AURI Connects: Webinar Wednesday

a monthly webinar series hosted by the Agricultural Utilization Research Institute

Every 2nd Wednesday
12 pm - 1 pm CT

www.auri.org/webinar-wednesday/

Wheat Variety and Sourdough Product Analysis for Anti-Nutrient Levels Related to Digestibility

George Annor, James Anderson, and Prabin Bajgain

University of Minnesota

UNIVERSITY OF MINNESOTA

Webinar Wednesday

auri connects

Wheat Production

Wheat is the third-largest field crop produced in the United States following corn and soybeans.

1.9 billion bushels of wheat produced in 2018

2019 STATE AGRICULTURE OVERVIEW

Minnesota

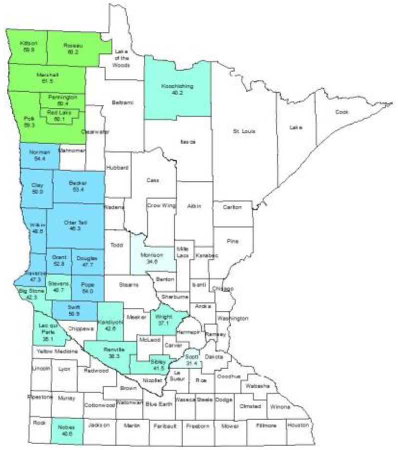
† *Survey Data from Quick Stats as of: Jun/30/2020*

+

Crops - Planted, Harvested, Yield, Production, Price (MYA), Value of Production †
Sorted by Value of Production in Dollars

Commodity	Planted All Purpose Acres	Harvested Acres	Yield	Production	Price per Unit	Value of Production in Dollars
WHEAT						
WHEAT	1,450,000	1,400,000	57 BU / ACRE	79,800,000 BU	4.7 $ / BU	375,060,000
WHEAT, SPRING, (EXCL DURUM)	1,450,000	1,400,000	57 BU / ACRE	79,800,000 BU	4.7 $ / BU	375,060,000
WHEAT, WINTER					(NA) $ / BU	(NA)

Wheat Production in Minnesota



United States Department of Agriculture
National Agricultural Statistics Service

Minnesota Ag News –
2019 Spring Wheat County Estimates

Minnesota Field Office · 375 Jackson St · Ste 610 · St. Paul, MN 55101 (651) 728-3113
fax (855) 271-9802 · www.nass.usda.gov
Cooperating with the Minnesota Department of Agriculture

December 12, 2019 *Media Contact: Dan Lofthus*

Area planted		Area Harvested		Yield per acre		Production	
2018	2019	2018	2019	2018	2019	2018	2019
1,610,000	1,450,000	1,570,000	1,400,000	59.0	57.0	92,630,000	79,800,000

Units: Bushels

The May 2020 price for spring wheat was $3.90 per bushel, down 58 cents from April and down 76 cents from May 2019.

2020 MN spring wheat acres planted is 1.3 million

Per Capita Wheat Consumption in the U.S.

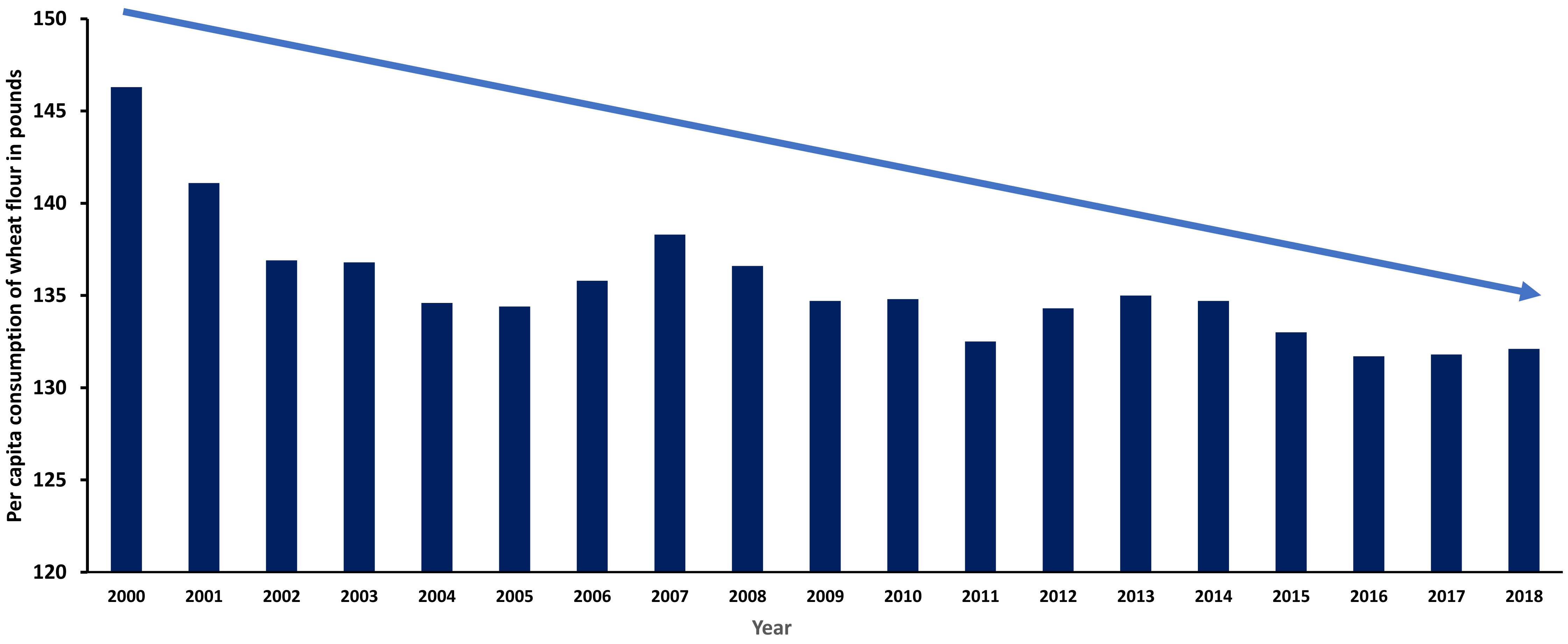
- *Wheat flour consumption was 225 pounds/capita in 1879*
- *Reached a low of 110 pounds in 1972*
- *Rebounded to 146 pounds by 2000*
    - *Popularization of flour-based foods such as pizza*
    - *Advent of bread machines.*

https://www.vvsupremo.com/recipe/pepperoni-pizza/

https://www.agmrc.org/commodities-products/grains-oilseeds/wheat

https://www.nytimes.com/wirecutter/reviews/best-bread-machine/

Per Capita Wheat Consumption in the U.S.



Per capita consumption of wheat flour in pounds

Webinar Wednesday

auri connects

Source: US Department of Agriculture; Economic Research Service: Conducted by the Economic Research Service; US Department of Agriculture Survey period: 2000 to 2018

Economic of restoring wheat consumption and demand

- Lost demand from 1879: 225-131.8 = 93.2 lbs/capita
- 93.2lbs x 320 million people in USA = 29,824,000,000 lbs.
- 29,824,000,000 lbs. / 60 wheat lbs./bushel = 497,066,666 bushels lost demand
- 497,066,666 /(70 bushel/acre MN wheat yield) = 7.1 million acres

Why the Decline?

Fad diets

Promotion of Fad diets, resulting in an increasing percentage of the population to remove starches from their diet

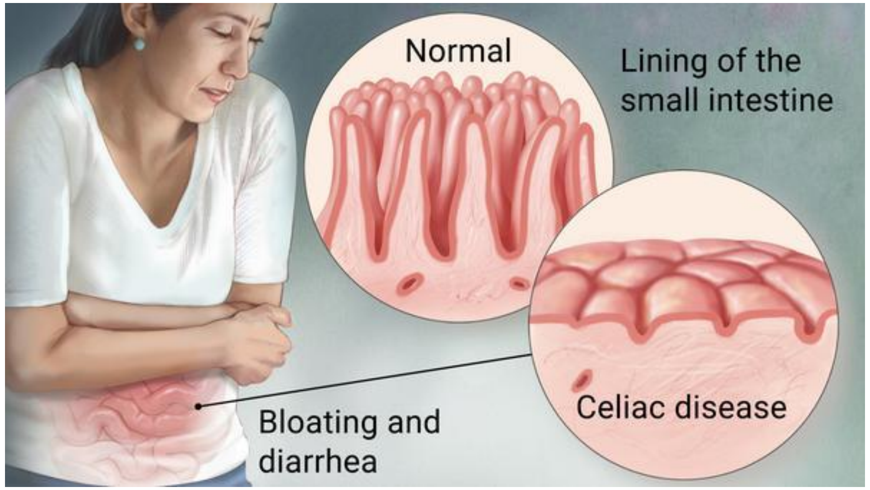
https://www.uab.edu/news/youcanuse/item/9287-fad-diets-or-lifestyle-changes-where-do-three-popular-weight-reduction-plans-fit-in

Why the Decline?

Celiac disease

Celiac disease is an immune disease in which people can't eat gluten because it will damage their small intestine.

Gluten is a protein found in wheat, rye, and barley.



https://www.drperlmutter.com/yes-gluten-sensitivity-is-very-real/

https://support.google.com/websearch/answer/2364942?p=medical_conditions&hl=en

Why the Decline?

Celiac disease

Toxic cereals in celiac disease

Cereal	Prolamine	Composition	Toxicity
Wheat	α-Gliadin	36% Q, 17%–23% P	+++
Barley	Hordeins	36% Q, 17%–23% P	++
Rye	Secalins	36% Q, 17%–23% P	++
Oats	Avenins	High Q, low P	+
Maize	Zeins	Low Q, high A, L	–
Millet	?	Low Q, high A, L	–
Rice	?	Low Q, high A, L	–

NOTE. The major prolamines that drive the immune response in celiac disease are rich in glutamine and proline. A, alanine; L, leucine; P, proline; Q, glutamine.

Schuppan, D. (2000)

Why the Decline?

Non allergy-non-celiac wheat sensitivity (NCWS)

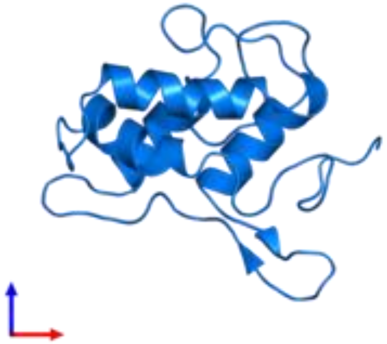
- NCWS is defined as mainly abdominal symptoms related to ingestion of gluten containing cereals
- Not caused by celiac disease and wheat allergy have been (largely) excluded.

https://enjoylifefoods.com/blogs/content/about-fodmap-friendly-living-enjoy-life-products

Why the Decline?

Possible causes of Non allergy-non-celiac wheat sensitivity (NCWS)

- **FODMAPS -**Fermentable Oligo-, Di- and Monosaccharides and Polyols
- **“ATI” -** Amylase Trypsin inhibitors



https://enjoylifefoods.com/blogs/content/about-fodmap-friendly-living-enjoy-life-products

Why the Decline?

- **FODMAPS**
  - Fermentable Oligo-, Di- and Monosaccharides and Polyols
- **They comprise**
  - Fructose, lactose, fructo- and galactooligosaccharides (fructans, and galactans)
  - Polyols (such as sorbitol, mannitol, xylitol and maltitol)

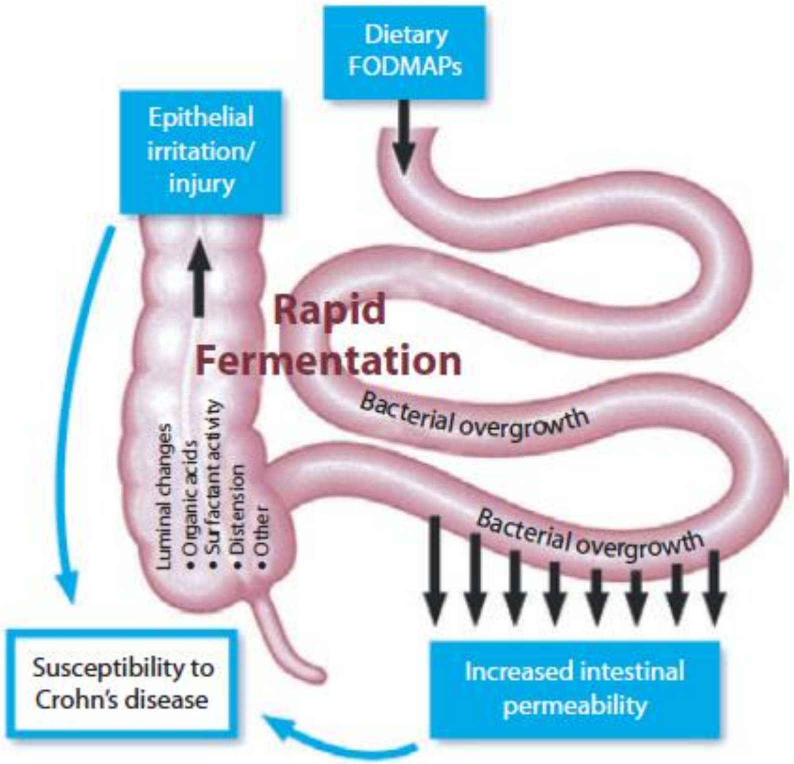
https://enjoylifefoods.com/blogs/content/about-fodmap-friendly-living-enjoy-life-products

Why the Decline?

FODMAPS

- ***Poorly absorbed in the small intestine***
  - *Results in irritation of intestines*
- ***Osmotically-active molecules***
  - *Exerts a laxative effect when given in sufficient dose by increasing the liquidity of luminal contents and subsequently affecting gut motility.*
- ***Rapidly fermented by bacteria***
  - *Results in intestinal distension from CO_2 production*

Why the Decline?



Gibson et al 2005

FODMAPS and Crohn's disease

Crohn's disease is an inflammatory bowel disease (IBD) resulting in inflammation of your digestive tract, which can lead to abdominal pain, severe diarrhea, fatigue, weight loss and malnutrition

https://www.mayoclinic.org/diseases-conditions/crohns-disease/symptoms-causes/syc-20353304

Low FODMAP Cutoff

Individual FODMAPs	Grams per serve† (individual food)
Oligosaccharides‡ (core grain products, legumes, nuts, and seeds)	<0.30
Oligosaccharides (vegetables, fruits, and all other products)	<0.20
Polyols—sorbitol or mannitol	<0.20
Total polyols	<0.40
Excess fructose§	<0.15
Lactose	<1.00

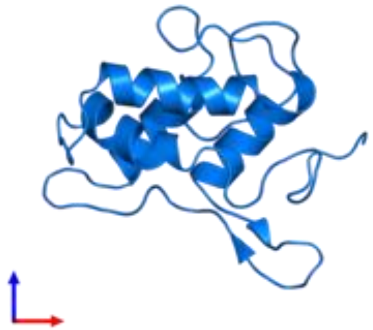
Low-FODMAP cutoff values for each FODMAP sugar (per serving of food per sitting) including oligosaccharides (total fructans plus galacto-oligosaccharides), polyols (sorbitol and mannitol), fructose in excess of glucose, and lactose

Varney, J., Barrett, J., Scarlata, K., Catsos, P., Gibson, P. R., & Muir, J. G. (2017)

Why the Decline?

- **"ATI"- Amylase Trypsin inhibitors**

- **What are they?**



  - Wheat ATIs are a family of up to 17 similar proteins of molecular weights around 15 kD and represent 2–4% of the wheat protein

  - ATIs can evoke intestinal inflammation by activating gut and mesenteric lymph node myeloid cells

  - ATIs are highly resistant to proteases and heat

https://www.ebi.ac.uk/pdbe/entry/pdb/1b1u/protein/1

Project Partners agreed to tackle issue

DEPARTMENT OF AGRICULTURE

Minnesota Wheat Research and Promotion Council

UNIVERSITY OF MINNESOTA

Agricultural Utilization Research Institute auri

Back When Foods

Reduce the discomforts resulting from the consumption of wheat-based products to improving the health of consumers and increasing the profitability of wheat farmers

https://soulsalt.com/long-term-goals/

Aim

- Reduce wheat sensitivity through the identification of wheat varieties with naturally low “anti-nutrient” levels for breeding purposes

- Explore fermentation as a processing technique to reduce FODMAPs.

Specific Objectives

- Characterize variation and identify genetic markers for FODMAPs and ATI activity in ancient, heritage and modern wheat varieties from different growing environments in Minnesota
- Explore the use of fermentation as a technique to reduce FODMAPs and ATI activity in wheat food products
- Establish a pathway to implement research outcomes to industry.

Materials and Methods

Objective 1

Characterize variation and identify genetic markers for FODMAPs and ATI activity in ancient, heritage and modern wheat varieties from different growing environments

Materials

- A panel of 200 ancient, heritage and modern wheat varieties were grown at U of MN field sites at Crookston and St. Paul, MN in 2019
- The panel represented heritage and hard red spring wheat diversity going back to the origins of the U of MN wheat breeding program (~ 1895) and regional breeding programs
- Plots were treated with fungicide as necessary to reduce damage from fungal pathogens

Methods

- FODMAPs was determined using High Performance Anion-Exchange Chromatography.
- ATI activity was determined by ELISA techniques
- Genetic markers were identified for the individual FODMAPs and ATI for breeding purposes

Methods

- Genetic markers were determined by extracting DNA from the panel of 200 wheat varieties and genotyped using Genotyping-By-Sequencing.

- Association mapping was used to identify DNA markers associated with FODMAPs and ATI activity.

Materials and Methods

Objective 2

Explore the use of fermentation as a technique to reduce FODMAPs and ATI activity in wheat food products

Methods

- Sour dough will be prepared from 30 of 200 wheat varieties to determine effects of different fermentation times on the levels of FODMAPs and ATI activity.

- Sample selection will be based on the classification of the wheat varieties into low, medium and high FODMAPs with 10 varieties from each group.

Methods

- The sourdough breads will be prepared based on traditional methods using a Type 1 sourdough culture.
- Doughs will be fermented at 72°F at 4, 8 and 12 hours to mimic commercial sourdough bulk fermentation
- FODMAPs and ATI will then be determined

https://jovialfoods.com/recipes/whole-grain-einkorn-sourdough-bread/

Beneficiaries

- **Minnesota Farmers**

  By providing the basis for possible breeding efforts to reduce wheat sensitivity, it is expected that consumer demand for wheat-based products will increase, thus resulting in increased profitability for farmers.

Beneficiaries

- **Bread Processors**
  - By processing products using fermentation techniques that could reduce anti-nutrients and reduce human digestive issues in populations with FODMAP sensitivities.

Beneficiaries

- **Consumers**
  - By enjoying products that have lower FODMAPs and anti-nutrients that cause digestive issues
  - For individuals with wheat sensitivity, less reactive wheat products can increase quality of life while enjoying the health benefits of wheat products

Preliminary Results

Wheat Materials for FODMAP Evaluation

Material	No. lines
Heritage wheats:	46
Modern wheats:	142
Durum:	5
Einkorn:	10
Emmer:	11
Synthetic hexaploids:	16
Total:	230

Evolution of Wheat

Triticum monococcum
AA (einkorn wheat)

X
~10,000 BC

Aegilops speltoides BB
(goatgrass)

Triticum turgidum
AABB (emmer wheat)
cultivated starting ~9,000 BC
(aka Durum wheat)

X
~8,000 BC

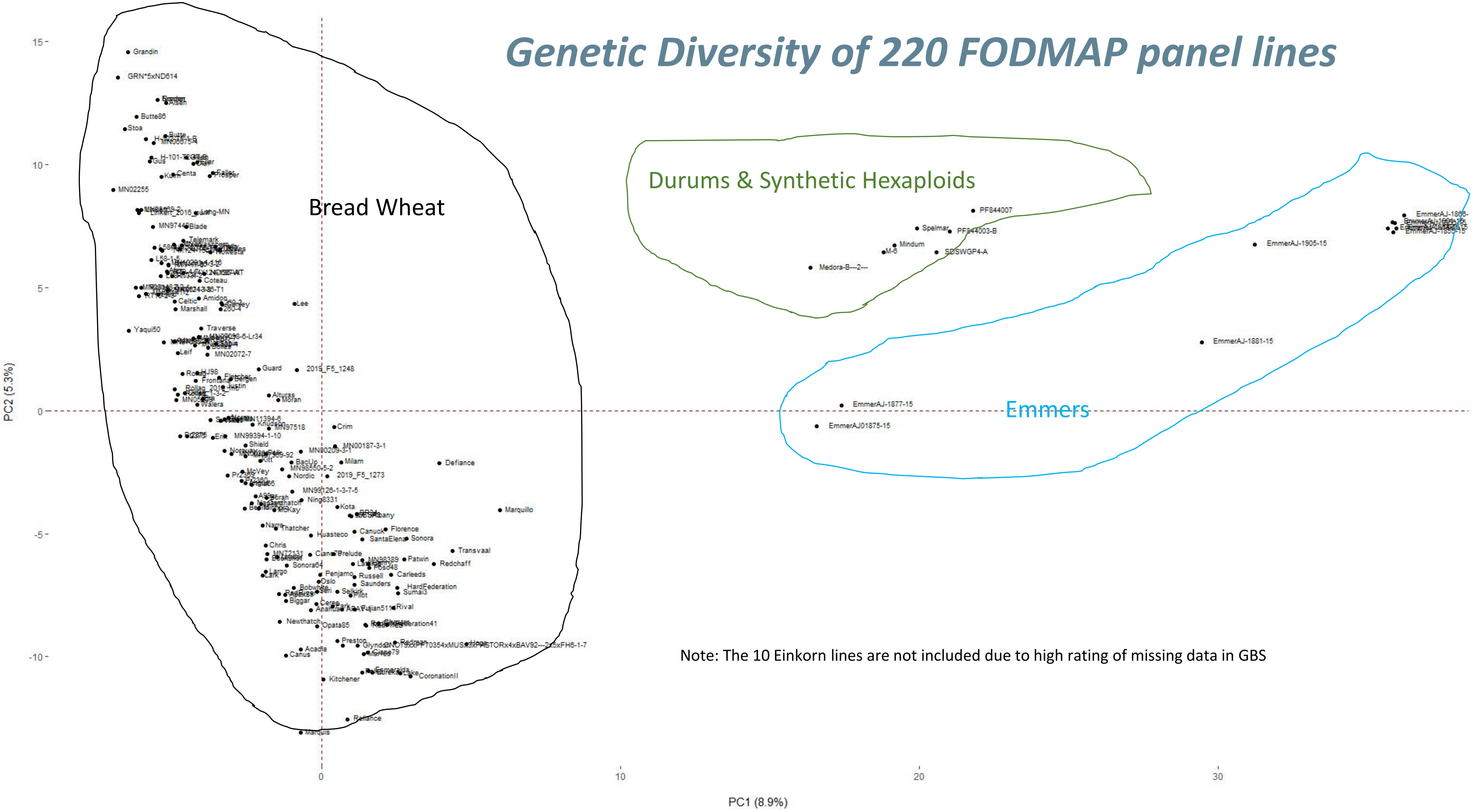
Ae. tauschii
DD (wild goatgrass)

Triticum aestivum
AABBDD (common wheat

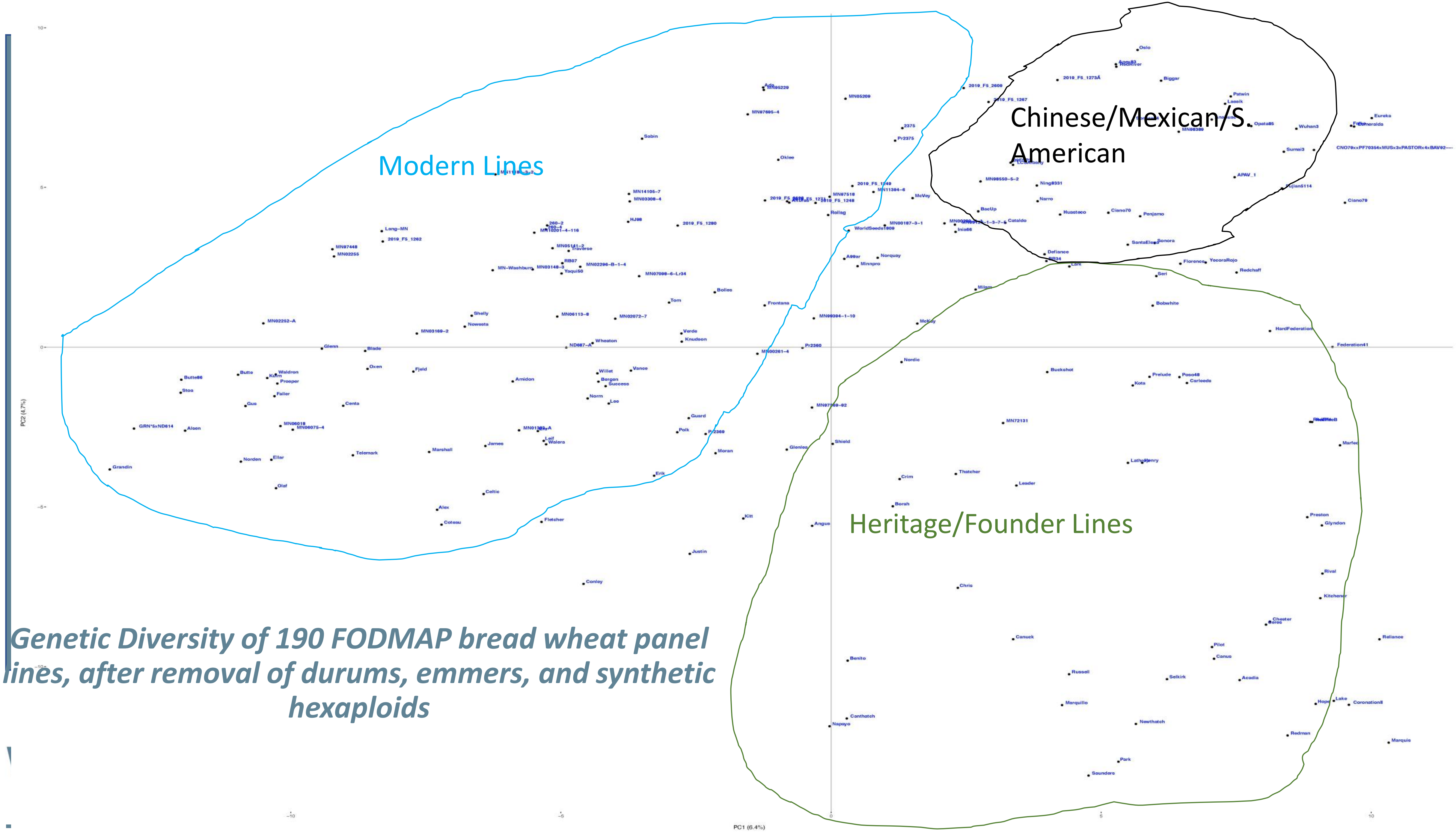
2019 FODMAP panel grow-out in Crookston

Lots of variation observed for heading date, height, yield

Genetic Diversity of 220 FODMAP panel lines

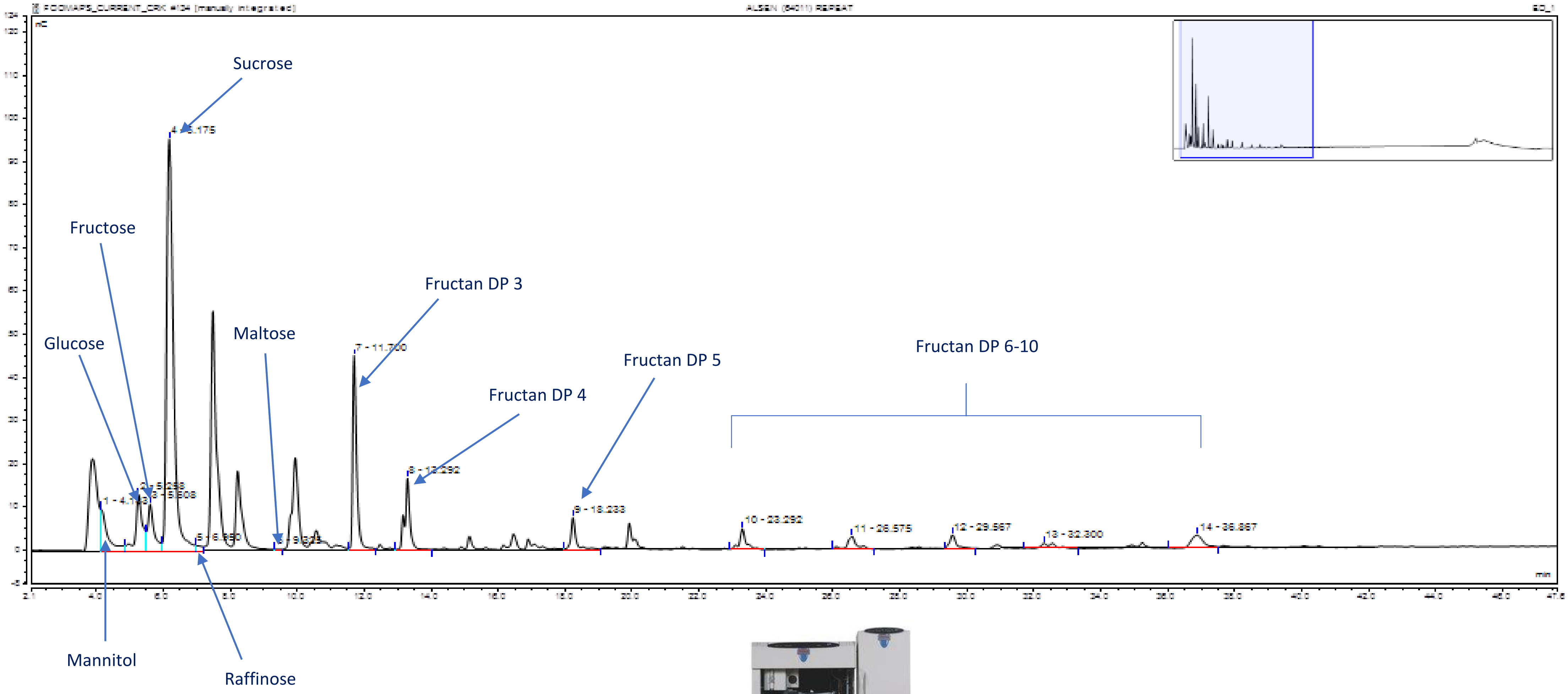


Note: The 10 Einkorn lines are not included due to high rating of missing data in GBS



Genetic Diversity of 190 FODMAP bread wheat panel lines, after removal of durums, emmers, and synthetic hexaploids

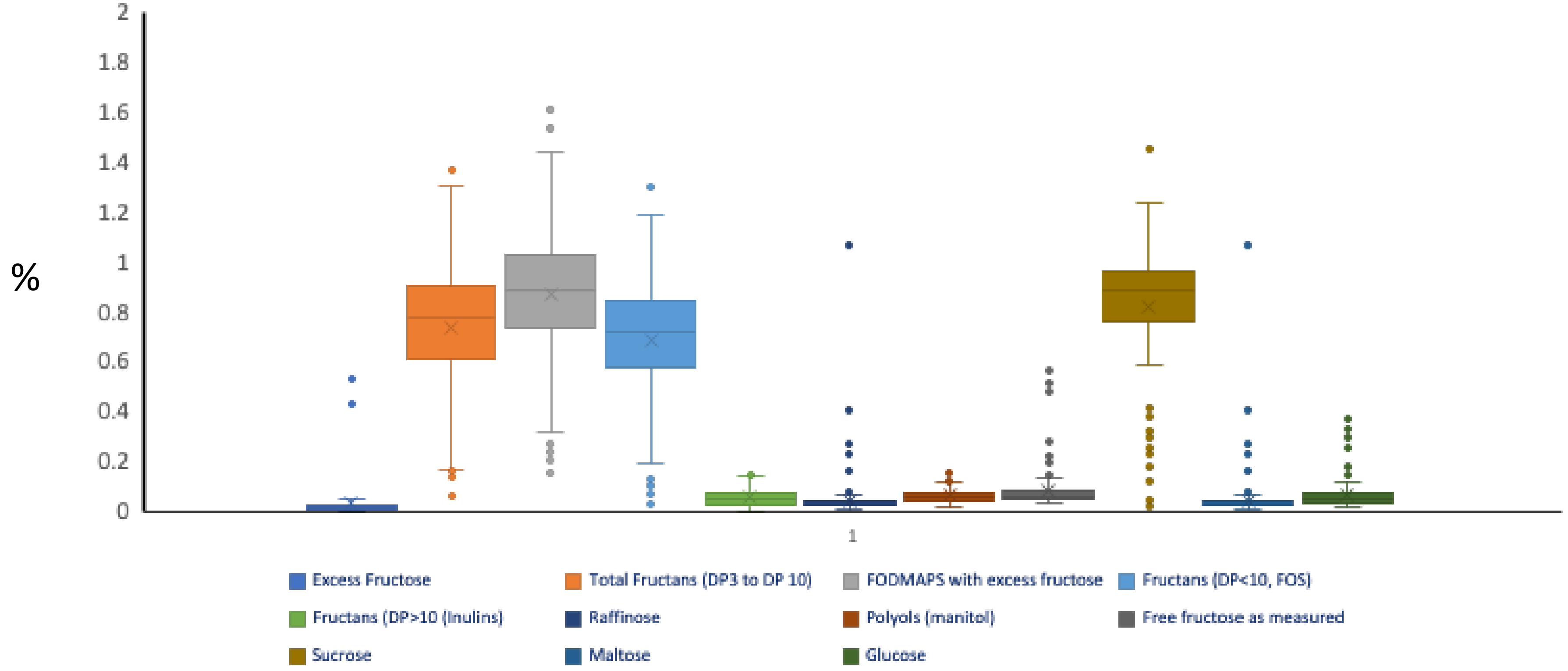
FODMAP Evaluation



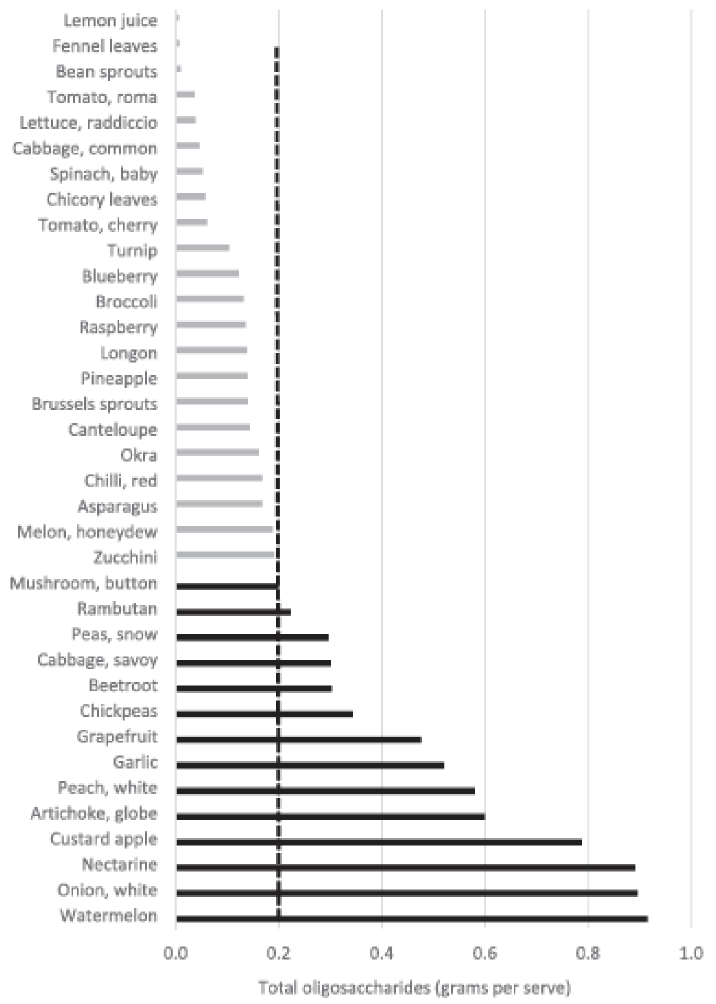
FODMAP Results (196 samples from Crookston MN)

Index (%)	Range	Mean
FODMAP	0.15 – 1.61	0.87
Total Fructan (DP 3-10)	0.06 – 1.37	0.74
Fructans (DP <10) (FOS)	0.03 – 1.30	0.69
Fructan (DP> 10) (Inulin)	0.00 – 0.16	0.05
Raffinose	0.01 – 1.07	0.04
Polyols (Mannitol)	0.02 – 0.15	0.06
Excess Fructose	0.00 – 0.53	0.03
Other saccharides		
Sucrose	0.02 – 2.07	0.83
Glucose	0.02 – 0.37	0.07
Maltose	O.01 – 1.07	0.04

FODMAP Results (196 samples from Crookston MN)



FODMAP Contents



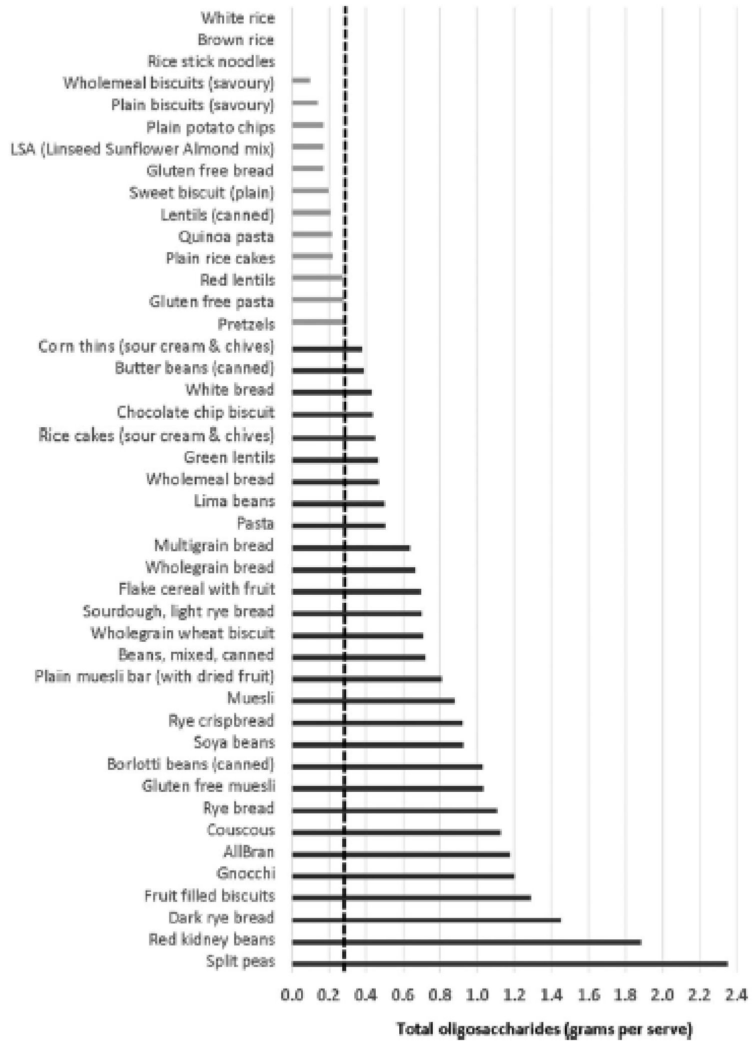
Oligosaccharide content of low-FODMAP ( ) and high-FODMAP ( ) fruits and vegetables.[12,13]

Webinar Wednesday

Varney, J., Barrett, J., Scarlata, K., Catsos, P., Gibson, P. R., & Muir, J. G. (2017)

auri connects

FODMAP Contents



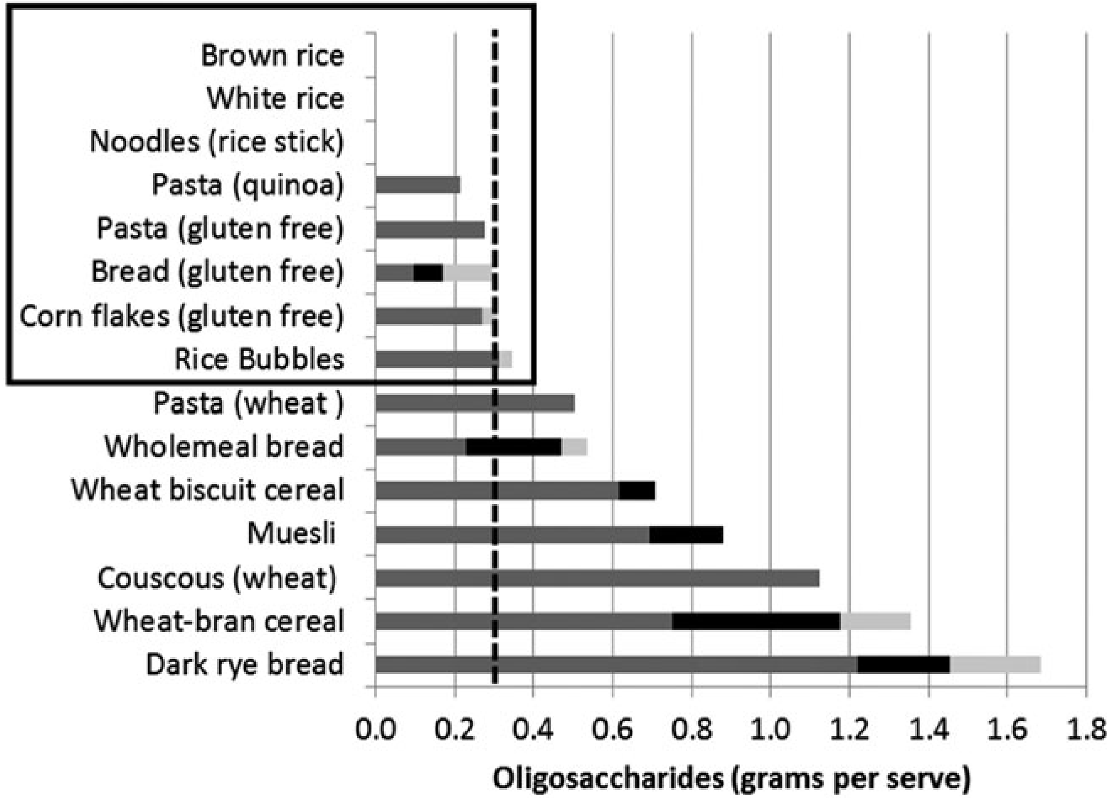
Oligosaccharide content of low-FODMAP (▥) and high-FODMAP (■) breads, cereals, legumes, nuts, and seeds.[14]

Webinar Wednesday

Varney, J., Barrett, J., Scarlata, K., Catsos, P., Gibson, P. R., & Muir, J. G. (2017)

auri connects

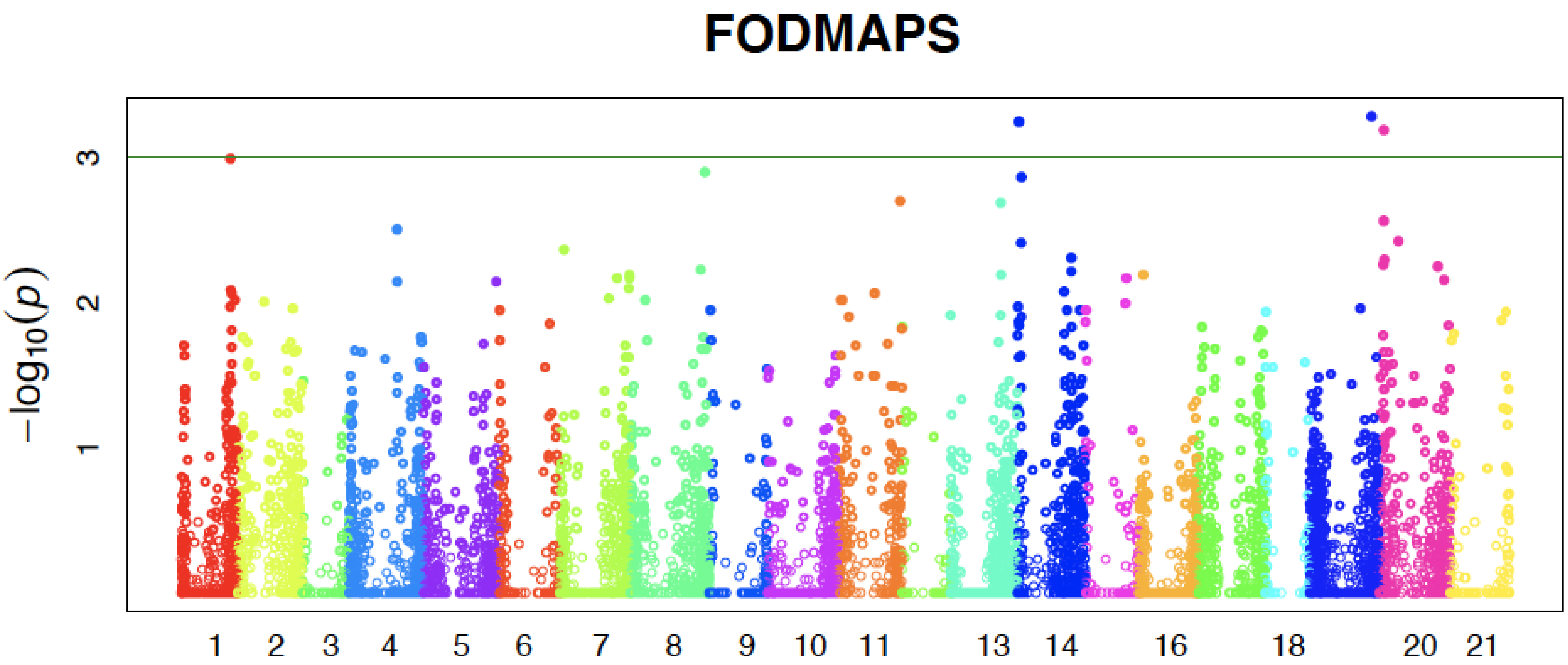
FODMAP Contents



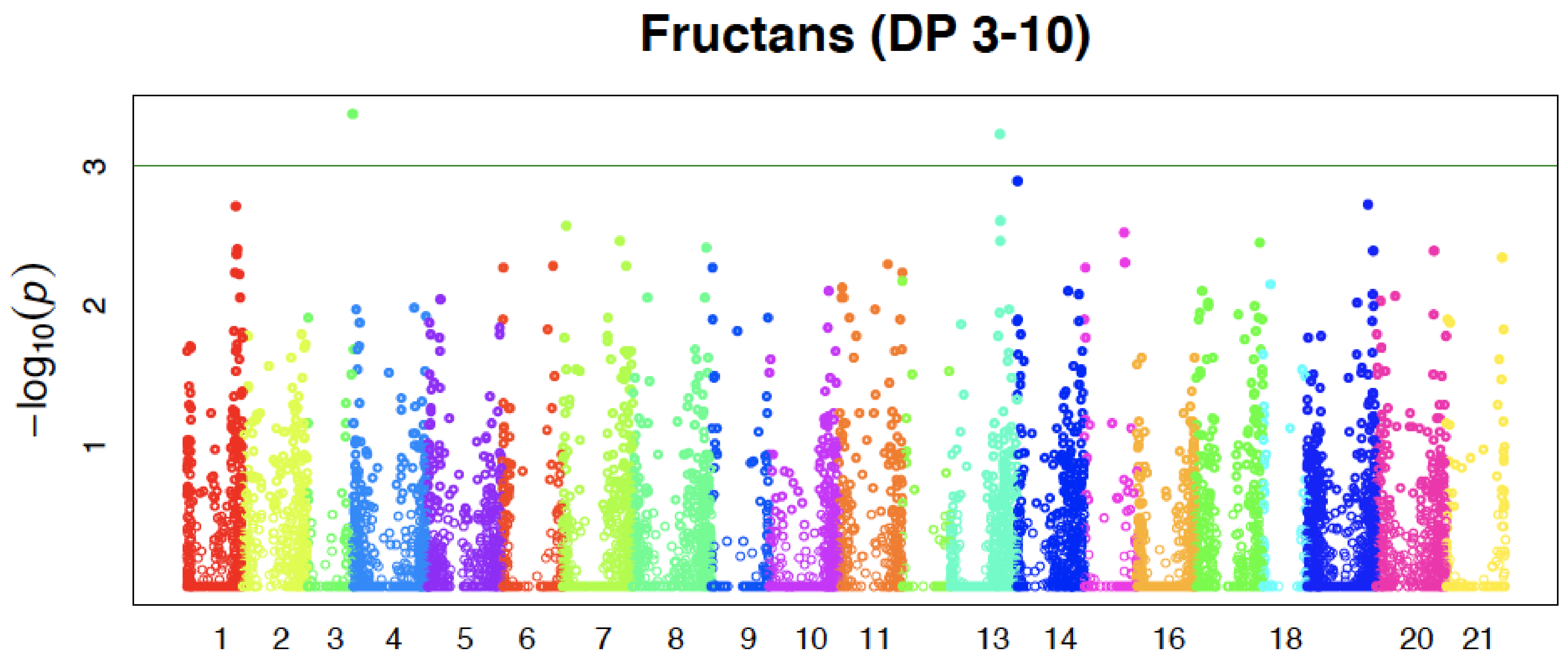
Oligosaccharide content of gluten-containing and gluten-free grains. ☐, gluten free; ■, fructan; ■, galacto-oligosaccharides; ■, excess fructose.[14]

Varney, J., Barrett, J., Scarlata, K., Catsos, P., Gibson, P. R., & Muir, J. G. (2017)

FODMAP Results (196 samples from Crookston MN)



FODMAP Results (196 samples from Crookston MN)



Wheat Materials for FODMAP Evaluation

Material	Anticipated Completion Date
FODMAP Crookston rep 1, 196 samples	Done – May 7, 2020
FODMAP Crookston rep 2, 113 samples	July 2020
FODMAP St. Paul, 2 reps, 336 samples	September 2020
ATI Crookston, 2 reps, 309 samples	December 2020
ATI St. Paul, 2 reps, 336 samples	March 2021

Preliminary findings summary

- **Based in the limited data so far, we can conclude that**

  - Wide differences exits in total Fructans, FODMAPS and Fructans with DP<10

  - Genetically diverse set of wheat lines being analyzed

  - No identifiable patterns regarding FODMAP and Total Fructan concentrations vs. year of release or wheat species

  - No genomic region is responsible for a large portion of the genetic variation for these traits

Acknowledgements

MN DEPARTMENT OF AGRICULTURE

Acknowledgements

Emily Conley (Researcher)

Susan Reynolds (Researcher)

Nate Stuart (Researcher)

Prince Boakye (PhD Student)

Ibilola Kougbglenou (Researcher)

Q&A

Join us next month!

www.auri.org/webinar-wednesday/