Mapping of QTL associated with seed phytic acid concentration in pea recombinant inbred lines

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Soils and Crops
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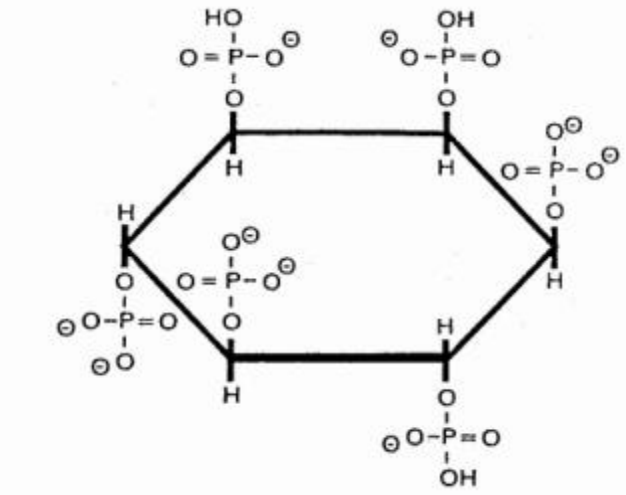
Outline

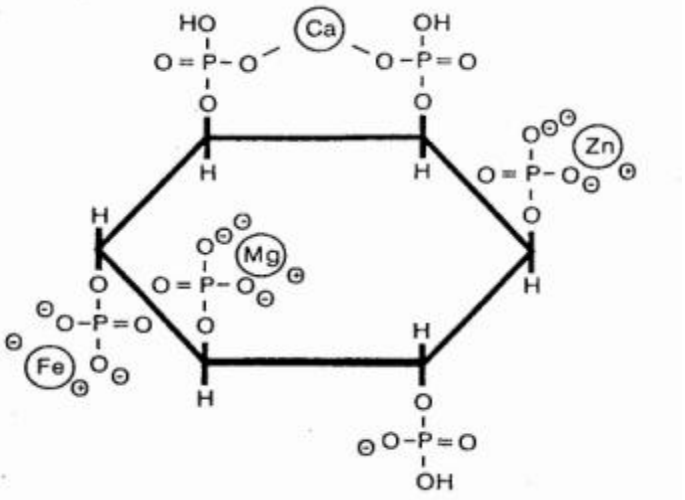
- Background
- Phytate in environment
- Low phytate pea lines
- Mapping phytic acid QTL
- Conclusion

Background

- Phytic acid
  - Storage form of P
  - Mixed cationic salt
- Binds K^{+}, Mg^{++}, Ca^{++}, Mn^{++}, Zn^{++}, Fe^{+++}



Myo-inositol hexakisphosphoric acid



Phytate-Metal Complex

(Ref: http://www.seedbiology.de)

Phytate in environment

Harvest

Storage of P as Phytate in mature seeds

Use of seeds for food

Seeds used to feed non-ruminants

Unable to digest phytate

Phytate decreases the bioavailability of iron and other minerals

Manure with undigested phytate is used to fertilize lands

80% of applied P in immobilized in soil & can't be taken up by plants

Growth to maturity

Industrial P added to fertilizer

P taken up from soil

Pools of P in soil

Eutrophication

(Modified from Brinch-Pedersen et al., 2002)

- **Consequences**

  - Micro nutrient deficiency
  - Environmental phosphorus pollution

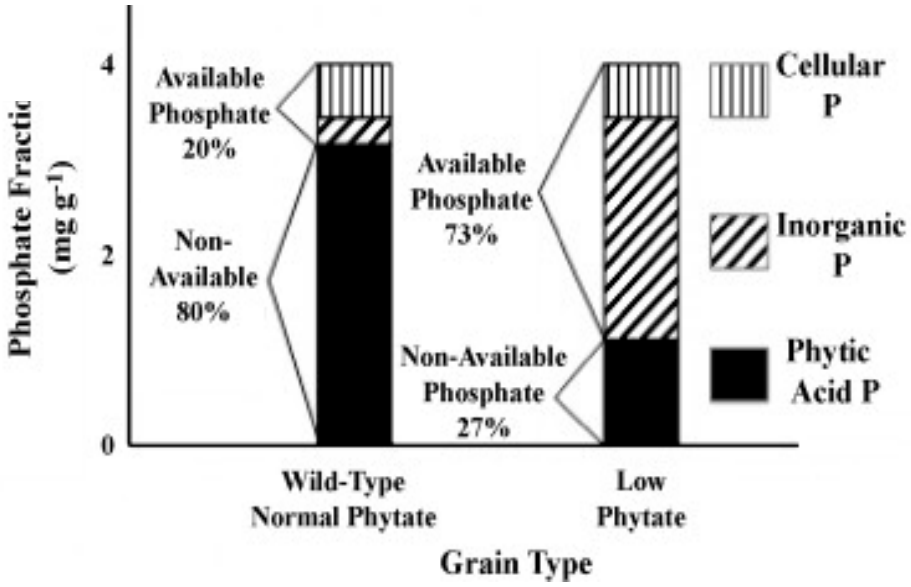
- **Strategies to reduce Phytate**

  - Fermentation
  - Soaking
  - Processing

Plant Breeding – Low Phytate Crops

Low Phytate Pea Lines

- Two low phytate (*lpa*)pea lines
  - 1-150-81 and 1-2347-144 (Warkentin. T.D., et.al, 2012)
  - Chemical mutagenesis of CDC Bronco



(Raboy.V., Plant Science 2009)

What do we know about these *lpa* pea lines?

- Reduced Phytate-P concentration (Warkentin. T.D., et al, 2012)
  - approx 60% reduction
- High in Inorganic Phosphorus
- Agronomic performance
  - similar to CDC Bronco
  - slower flowering time and maturity
  - lower seed weight and yield

Mapping of QTL for Phytate-P concentration

- Hypothesis

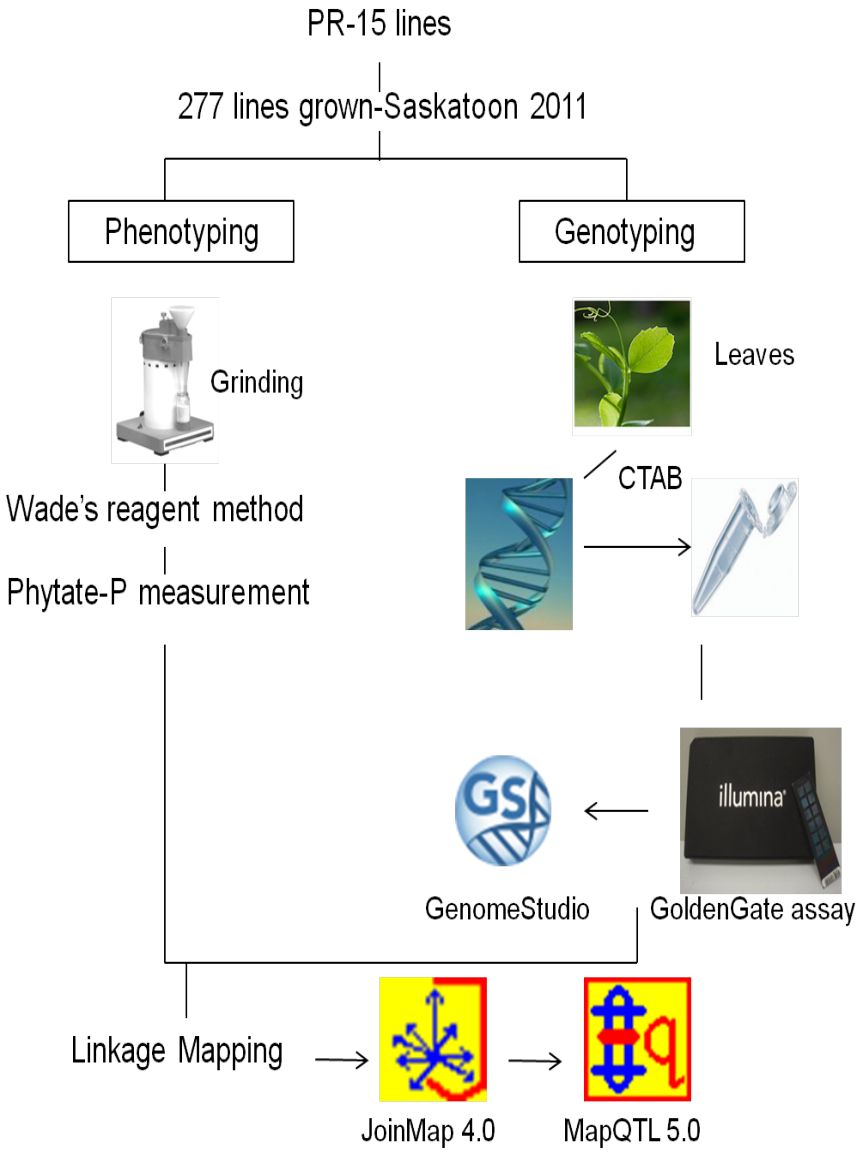
  QTL associated with seed phytic acid concentration can be identified from the recombinant inbred lines developed

- Objective

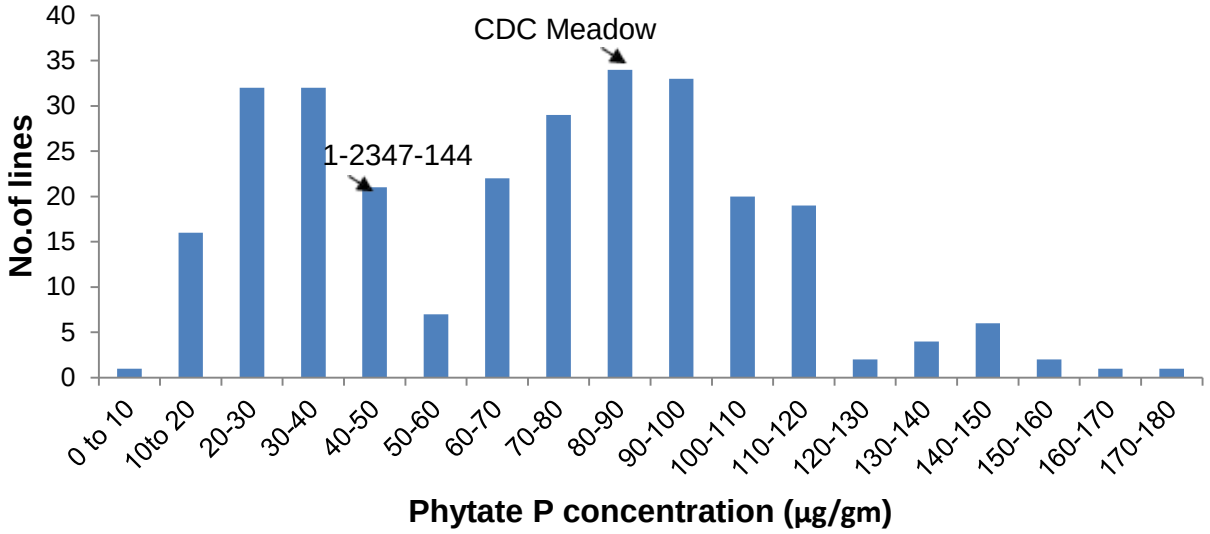
  Mapping of QTL associated with seed phytic acid concentration in pea recombinant inbred lines

Materials and Methods

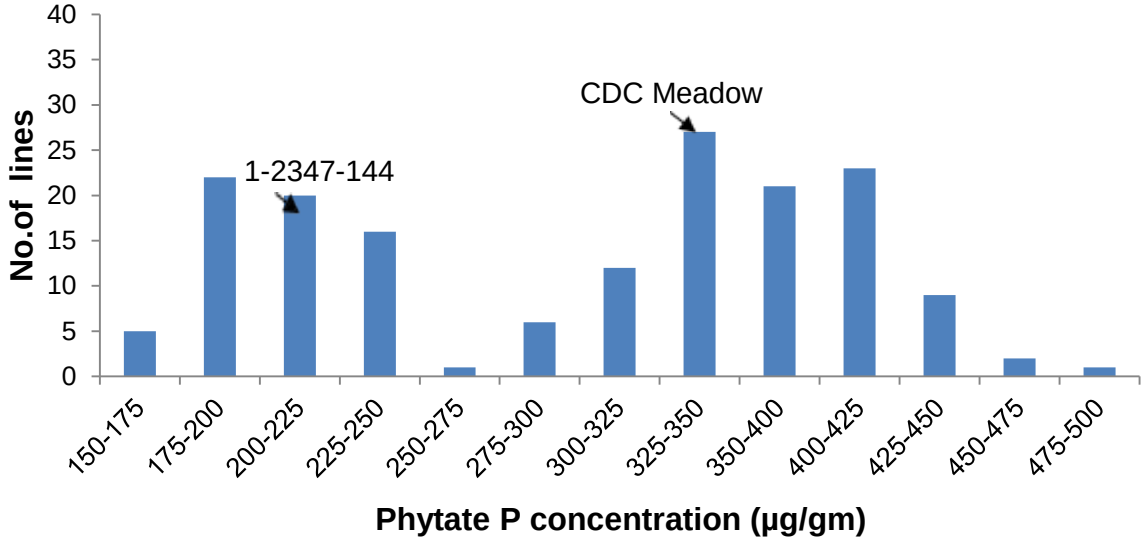
- PR-15
  - Recombinant Inbred lines
  - Sutherland 2011
  - Sutherland & Rosthern 2012, 2013
- Phenotyping
  - Phytate –P estimation
- Genotyping
  - GoldenGate assay
  - 1536 SNP markers
- Statistics
  - SAS 9.3 PROC MIXED



Results – Phytate-P concentration

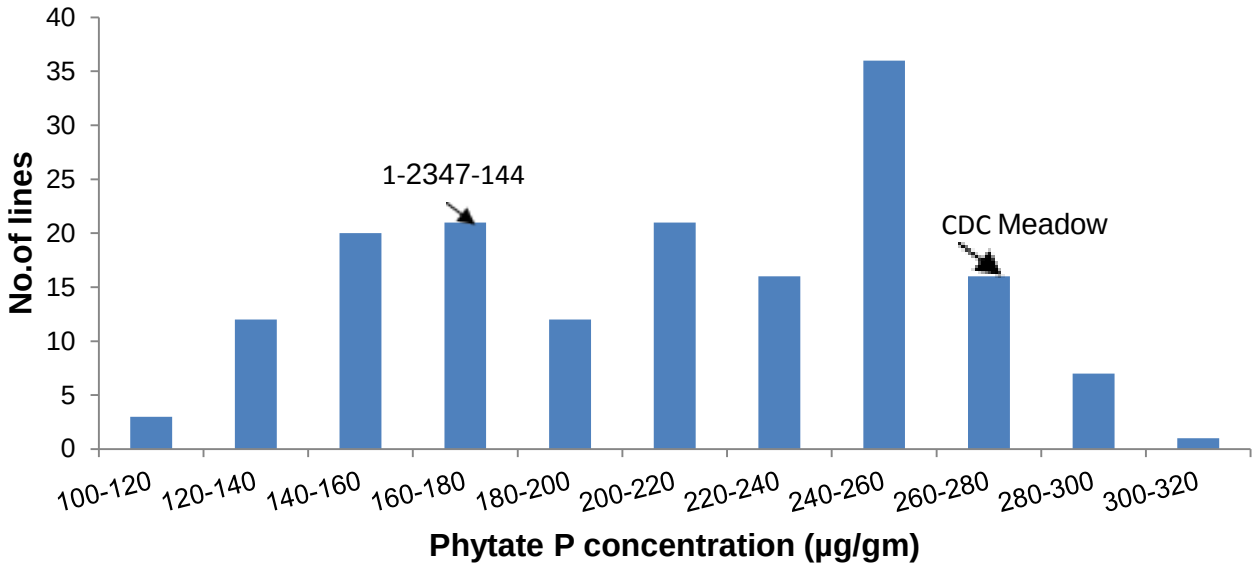


Distribution of Phytate P in PR-15 lines at Sutherland 2011



Distribution of Phytate P in PR-15 lines at Sutherland & Rosthern 2012

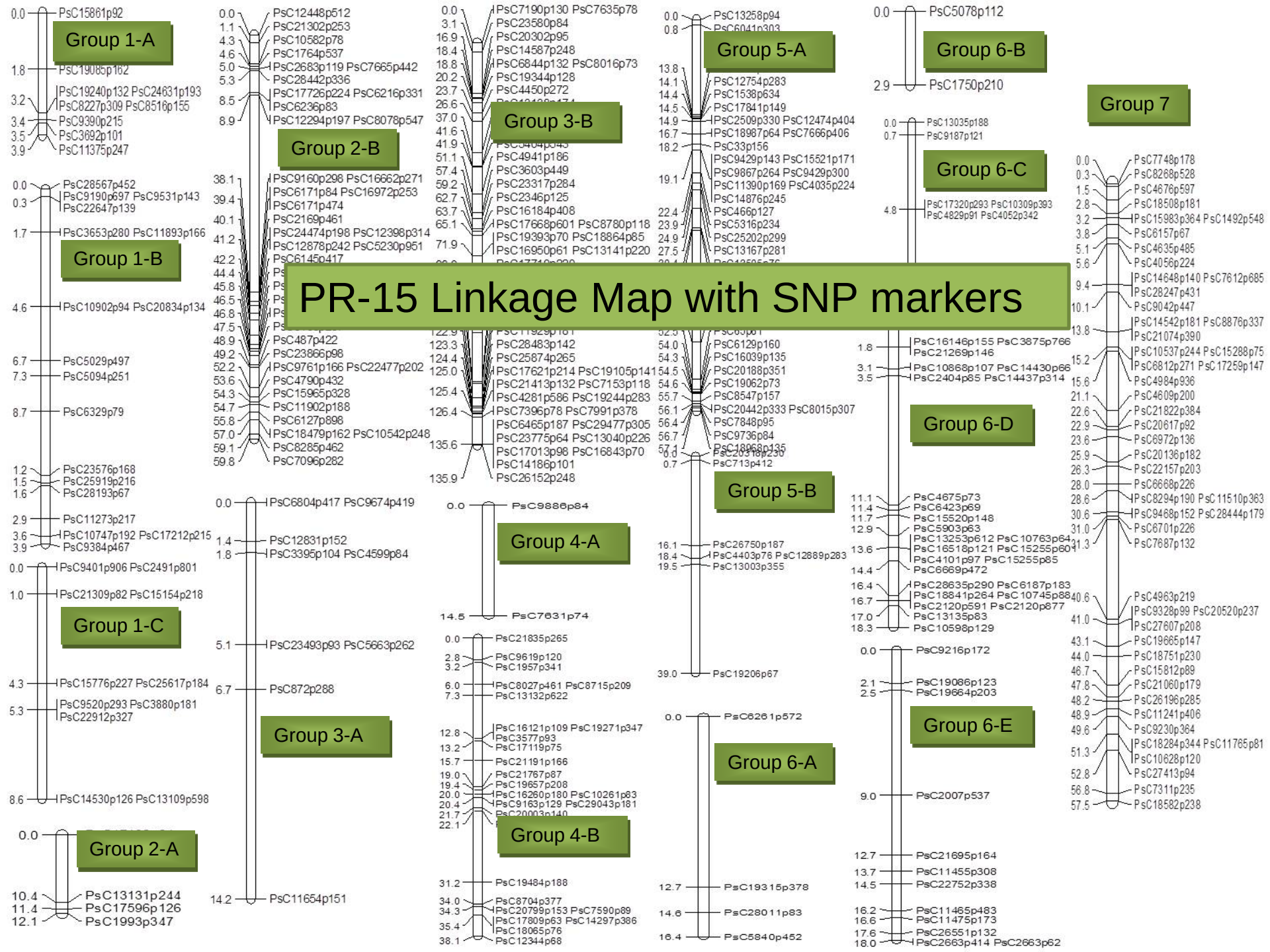
Results – Phytate-P concentration



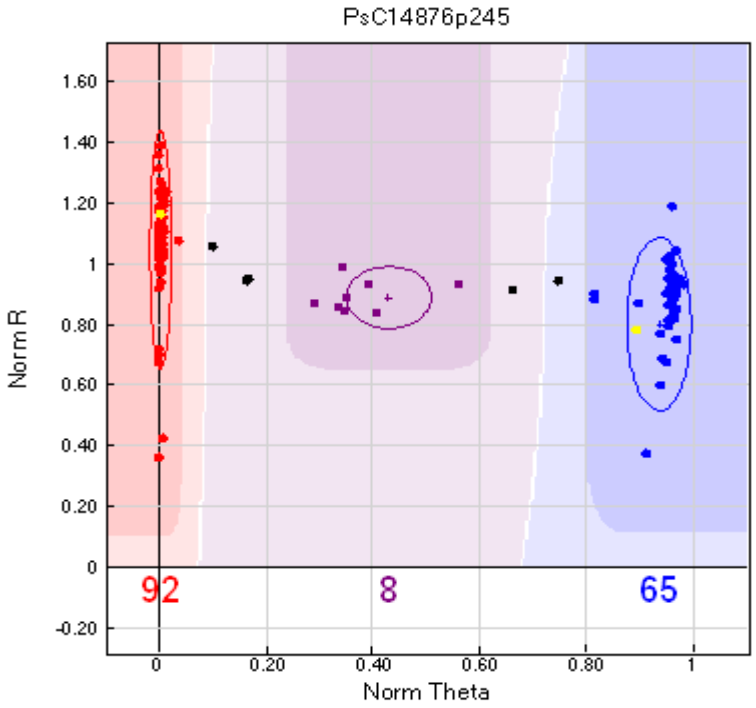
Distribution of Phytate P in PR-15 lines at Sutherland & Rosthern 2013

ANOVA for phytate-P concentration in 2012 & 2013

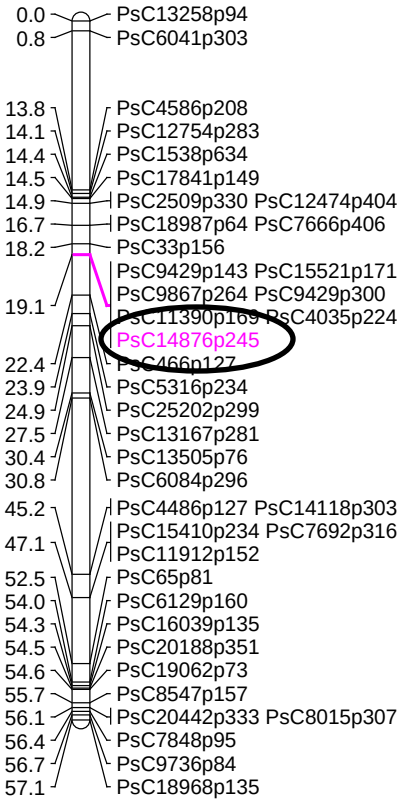
Effect	Num DF	Den DF	F Value	Pr > F
Variety	164	344	2.45	<.0001
Year	1	2	2.57	0.2498
Year*Variety	164	344	1.45	0.0025


PR-15 Linkage Map with SNP markers
Group 1-A
Group 1-B
Group 1-C
Group 2-A
Group 2-B
Group 3-A
Group 3-B
Group 4-A
Group 4-B
Group 5-A
Group 5-B
Group 6-A
Group 6-B
Group 6-C
Group 6-D
Group 6-E
Group 7

Results – QTL for Phytate P



GenoPlot display in GenomeStudio showing PR-15 lines with 2 distinct clusters for PsC14876p245 SNP marker



PsC14876p245 associated with phytate-P in PR-15

Results – QTL for Phytate P

QTL associated with Phytate-P in PR-15 lines across 5 site years

Year	Locus	Linkage Group	LOD	Phenotypic variation (%)
Sutherland 2011	PsC14876p245	5-A	21.96	47.1
Sutherland 2012	PsC14876p245	5-A	19.1	42.5
Rosthern 2012	PsC14876p245	5-A	20.68	45.1
Sutherland 2013	PsC14876p245	5-A	20.11	44.2
Rosthern2013	PsC14876p245	5-A	20.46	44.7

Conclusion

- Phytate P QTL
  - consistent in all 5 site years
  - explains high phenotypic variation
- Validation of QTL
  - in PR-15 and other lines

What are the possible outcomes of this project?

- SNP marker -Marker assisted selection (MAS)
- Lpa pea varieties with improved mineral nutrition
- Reduced environmental pollution

We don't eat nutrients….
We eat food that gives us nutrients….

Acknowledgement

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University of Saskatchewan

Saskatchewan pulse Growers

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