Evaluating Teosinte Alleles for Kernel Composition in Maize

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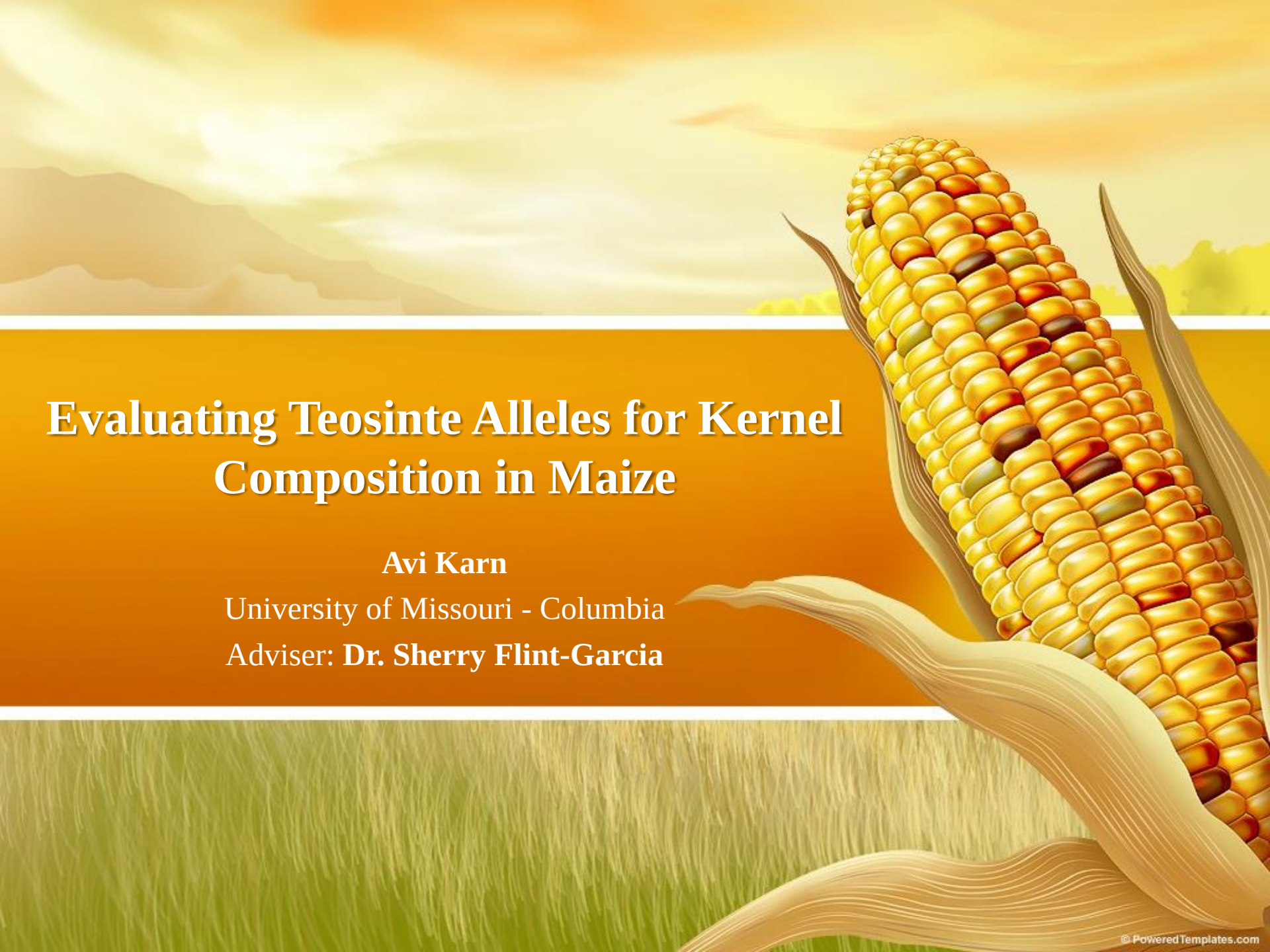
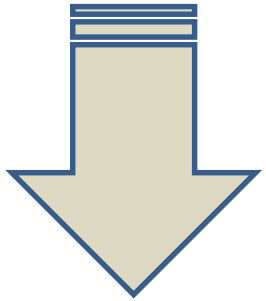


Teosinte

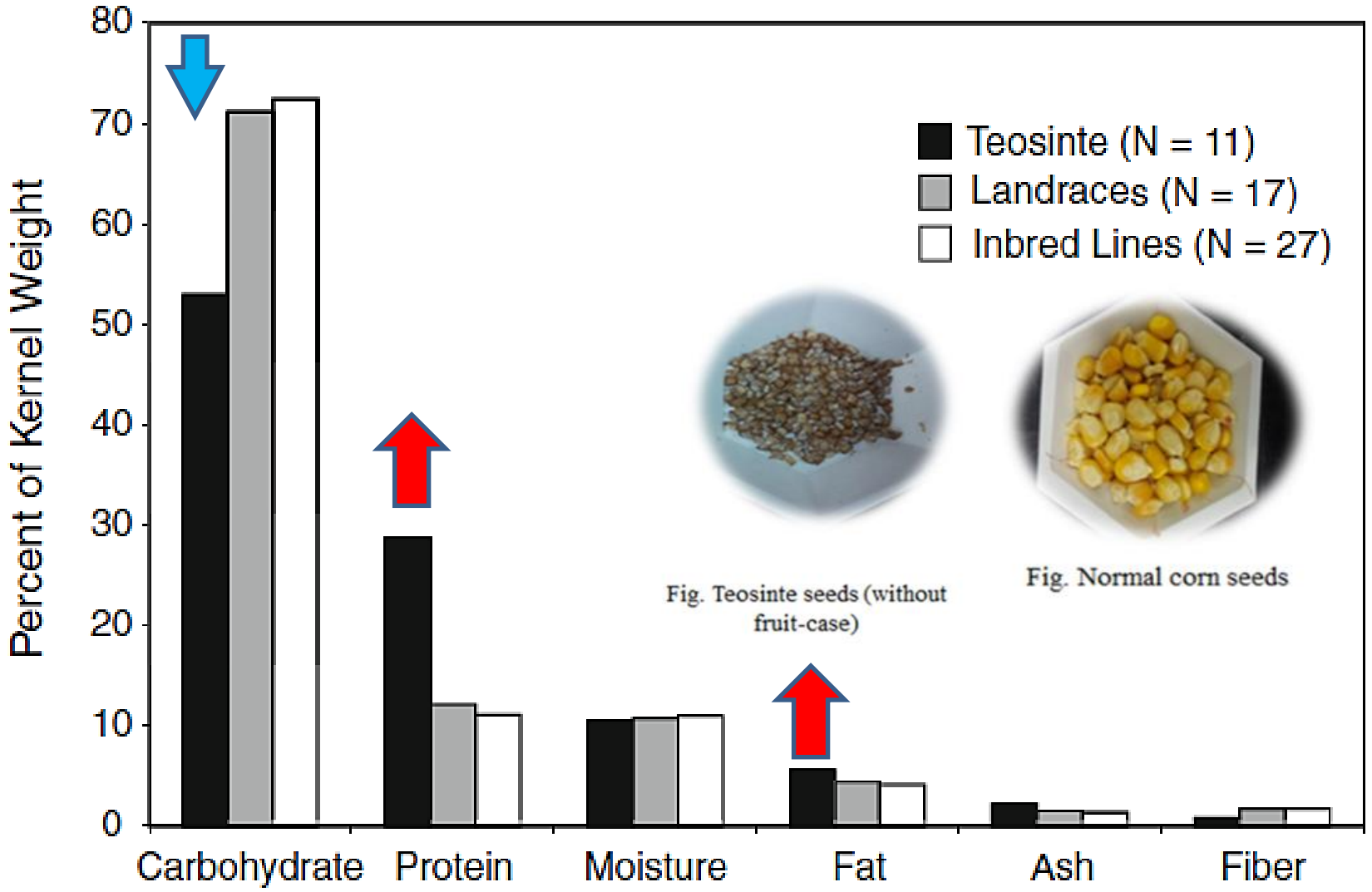
Artificial Selection & Breeding

Maize



- Alleles for kernel composition (Starch, Protein and Oil) selected and lost during the domestication process of maize?
- Performance of teosinte alleles relative to maize alleles (B73)?

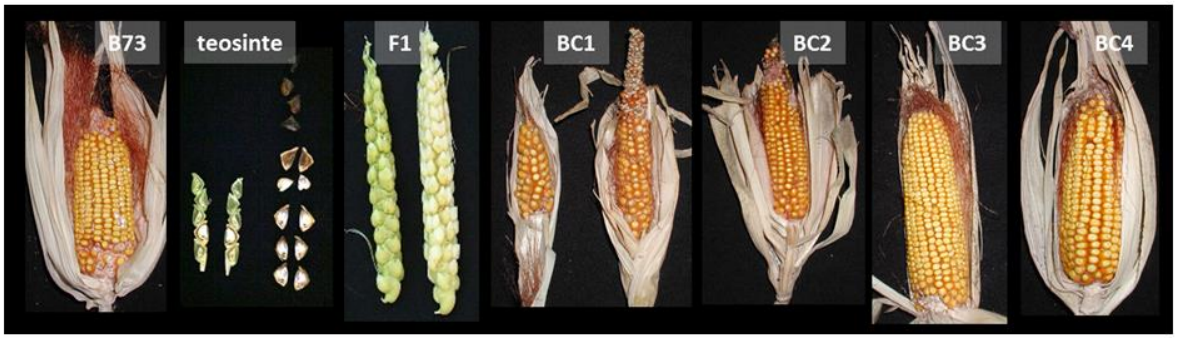
Kernel composition of teosinte, landrace, and inbred lines



Flint-Garcia et al. Theoretical and Applied Genetics (2009) 119:1129–1142

B73

Teosinte



F_1

B73

BC_1

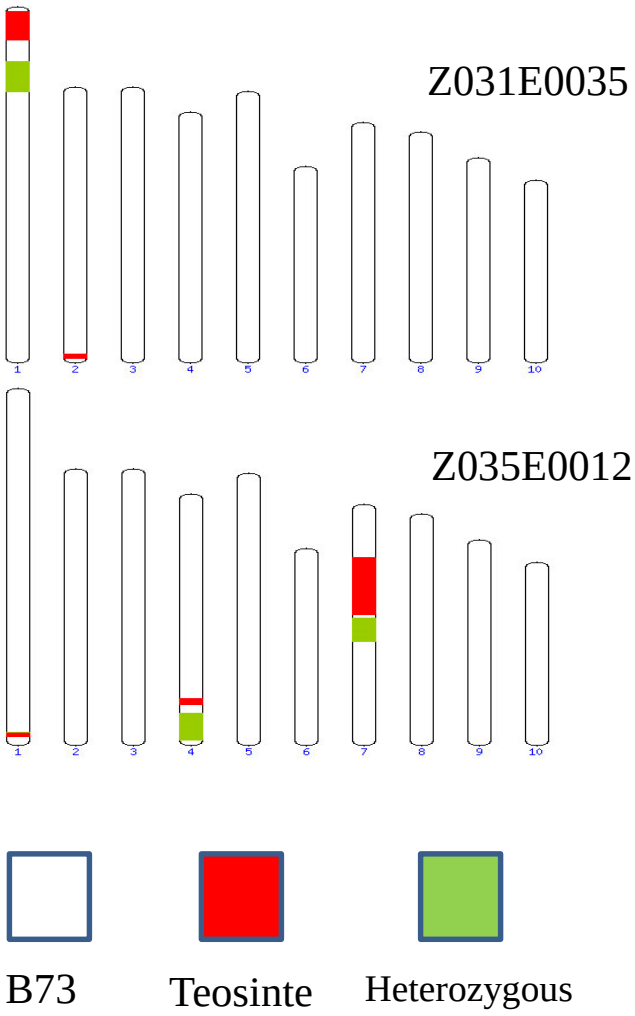
B73

BC_4S_2

Population Structure

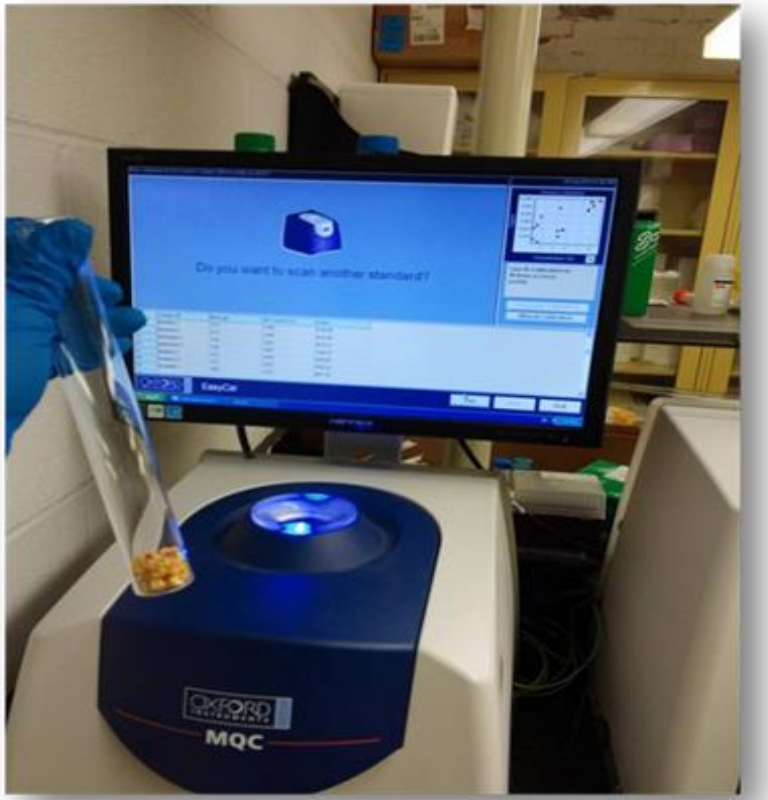
- 10 NIL populations (total of 961 NILs)
- Developed from 10 geographically diverse *parviglumis* accessions by backcrossing ten accessions into B73 background
- % introgression in BC_4S_2 Teo-NILs
  - ~96% homozygous B73
  - ~2.6% heterozygous
  - ~1.5% homozygous Teosinte

Example



High-throughput and Non-Destructive Phenotyping

FOSS® 6500 Near Infrared Reflectance (NIR) Instrument



Oxford Inst. Nuclear Magnetic Resonance (NMR) Instrument

NIR and NMR calibration statistics

Calibration statistics of NIR for total protein and starch on a dry matter basis in intact maize kernels

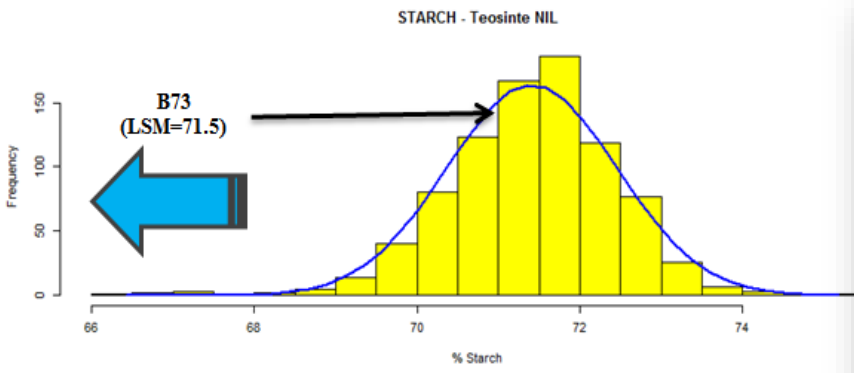
Trait	Instrument	*n*	*r*	Error	Treatment	Spectral range
Starch	NIRS	210	0.82	2.705	MSC; 1st Deriv	900 - 2500 nm
Protein	NIRS	210	0.97	0.719	MSC	900 - 2500 nm

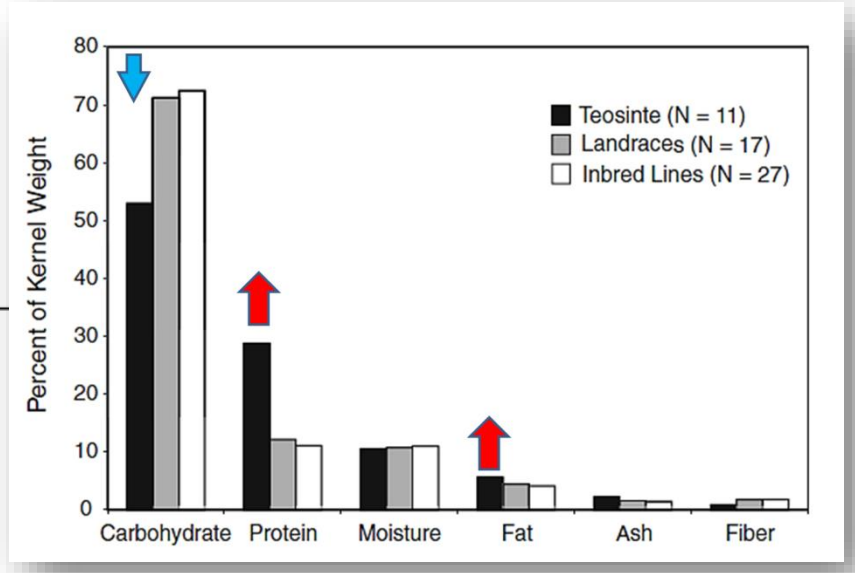
Calibration statistics of NMR for total oil content on DMB in intact maize kernels

Trait	Instrument	*n*	*r*	Error	Weight	Frequency (MHz)
Oil	NMR	45	0.98	0.09	~10gm	5

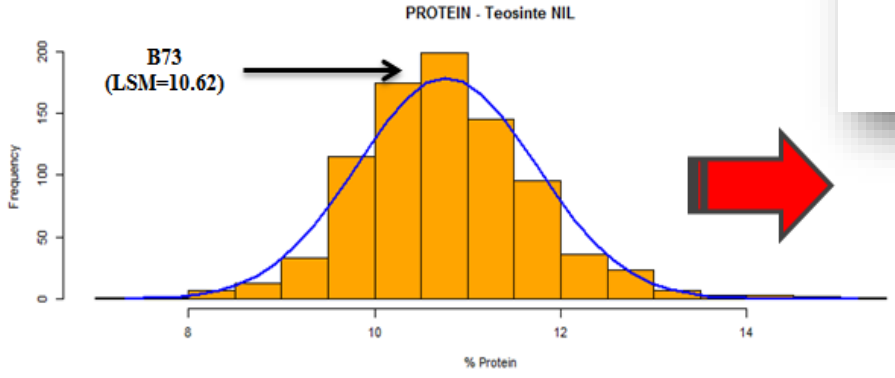
Distribution of kernel starch, protein and, oil

Starch

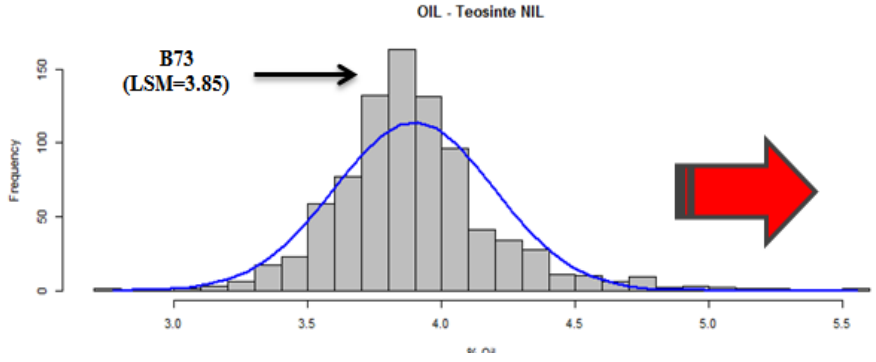




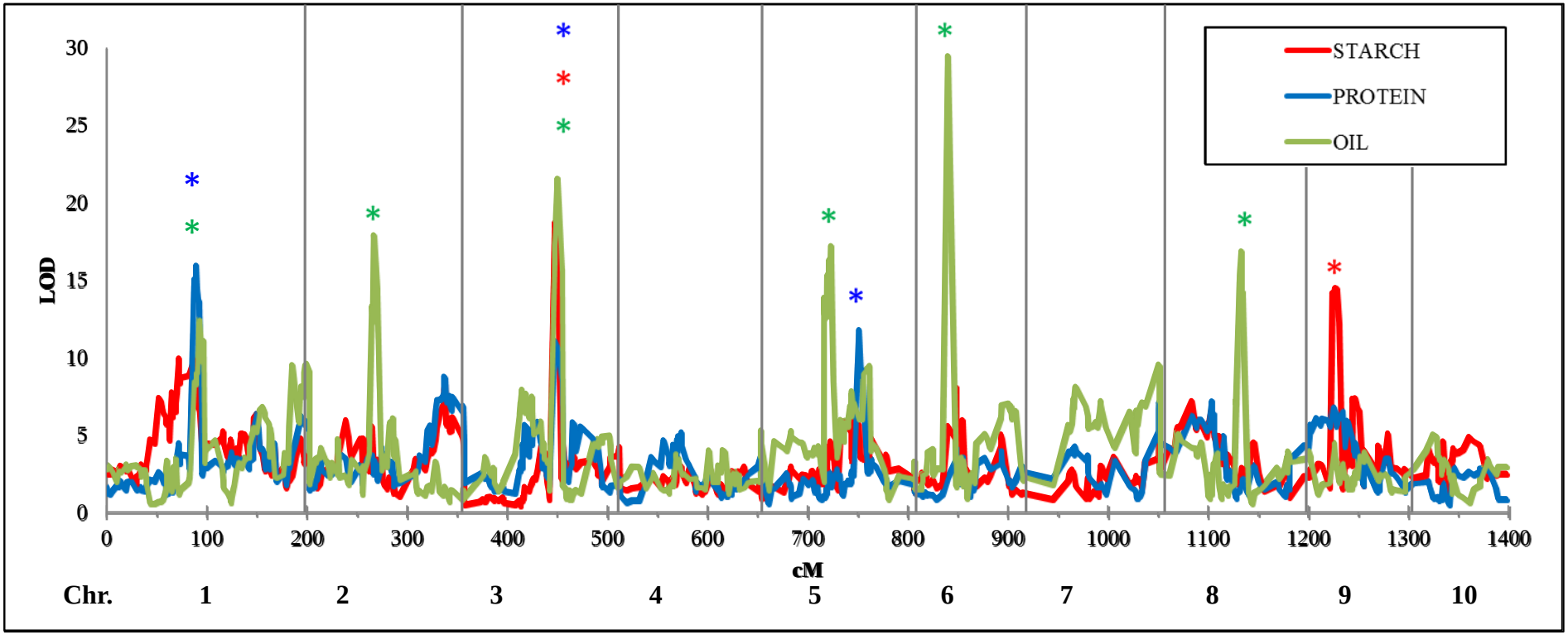
Protein



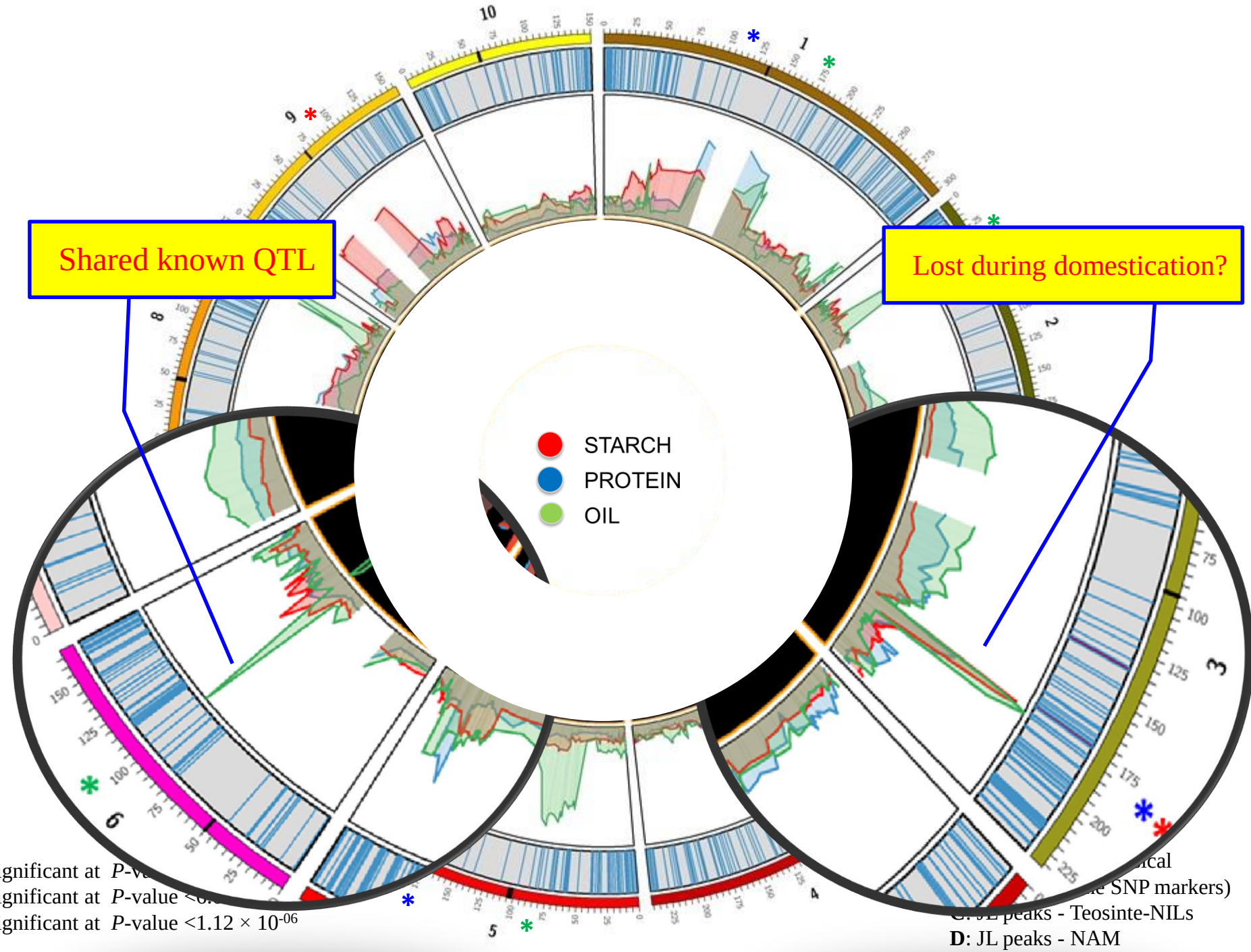
Oil



Joint-linkage QTL analysis for total kernel Starch, Protein, and Oil



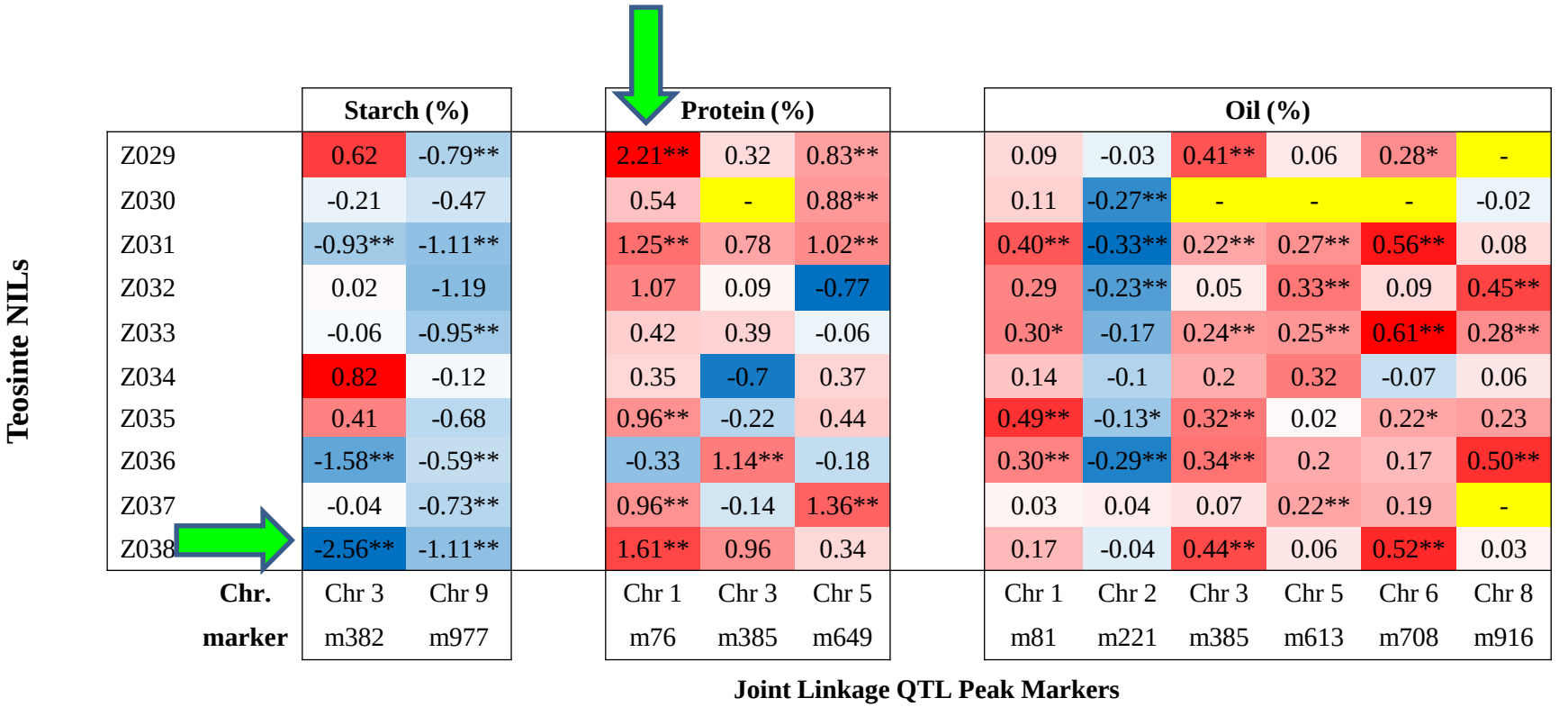
* **STARCH -** Significant at *P*-value <1.31×10^{-06}
* **PROETIN -** Significant at *P*-value <6.06×10^{-07}
* **OIL** - Significant at *P*-value <1.12×10^{-06}



* Significant at *P*-v
* Significant at *P*-value <6.
* Significant at *P*-value <1.12 × 10^{-06}

ical
e SNP markers)
C: JL peaks - Teosinte-NILs
D: JL peaks - NAM

Heatmap: Additive effects of teosinte alleles relative to B73



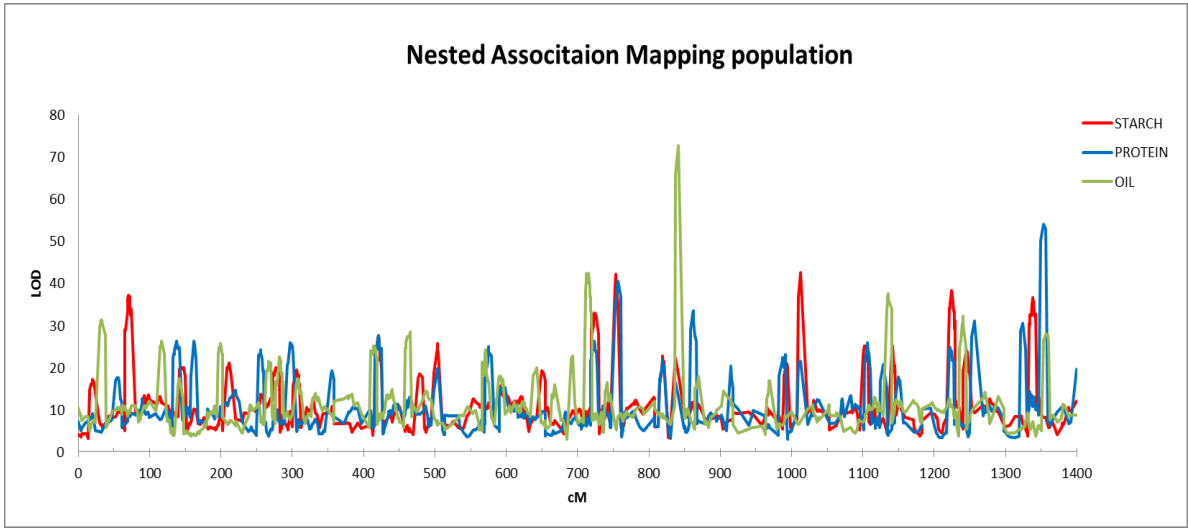
* Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

\- No Teosinte Introgression

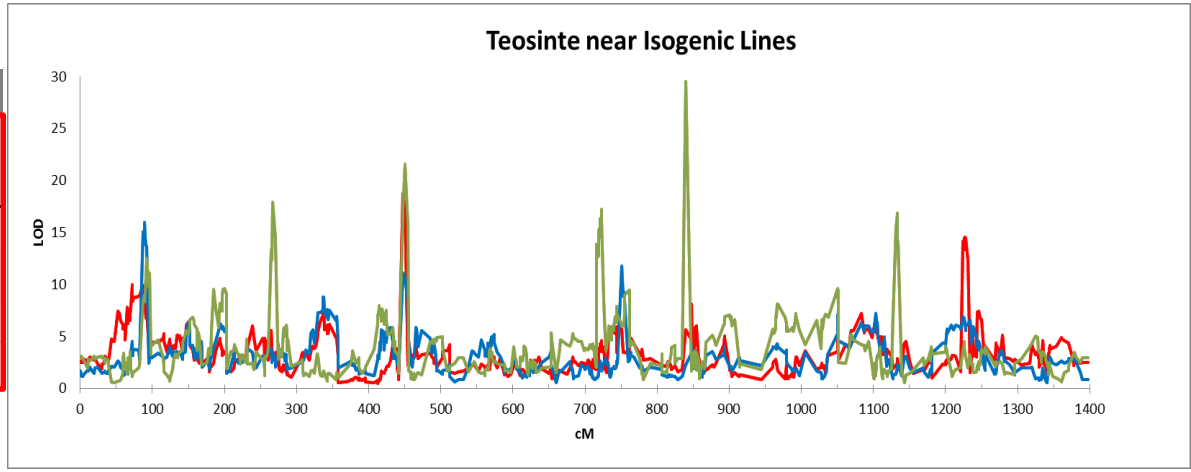
Comparing QTLs and additive effects of NAM (Maize alleles) and Teosinte alleles for kernel composition traits

NAM Population				
			Allelic Effects	
Trait		QTLs	Min (%)	Max (%)
Starch		21	-0.62	0.65
Protein		26	-0.38	0.34
Oil		22	-0.12	0.21

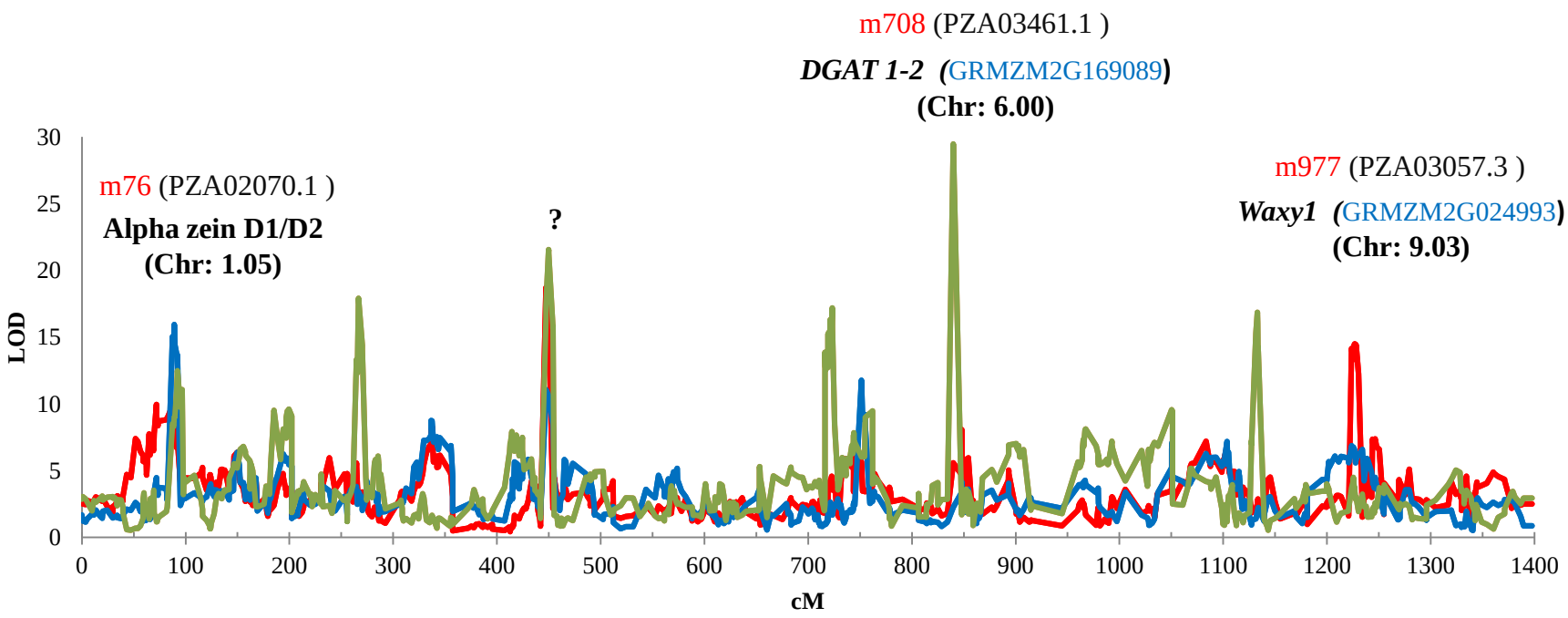


JP Cook et al. Plant Physiology (2012) vol. 158: 824-834

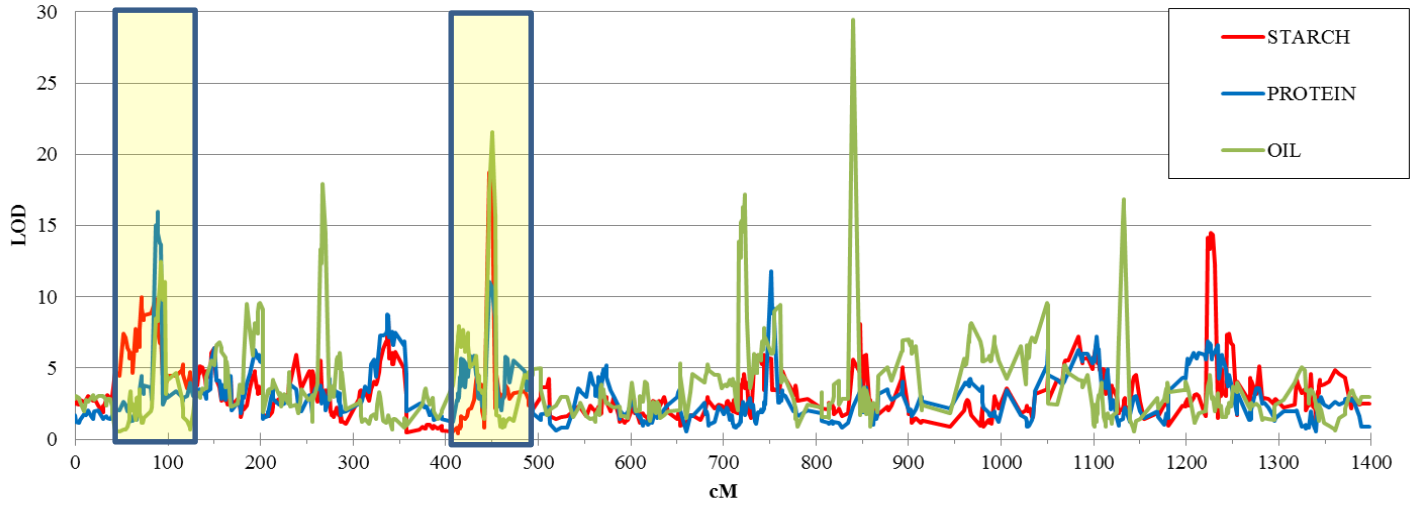
Teosinte NILs				
			Allelic Effects	
Trait		QTLs	Min (%)	Max (%)
Starch		2	-2.56	0.82
Protein		3	-0.77	2.21
Oil		6	-0.33	0.61



Putative **Candidate Genes** underlying the major QTLs



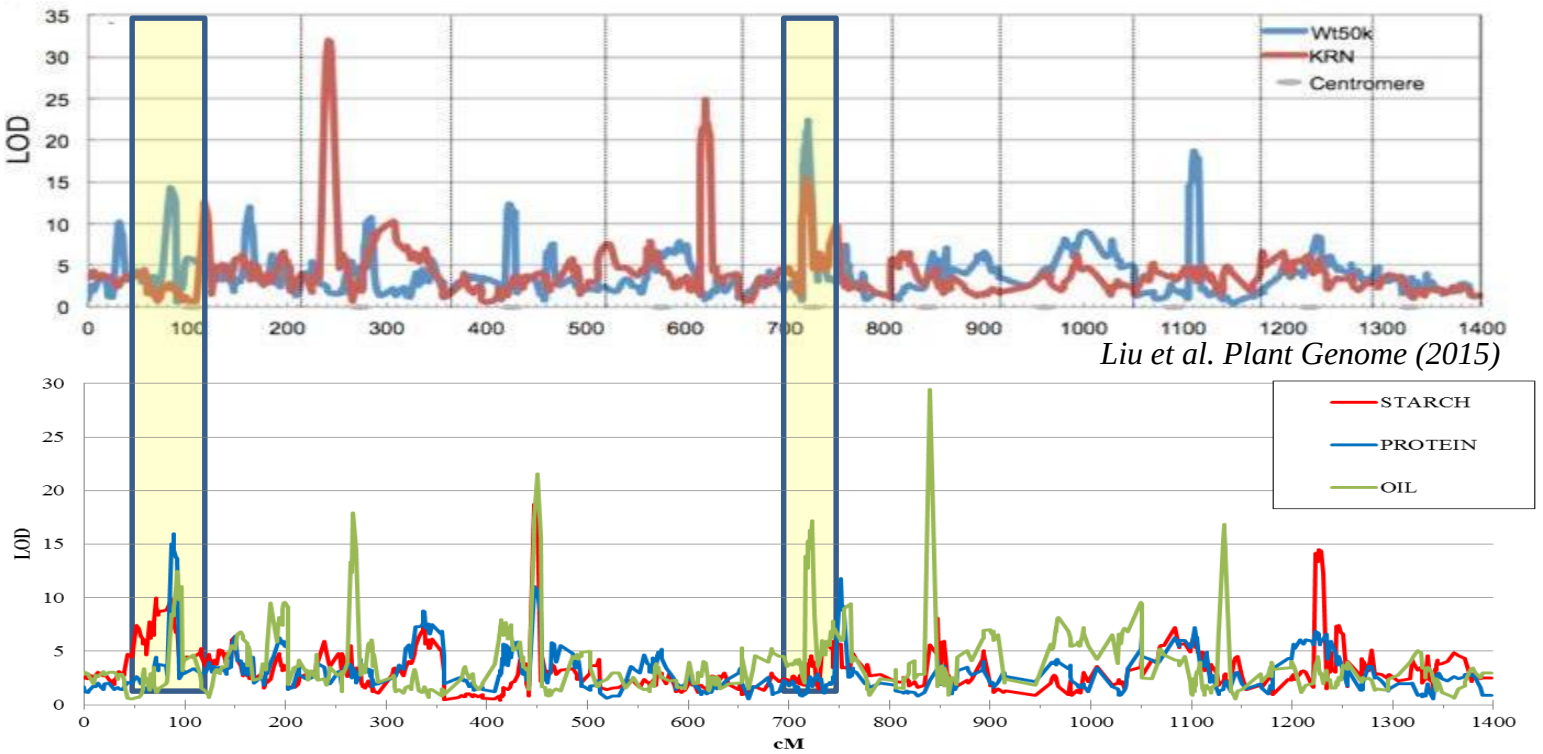
Pleiotropic effects between overlapping starch, protein, and oil QTL intervals on Chr. 1 and 3



	Overlapping QTL Marker Intervals			Correlations		
Chr	**Starch**	**Protein**	**Oil**	**S/P**	**S/O**	**P/O**
1	---	m76 [89.1]	m81 [92.0]	---	---	-0.185
3	m382 [90]	m385 [92.6]	m385 [92.6]	-0.834*	-0.392	0.523

* Significant at $p \leq 0.05$
** Significant at $p \leq 0.01$

Pleiotropic effect: Protein, Oil, and Kernel Weight (KWT) QTL intervals



Liu et al. Plant Genome (2015)

Overlapping QTL Marker Intervals | **Correlations**

Chr	Protein	Oil	KWT	KRN	KWT/P	KWT/O	KRN/P	KRN/O
1	m76 [89.1]	m81 [92.0]	m66 [82.4]		-0.046	-0.439	---	---
5	---	m613 [68.1]	m618 [70]	m613 [68.1]	---	-0.67	---	-0.43

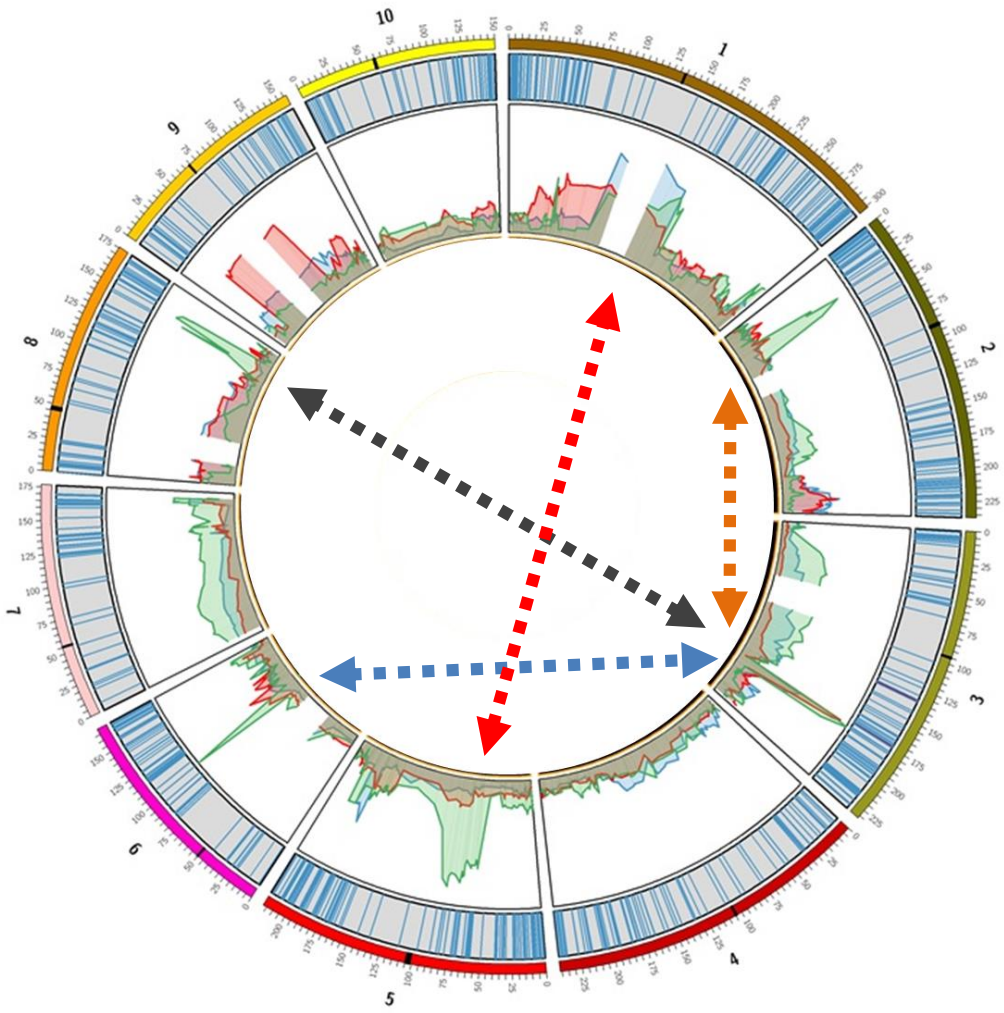
* Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

Conclusion:

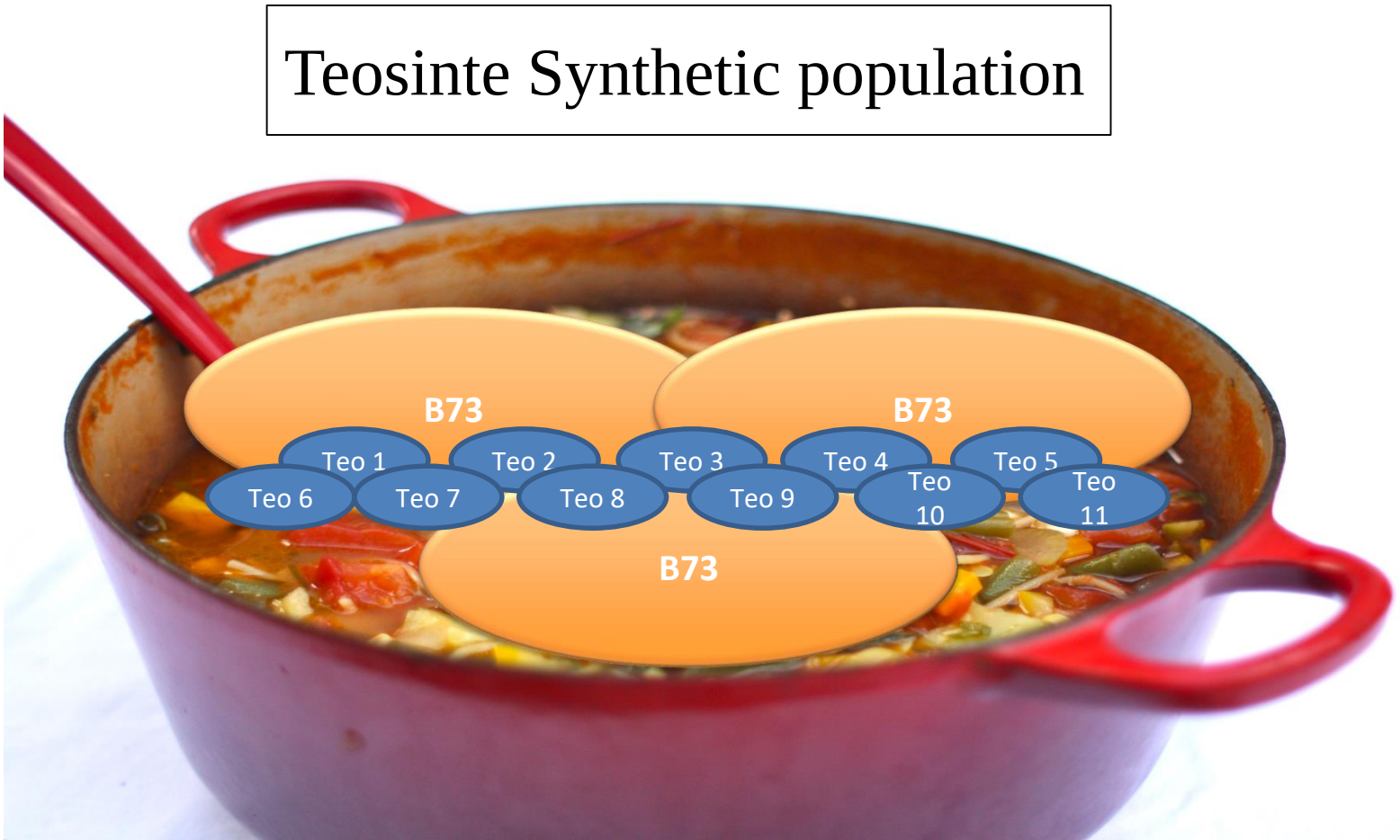
- Identified 2 starch, 3 protein and 6 oil QTLs, which collectively explained 18%, 23% and 45% of the total variation, respectively, with a range of stronger additive allelic effects for kernel starch, protein and oil content than NAM.
- Teosinte *does* harbor stronger and novel alleles for kernel composition that can be utilized for the improvement of kernel traits in modern maize germplasm.

What's next ?



- Role of rare alleles for in complex quantitative traits such as adaptation and kernel composition
- Explore if rare alleles are involved in epistatic interactions
- Answer to these questions cannot be explored in the teosinte NILs

- Randomly mating backcrossed (BC_1) progeny of 11 parviglumis accessions in the B73 background for several generation.
- An expected genetic ratio of **~25% teosinte** and **~75% B73**
- **Stay tuned!**



Acknowledgments

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Thank you for your attention!