



Genome structural variations for environmental adaptation

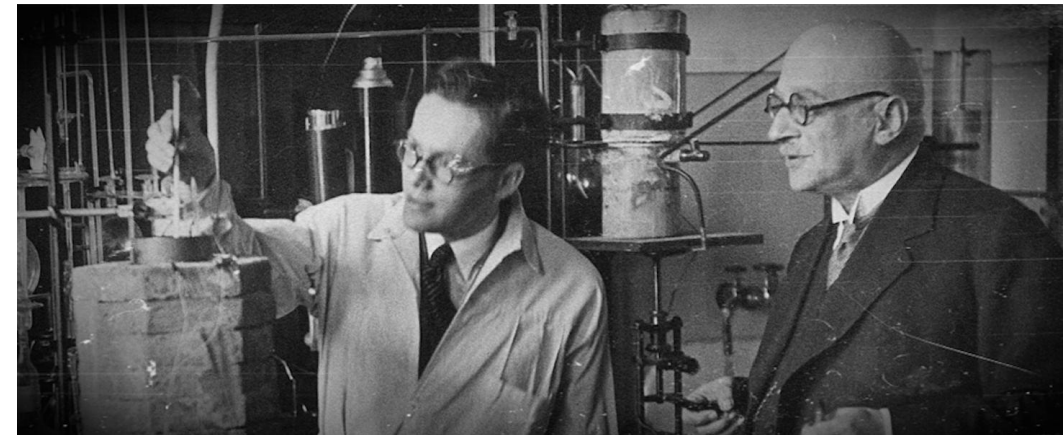
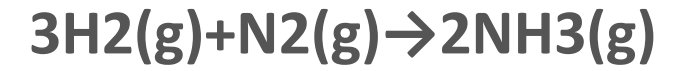
Chengdao Li
Western Crop Genetics Alliance
March 2026

The Green Revolution



Norman Borlaug Awards Nobel Peace Prize 1970

The Haber-Bosch process

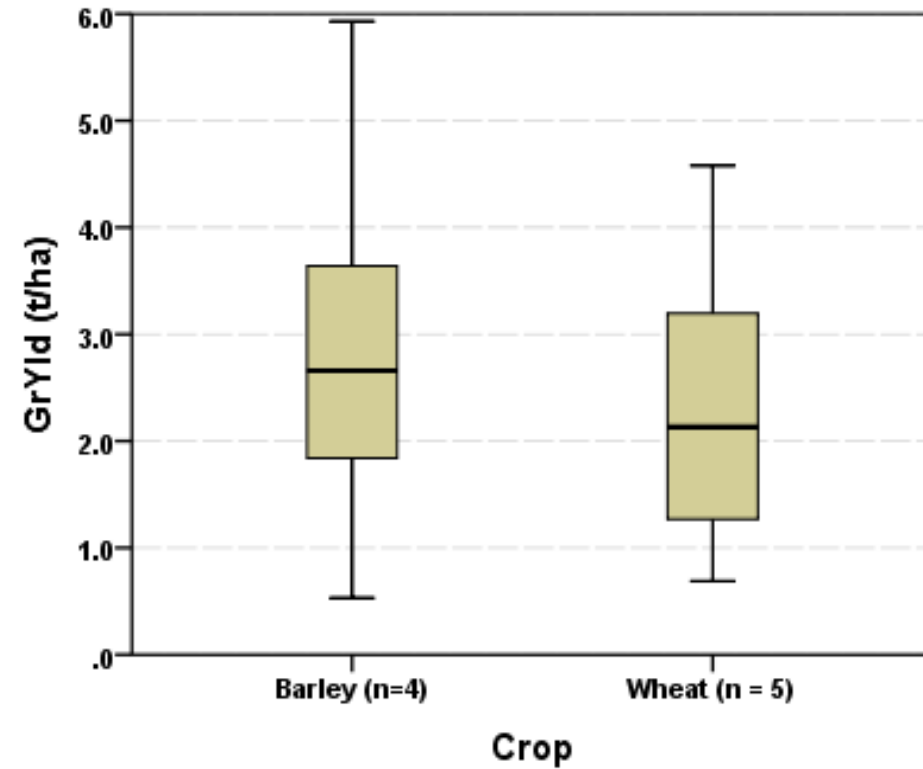


Fritz Haber 1918 Nobel Chemistry

Carl Bosch 1931 Nobel Chemistry

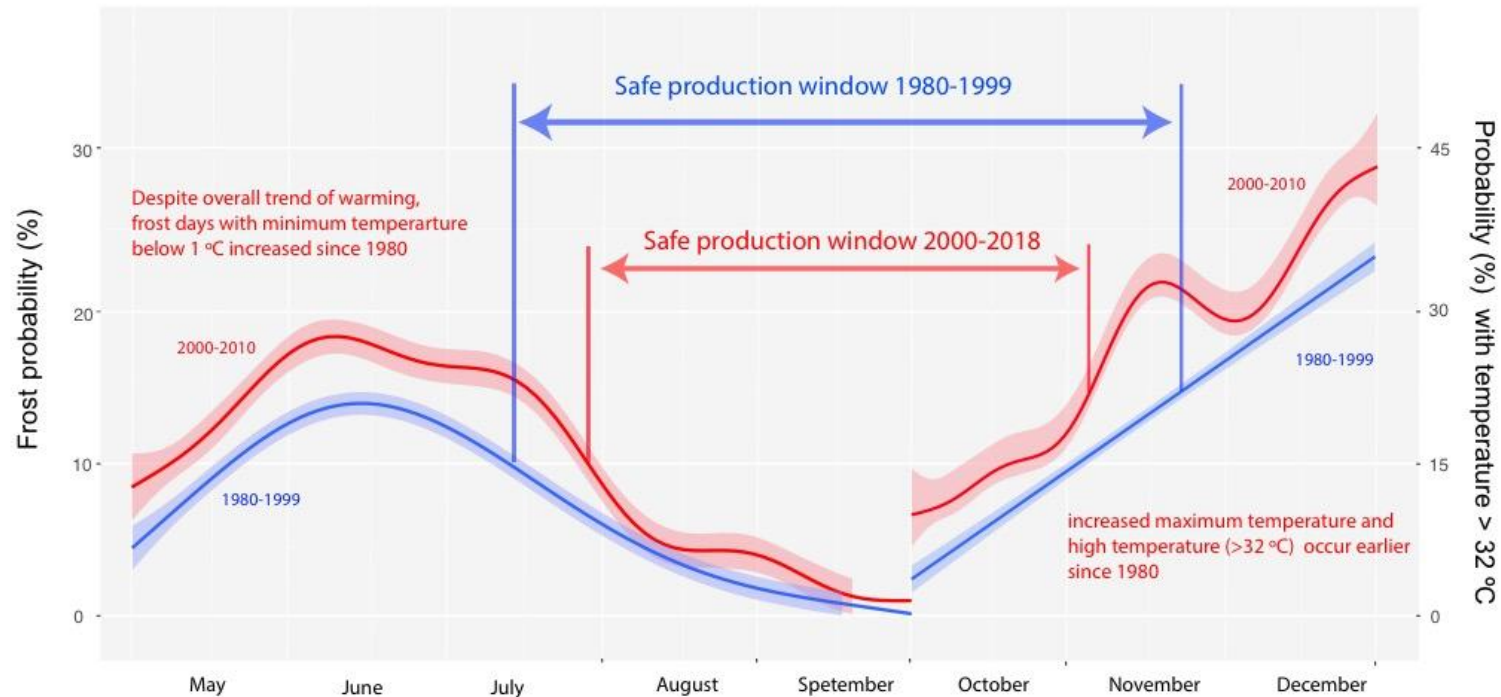
Impact of climate changes on barley and wheat yield since 1950

Barley out yield of wheat by average of 22%
WBGA Field Trials



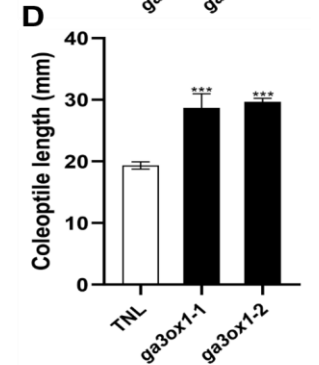
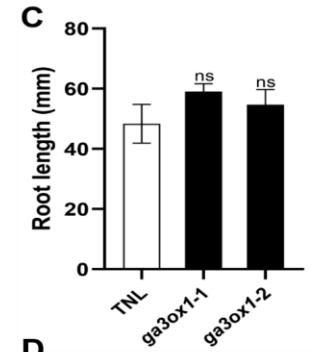
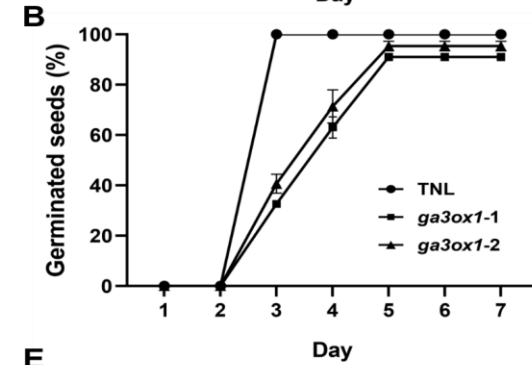
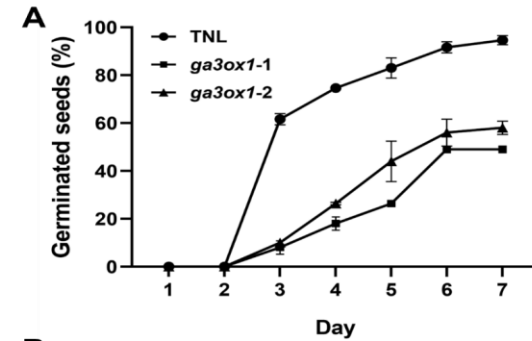
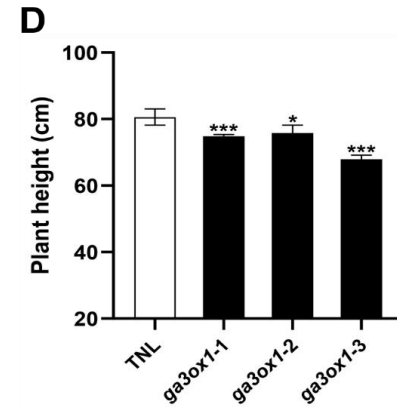
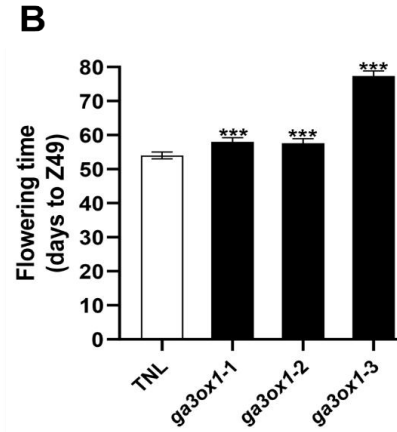
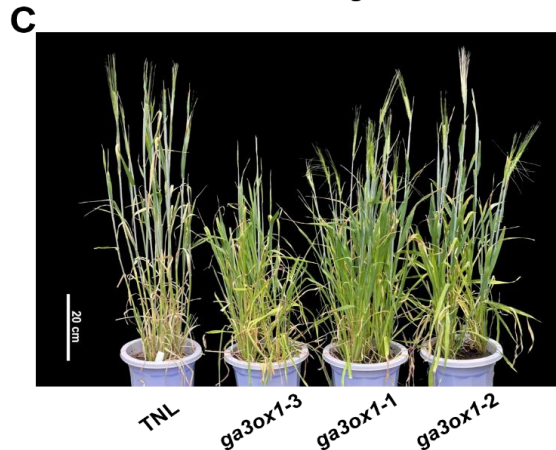
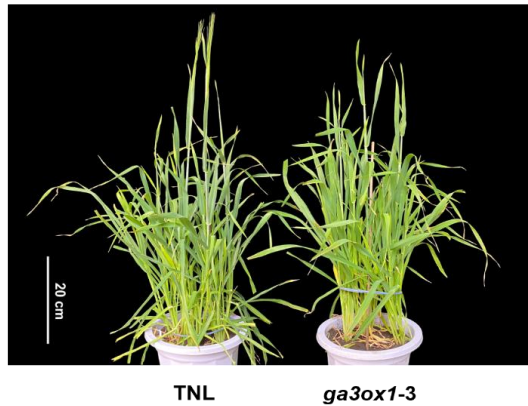
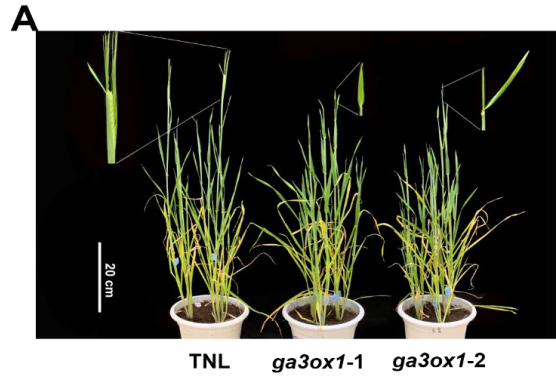
Boxplot of grain yield in four barley varieties and five wheat varieties evaluated in 13 – 14 different environments in WA, SA, VIC and QLD during 2017 and 2018 growing seasons

The challenge now and ahead: safe production window squeeze



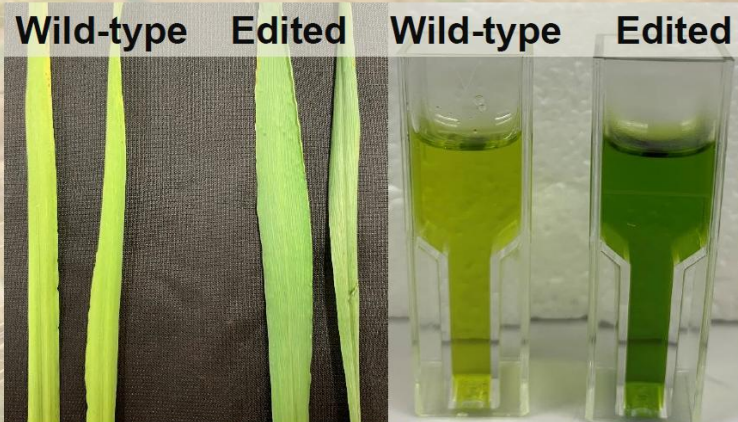
Climate change squeezing the barley safe production window

Gene-editing to create a new semidwarf barley with long coleoptile



Enhancing nitrogen use efficiency by Gene Editing

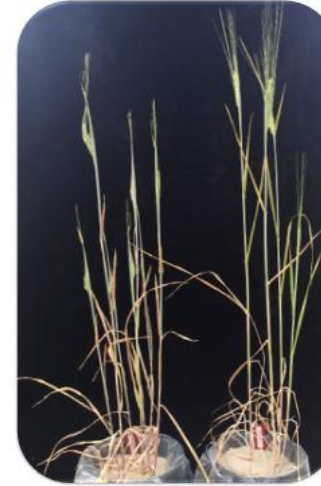
Enhanced Nitrogen Use Efficiency



	Total Chlorophyll (mg g ⁻¹ FW)
WT1	0.33
WT2	0.56
MutantE1	2.20
MutantE2	2.03

Four-fold chlorophyll in mutants flag leaves via targeted gene mutation

Low N (20mg/kg)



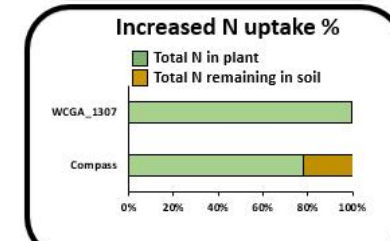
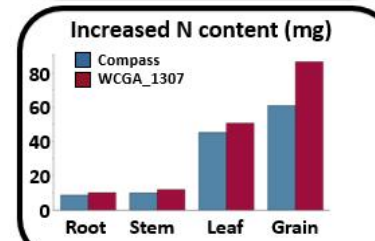
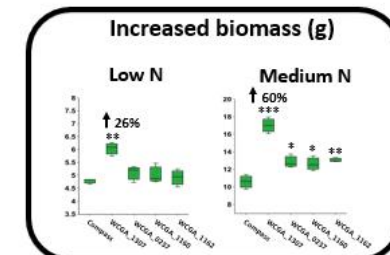
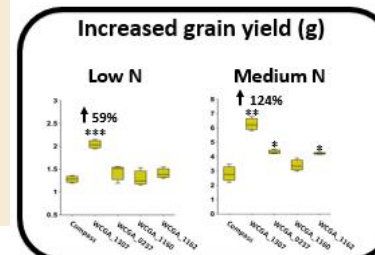
Compass WCGA_1307

Medium N (50mg/kg)



Compass WCGA_1307

WCGA_1307 vs Compass



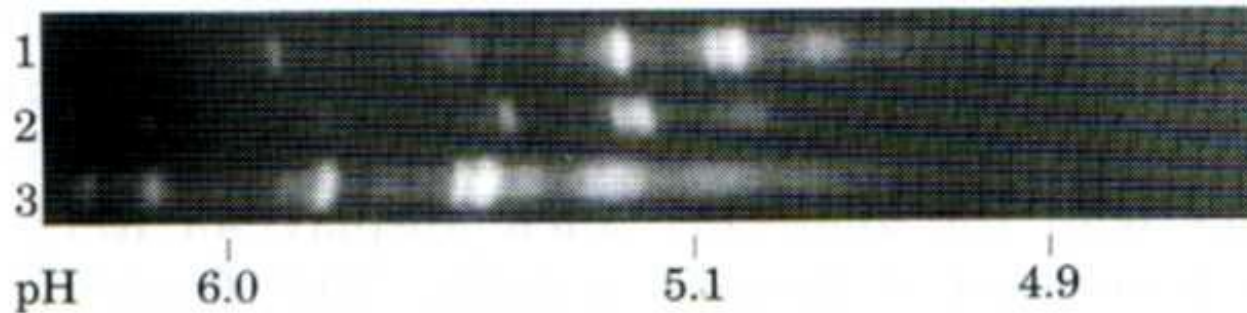
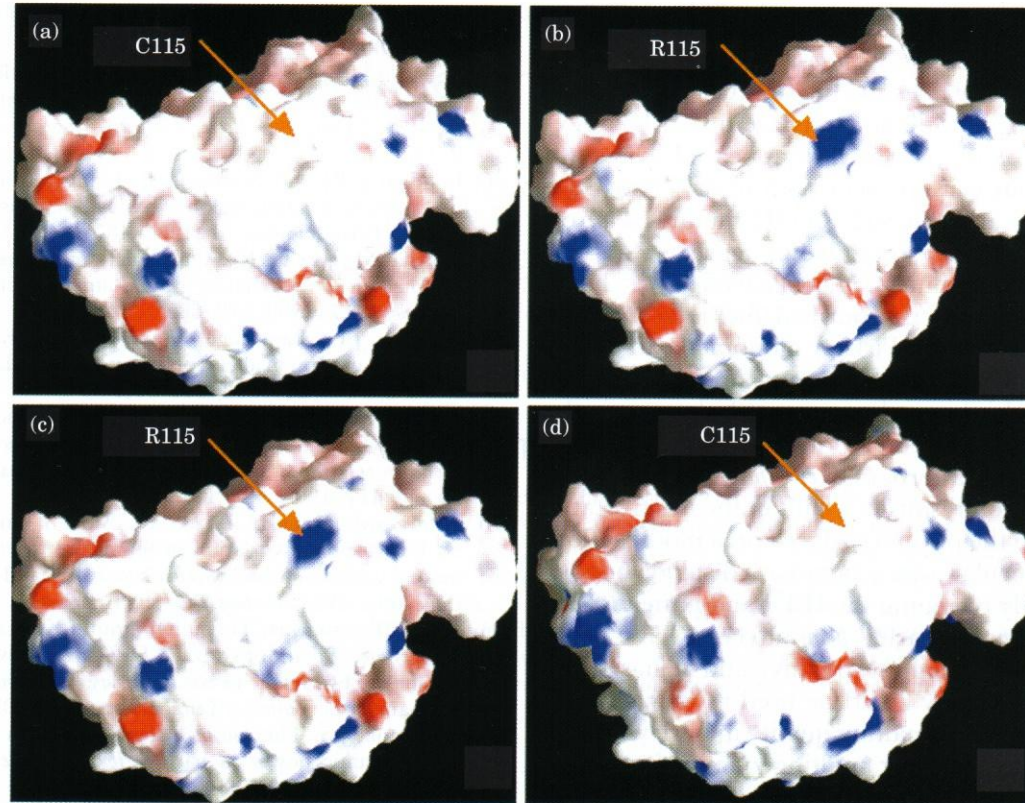
Novel Design of Imputation-Enabled SNP Arrays for Breeding and Research Applications Supporting Multi-Species Hybridization

Marker name	Technical requirements				Technical characteristics			
	Restriction enzyme	PCR	Specific primers	Gel	Development effort	Genotyping effort	Reproducibility ¹	Accuracy ²
RFLP	+	-	- ³	+	High	High	High	Very high
PCR-RFLP	+	+	+	+	High	Medium	High	Very high
RAPD	-	+	-	+	Very low	Very low	Low	Very low
AFLP	+	+	-	+	Low	Very low	High	Medium
SSCP	-	+	+	+	Medium	Medium	Medium	Medium
Microsatellite	-	+	+	+	High	Low	High	High
SNP	-	+	+	+/- ⁴	High	Variable ⁴	High	Very high

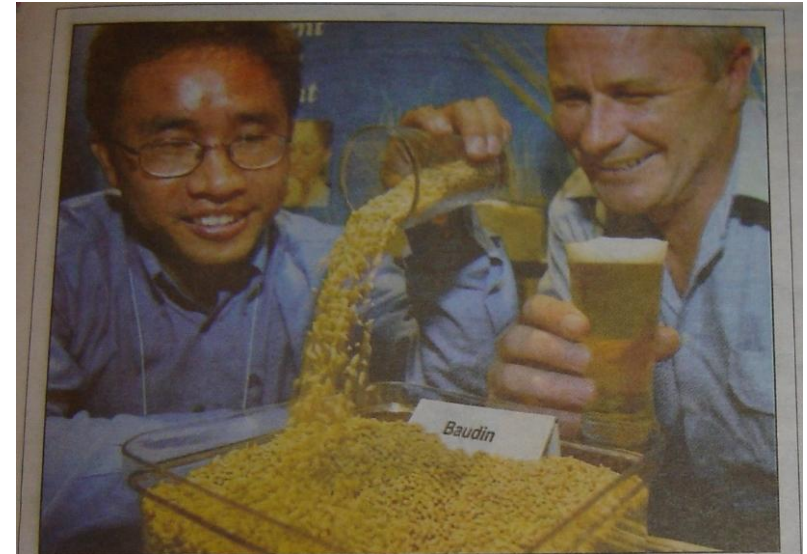
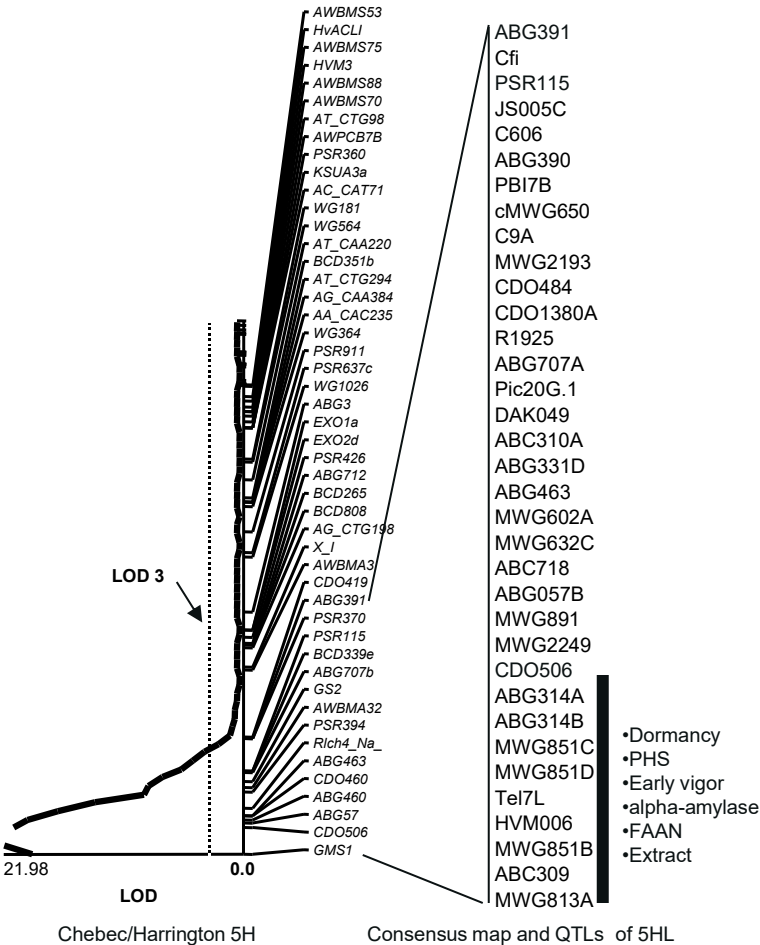


A lot of advantages of SNP markers

Selection of SNP for high thermostability



Marker-assisted breeding for malting quality



Grain gain: Dr Chengdao Li, one of the breeders of the new WA barley strains, shows Baudin grains to Swan senior brewer Hugh Dunn at the barley launch yesterday. PICTURE: DON PALMER

New barley brewed for Asian beer

By Peter Trott

THERE wasn't enough to give anyone a sore head when beer brewed from a new variety of barley was tapped at the Swan Brewery yesterday.

But members of the industry consortium which fostered development of two new barley varieties are hoping Asian brewers will add a good head to the industry which has doubled production in the past 13 years.

The new varieties, Hamelin and Baudin, are expected to

boost malting barley production by up to 10 per cent with better yield and quality.

Breeders hope they will appeal more to Japanese and other Asian brewers, who form the major market for Australian malt, and China, the major importer of barley.

Gordon Allan, general manager of technical services at Joe White Maltings, said WA led the nation in breeding and growing high-quality malting barley.

He said Hamelin, which is expected to replace the stalwart Stirling variety, had higher fer-

mentability and other improved brewing qualities.

Baudin, a high-yielding variety suited to high-rainfall areas, is expected to replace Gairdner.

"The first step is getting what we believe is a very high-quality line and feeding it into the breweries," he said.

Mr Allan said malt exports earned Australia about \$250 million a year, mainly from Japan, the Philippines, Korea and South-East Asia.

Barley is WA's second biggest crop after wheat and is worth about \$315 million a year.

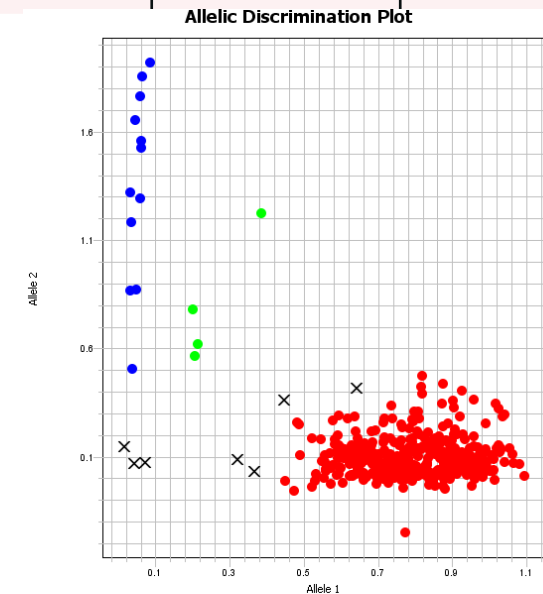
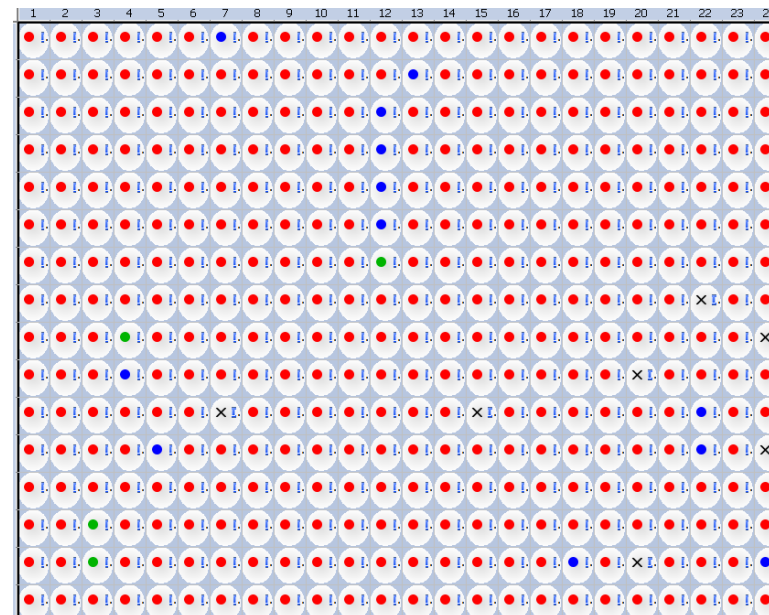
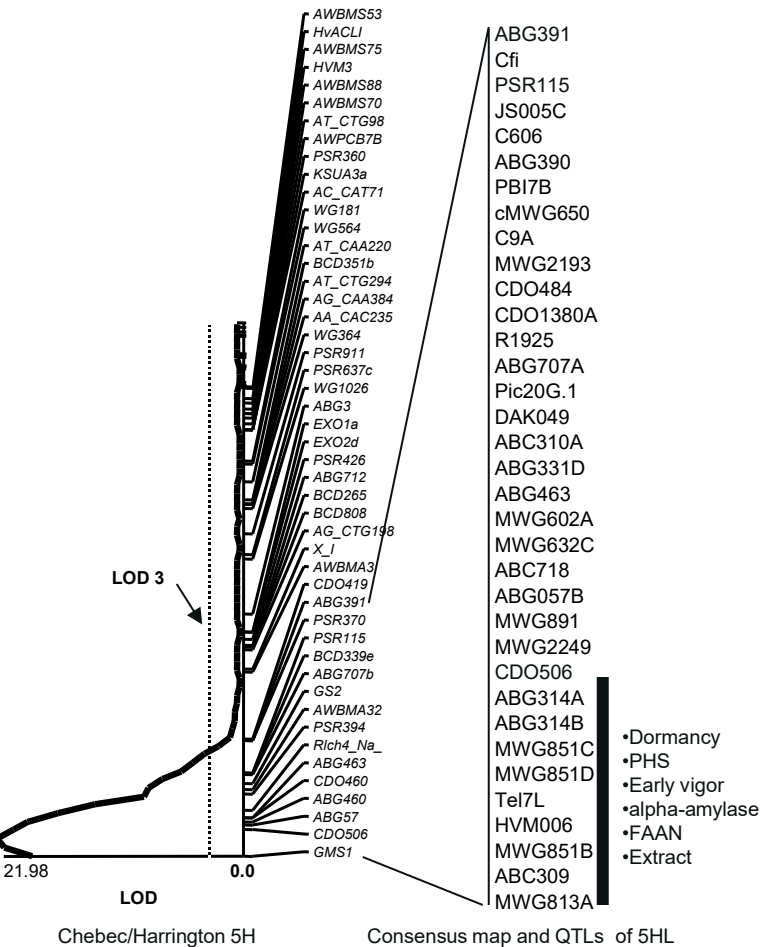
Mitogen-Activated Protein Kinase Kinase 3 Regulates Seed Dormancy in Barley



Nakamura et al., 2016, Current Biology 26, 775–781

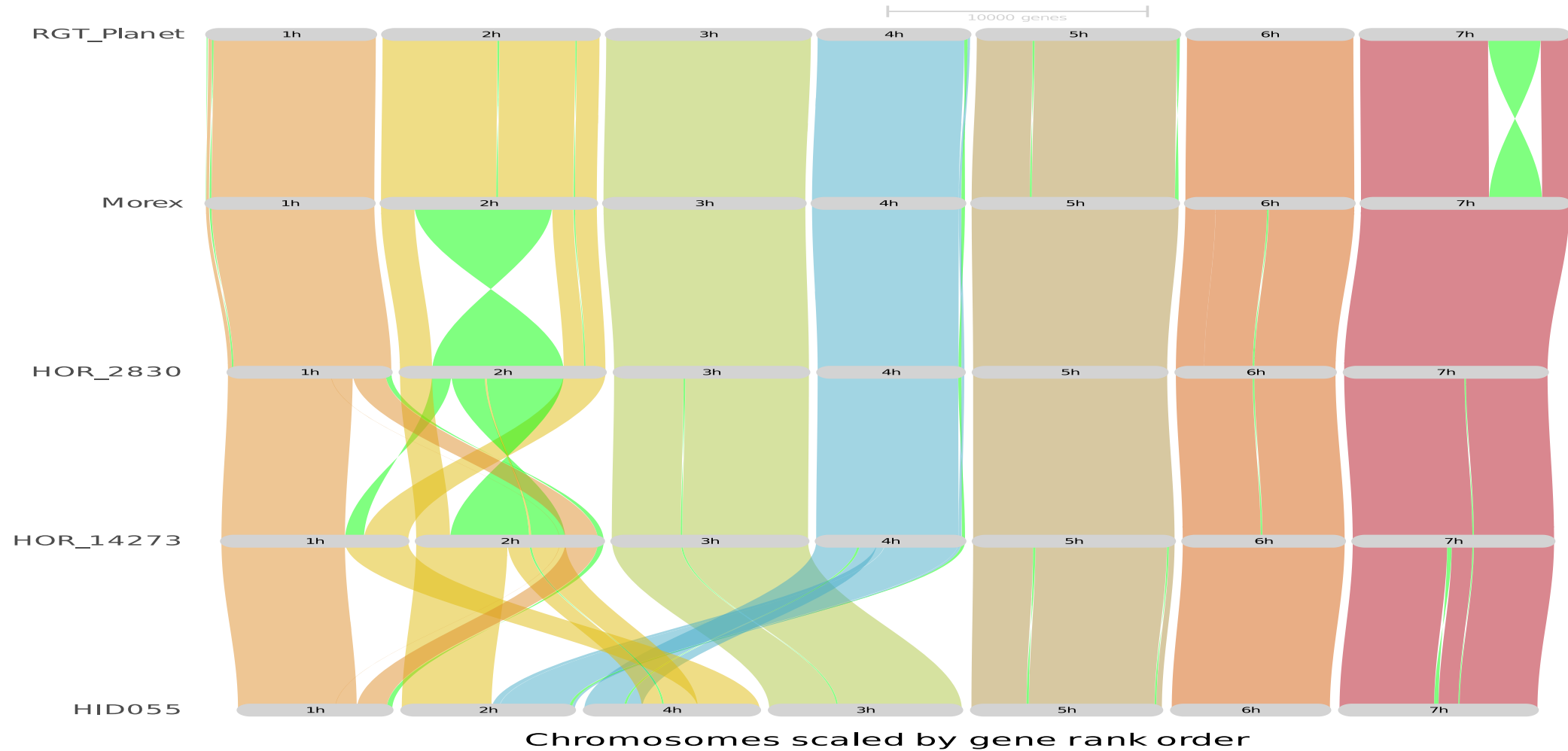
N260T substitution in the dormant allele decreases activity and determine seed dormancy

	Hamelin	Stirling	Step toe	Gairdner	Franklin
AA260	N	N	N	N	N
C42177prom	2	1	2	1	1
C42177 mite	1	2	2	2	2
phenotype	ND	D	D	D	D

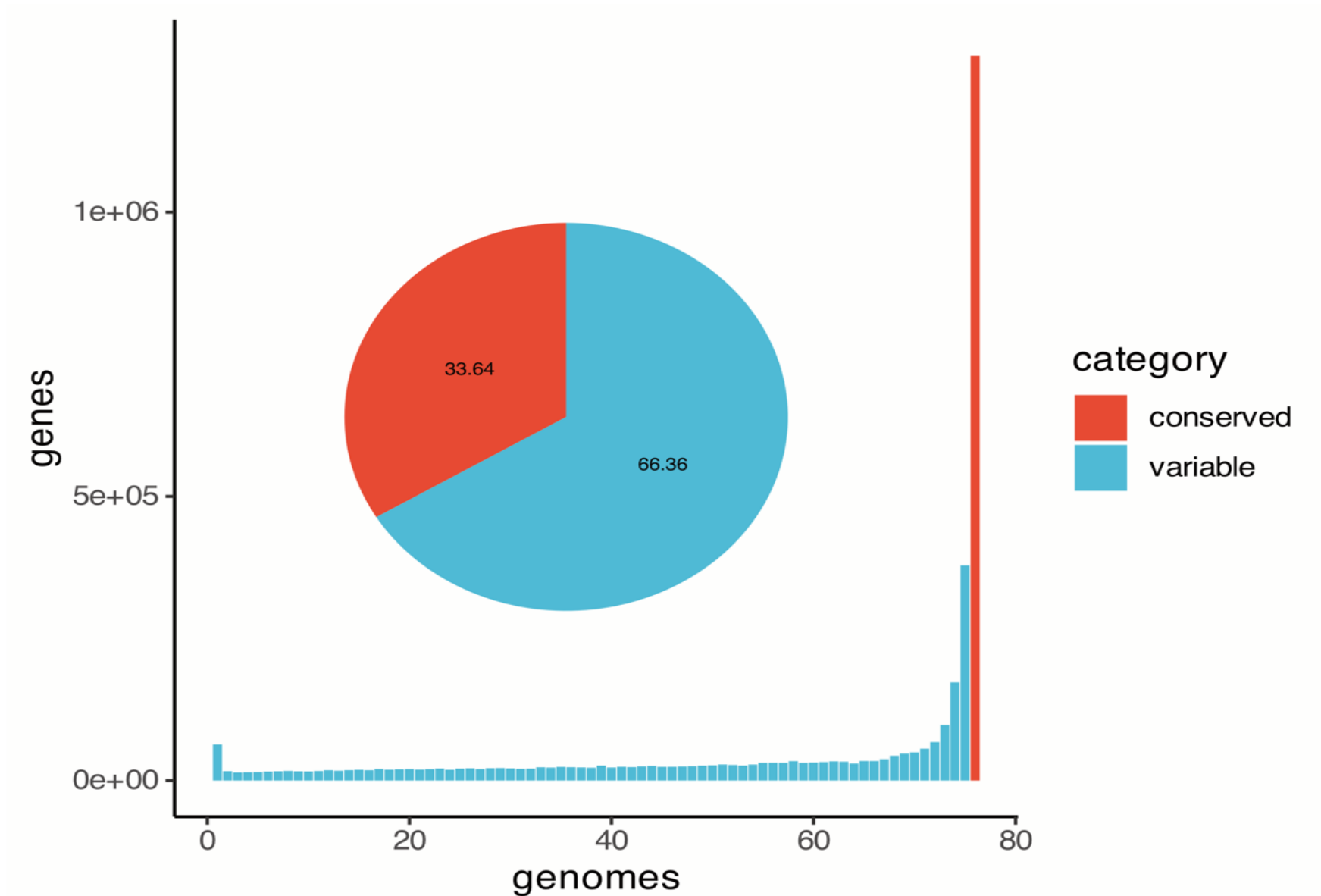


Legend
 ● Homozygous Allele 1/Allele 1 ● Homozygous Allele 2/Allele 2
 ● Heterozygous Allele 1/Allele 2 × Undetermined

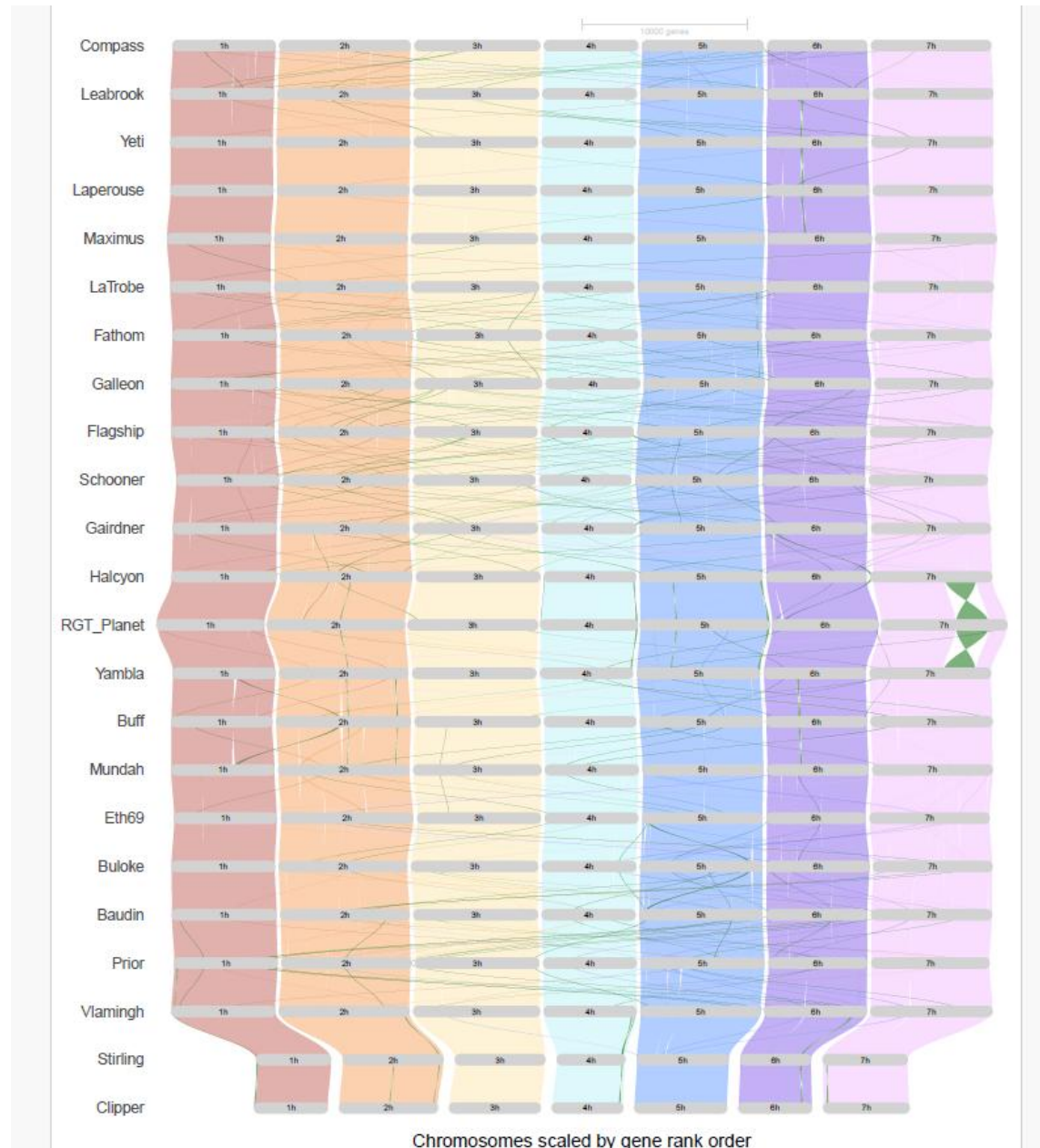
Large chromosomal structural changes in the barley pan genome



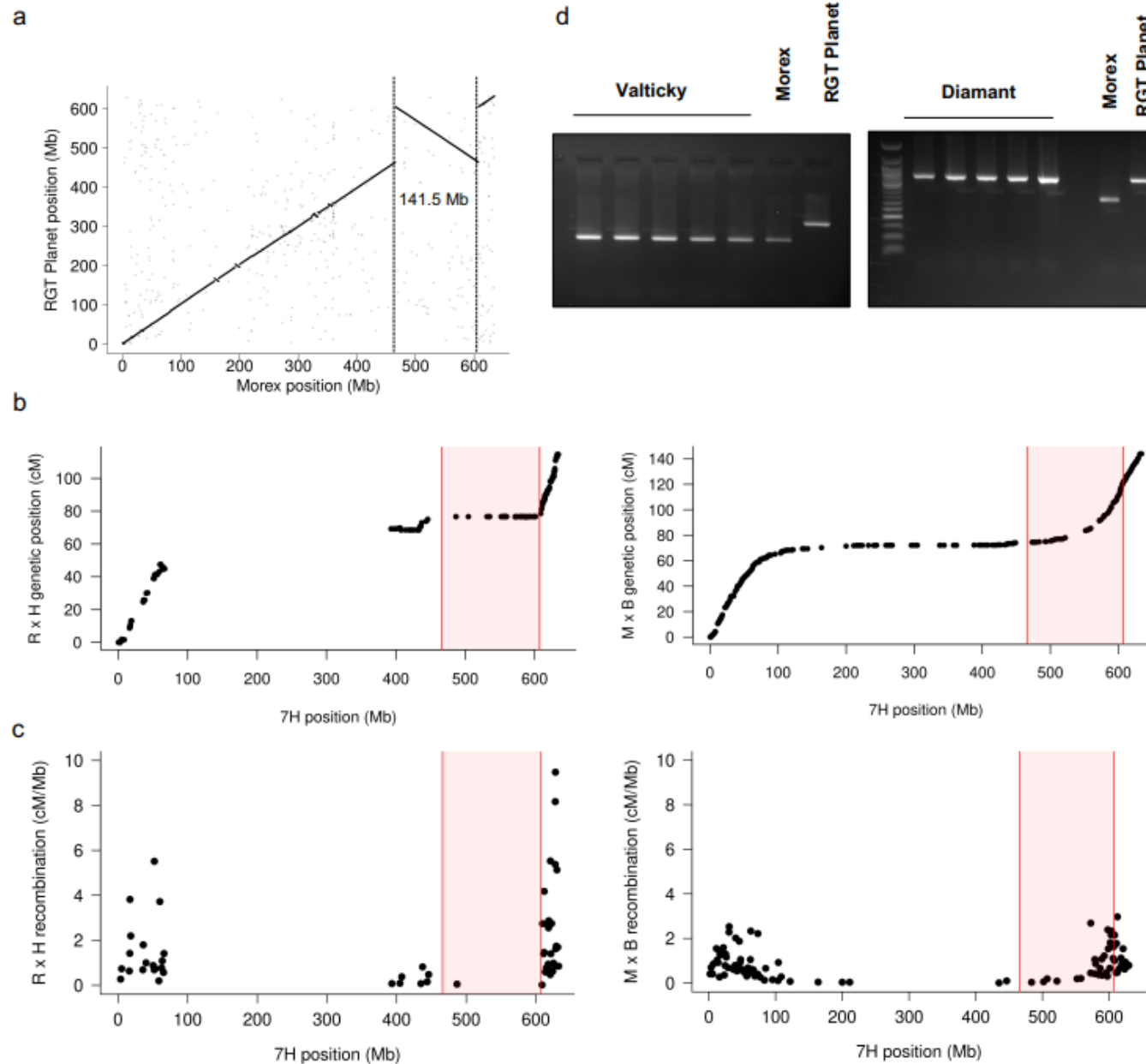
Conserved vs variable genes



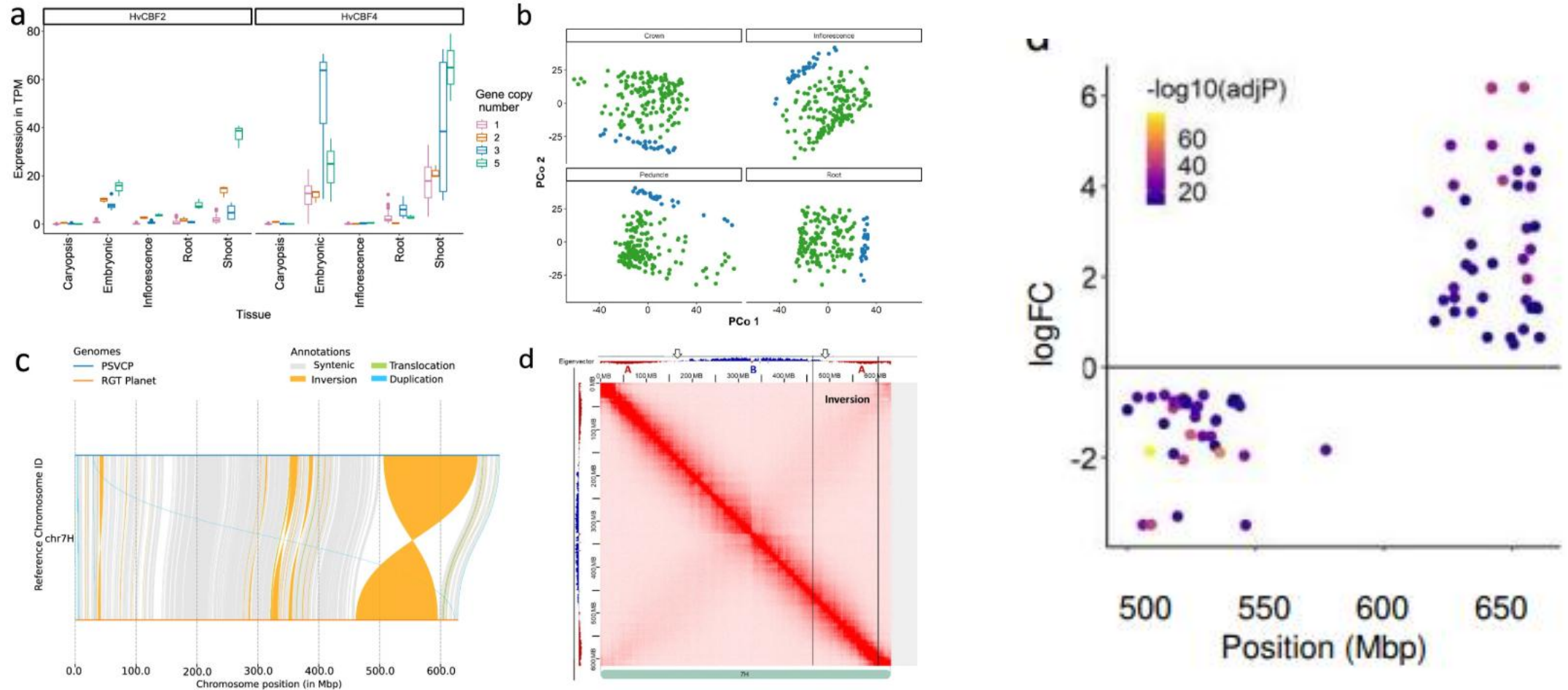
The Australian Barley Pan Genome



Inversion prohibit recombination in breeding

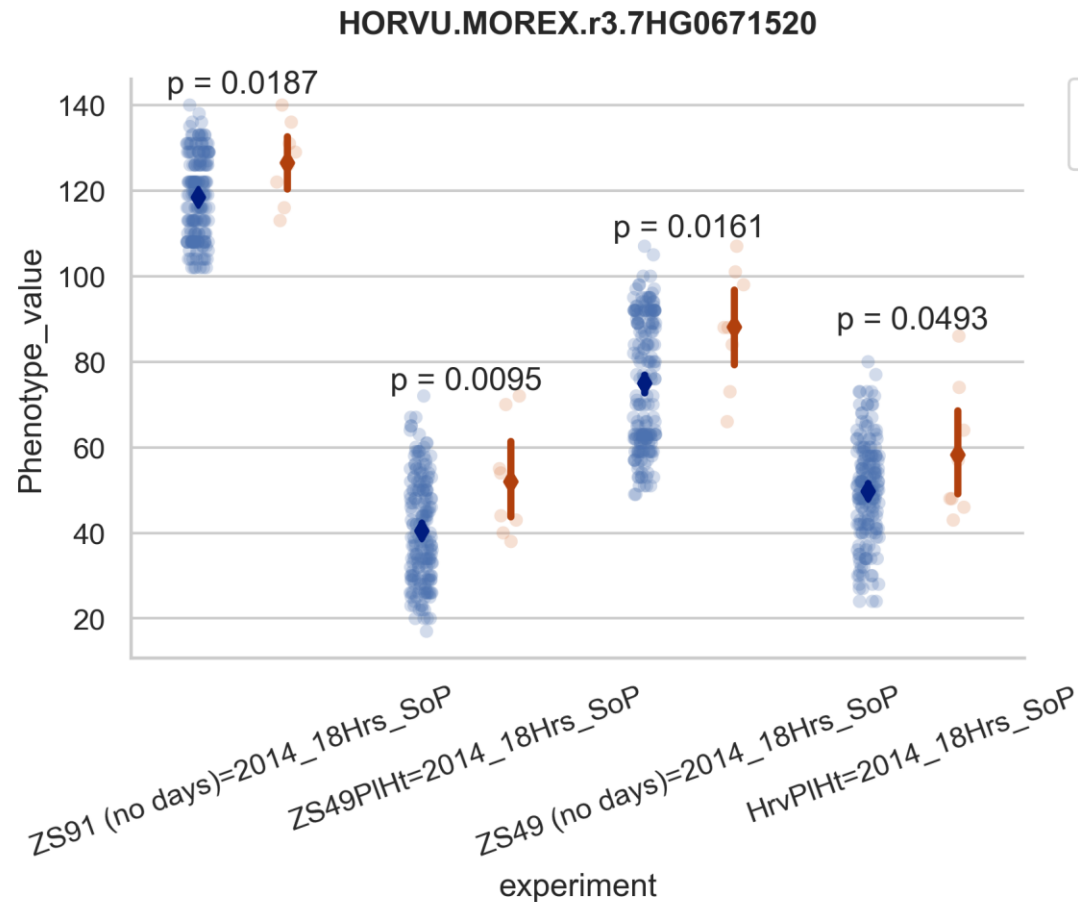


Inversion changes chromosome compartment and gene expression



Guo et al. Nature Genetics 2025

CVN of HvCO1 gene is associated with agronomic traits



Gene name	Annotation
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HvCO1	zinc finger transcription factor CONSTANS
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Descriptions:

CONSTANS (CO) is an important flowering-time gene in the photoperiodic flowering pathway of annual *Arabidopsis thaliana* in which overexpression of CO induces early flowering, whereas mutations in CO cause delayed flowering.

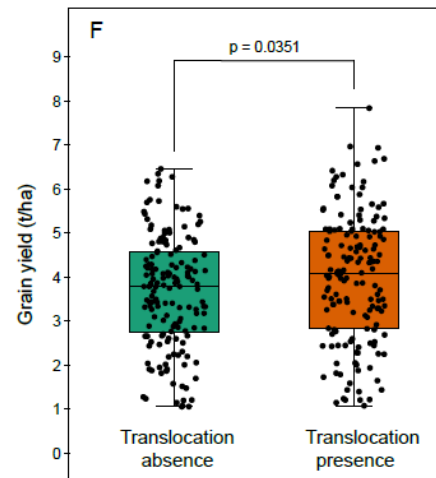
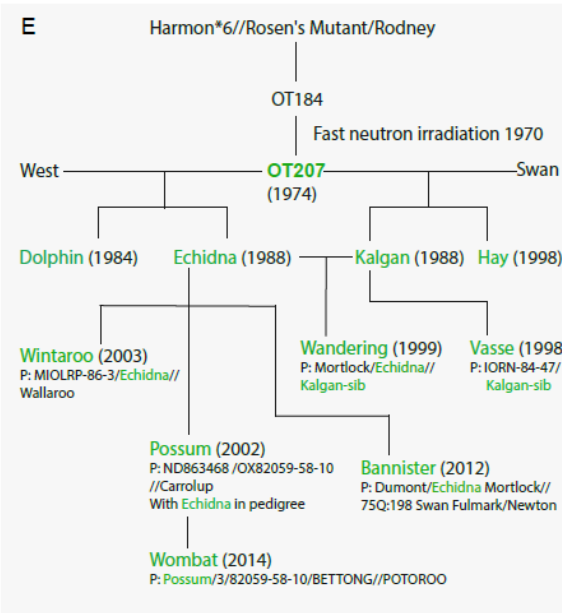
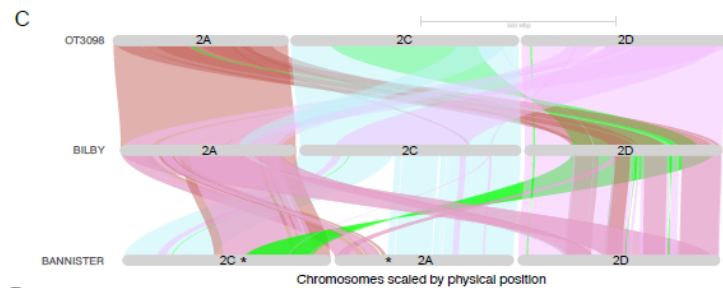
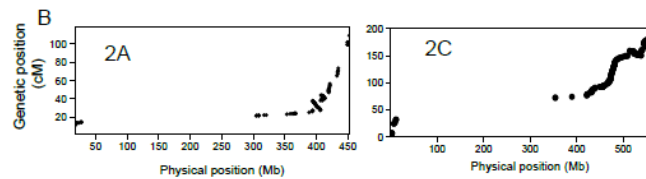
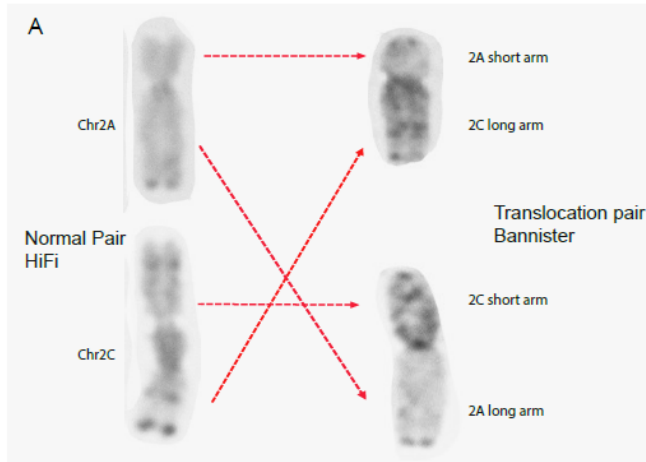
Associated traits:

ZS49: spike headset time
HrvPIHt: plant height
ZS91: gain harding (maturing) time

CNV in 76 pangenomes:

Min: 1
Max: 3
Std: 0.275 and 0 in domesticated and wild barley, respectively. (wild barley has conserved 1 copy)

Oat chromosomal variation for Australian adaptation



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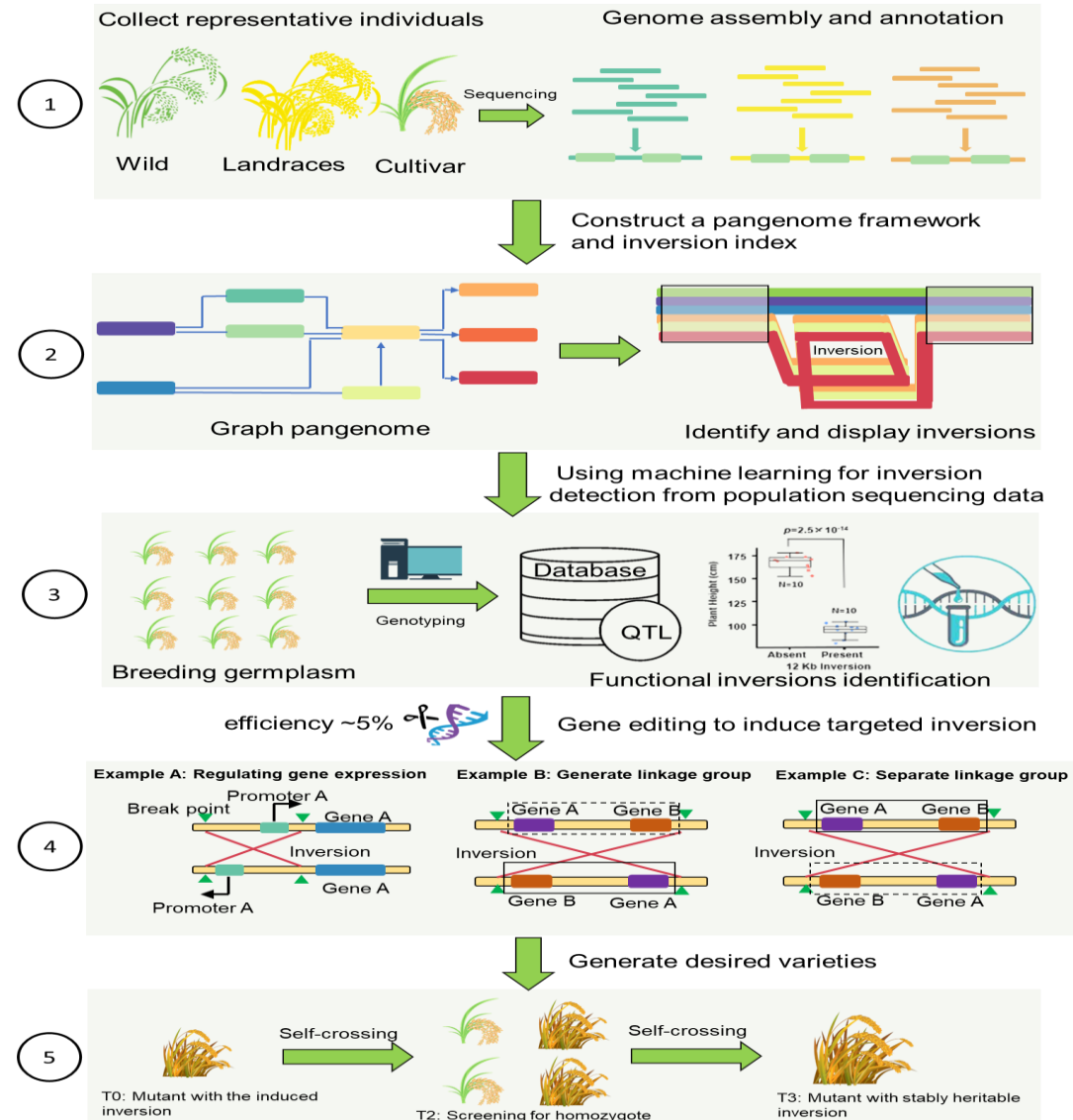
Article | [Open access](#) | Published: 29 October 2025

A pangenome and pantranscriptome of hexaploid oat

What structural variations can offer for breeding

- **Genetic materials**
- **Diagnostic test**
 - **New traits**
- **New breeding strategy**

Utilization of structural variations



Hu et al. PBJ 2024



Western Crop Genetics Alliance



Department of
Primary Industries and
Regional Development



International Barley Pan Genome Consortium:

Chengdao Li, Australia
Kazuhiro Sato, Japan
Shun Sakuma, Japan
Curtis Pozniak, Canada
Gurcharn Singh Brar, Canada
Ana Badea, Canada
Christoph Dockter, Denmark
Mats Hansson, Sweden
Nils Stein, Germany
Martin Mascher, Germany
Dragan Perovic, Germany
Thomas Schmutzer, Germany
Gary Muehlbauer, USA
Brian Steffenson, USA
Robbie Waugh, Scotland
Beat Keller, Switzerland
Simon Krattinger, S.Arabia

Murdoch University

Tianhua He
Tefera Angessa
Xiaoqi Zhang
Camilla Hill
Ricky Hu
Yong Jia
Hao Luo
Brett Chapman
Penghao Wang
Sharon Westcott
Yong Han
Gaofeng Zhou

Australia Barley genome

Peter Langridge
Ken Chalmers
Gabriel Keeble-Gagnere
Josquin Tibbits

Breeding Companies and breeders

Paul Telfer
David Moody
David Leah
Steward Coventry
Amanda Box



Thank you