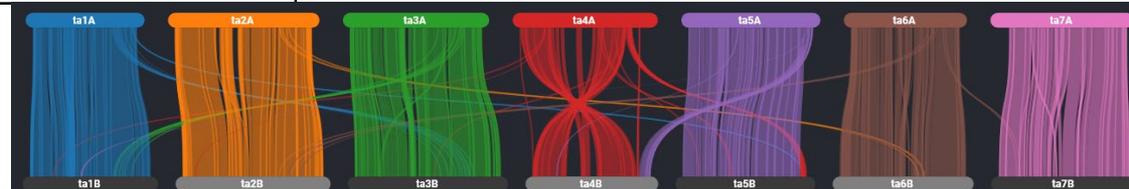


R. Appels et. al. (2018) Shifting the limits in wheat research and breeding using a fully annotated reference genome. *Science*. 361 (6403) eaar7191.

Unlocking Global Genetic Diversity



Genomic Diversity Analysis:
Narrowing genetic diversity
an issue for evolving pests
and pathogens of wheat

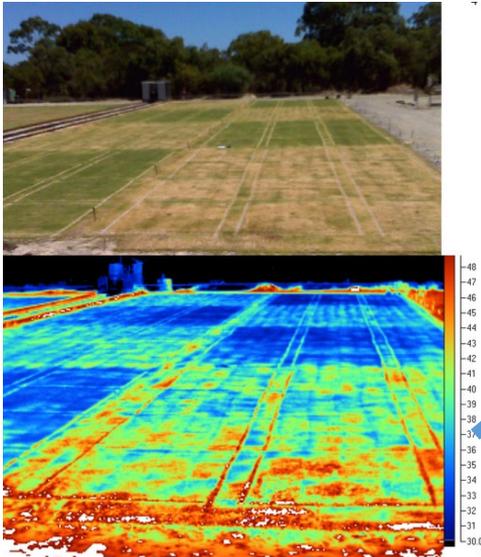


Predictive Selection

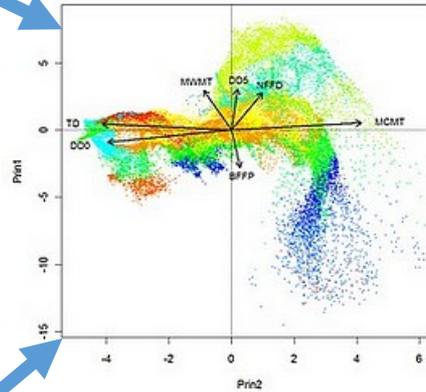
Genotyping



Phenotypic Data

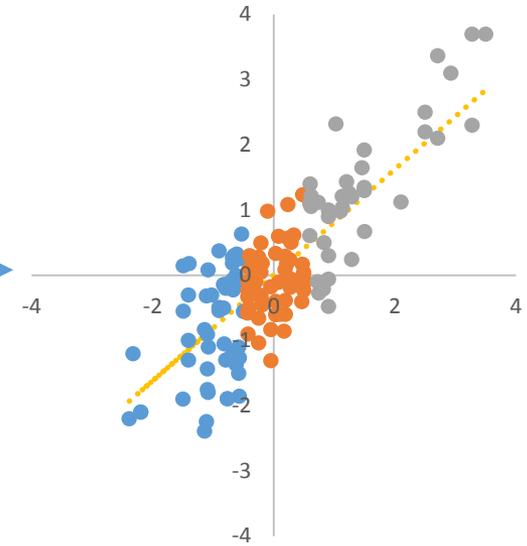


Multivariate Statistics



Predictive Models

PREDICTIVE BREEDING



Actual vs. Predicted Yield



Summary: Impact of Genomics on Breeding

- Reference sequences are the starting point for integrated genomics
- Characterizing the full diversity of the species, and wild relatives
- Identifying the function of genes, and assigning marker trait associations
- Shift in towards predictive breeding strategies combined with classical plant breeding approaches



Acknowledgements



Dr. Ron MacLachlan
Dr. Amidou N'Diaye
Dr. John Clarke
Dr. Aron Cory
Dr. Sean Walkowiak
Krysta Wiebe
Jennifer Ens
Lexie Martin
Justin Coulson
Russel Lawrie
Ryan Babonich
Heidi Lazorko
Vinh Tang
Dr. Karen Tanino
Dr. Ian Willick
Dr. Prakash Venglat



Dr. Brian Beres
Dr. Yuefeng Ruan
Dr. Fran Clarke
Dr. Richard Cuthbert
Dr. Ron Knox
Dr. Steve Robinson



Dr. Andrew Sharpe
Dr. Kevin Koh

Funding provided by:

Robert P. Knowles Scholarship
Earl Davis Mallough Scholarship
Gerhard Rakow Memorial Award



CTAG²

Canadian Triticum Applied Genomics



GenomeCanada



Dr. Raju Datla
Dr. Daoquan Xiang
Dr. Teagen Quilichini
Dr. Gao Peng



Canadian Light Source
Centre canadien de rayonnement synchrotron

Dr. Chithra Karunakaran
Toby Bond



Canada's Seed Partner



GenomePrairie

Questions ?

