Increasing the value of canola (*Brassica napus* L.) meal through breeding for higher protein and decreased fiber contents

Steven King, Dave Charne, Chad Koscielny, Jean-Claude Pruvot, Ray Cowley, Igor Falak, Raju Jetty, Xiuqiang Huang, Ushan Alahakoon

International Rapeseed Congress, Sydney AU

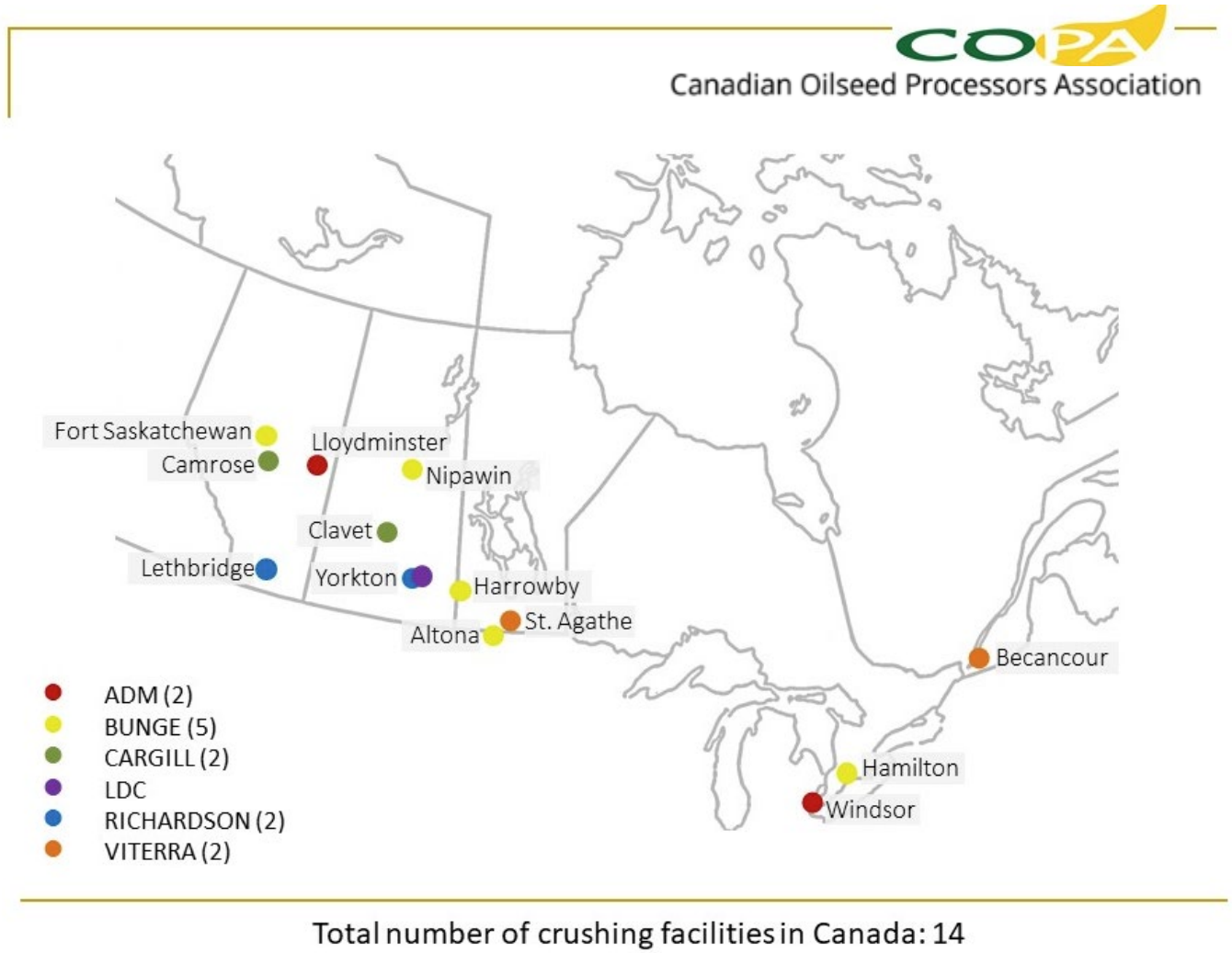
September 25, 2023

Outline

Objective: Increase the value of canola meal

1. Introduction and objective
2. Understanding seed composition GxE
3. Increasing protein content
4. Decreasing fiber content
5. Increasing feed energy value
6. Summary

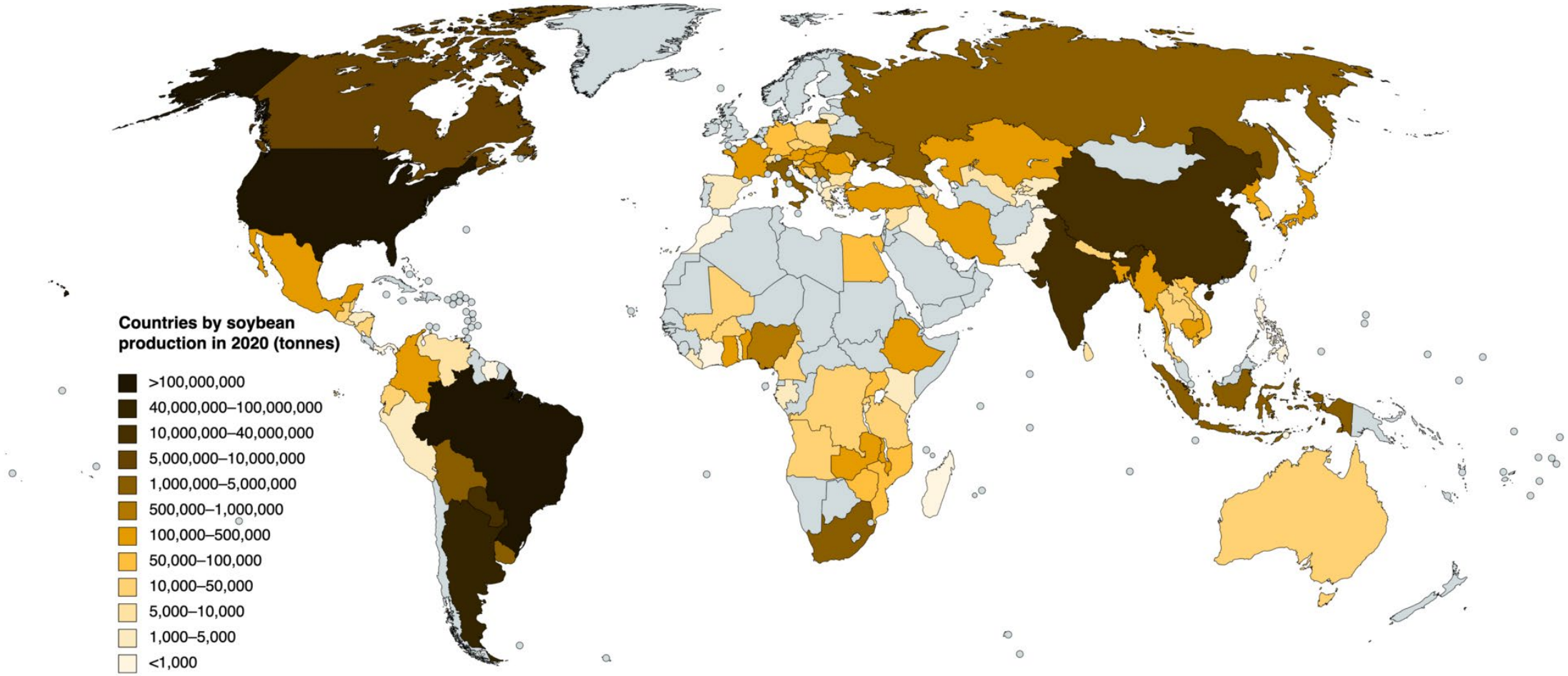
Canada domestic canola crush capacities increasing



- "Canadian canola crushers have announced plans to expand annual capacity by 6.7 million tonnes, a 60 percent increase over current levels" *Source: The Western Producer, June 21, 2023.*
- Growth driven by renewable fuel initiatives
- More domestic crush means more canola meal to market
- US soybean crush capacities also increasing

Europe and Australia import soybeans

A domestic source of plant protein is an advantage



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Current canola meal utility as a feed ingredient

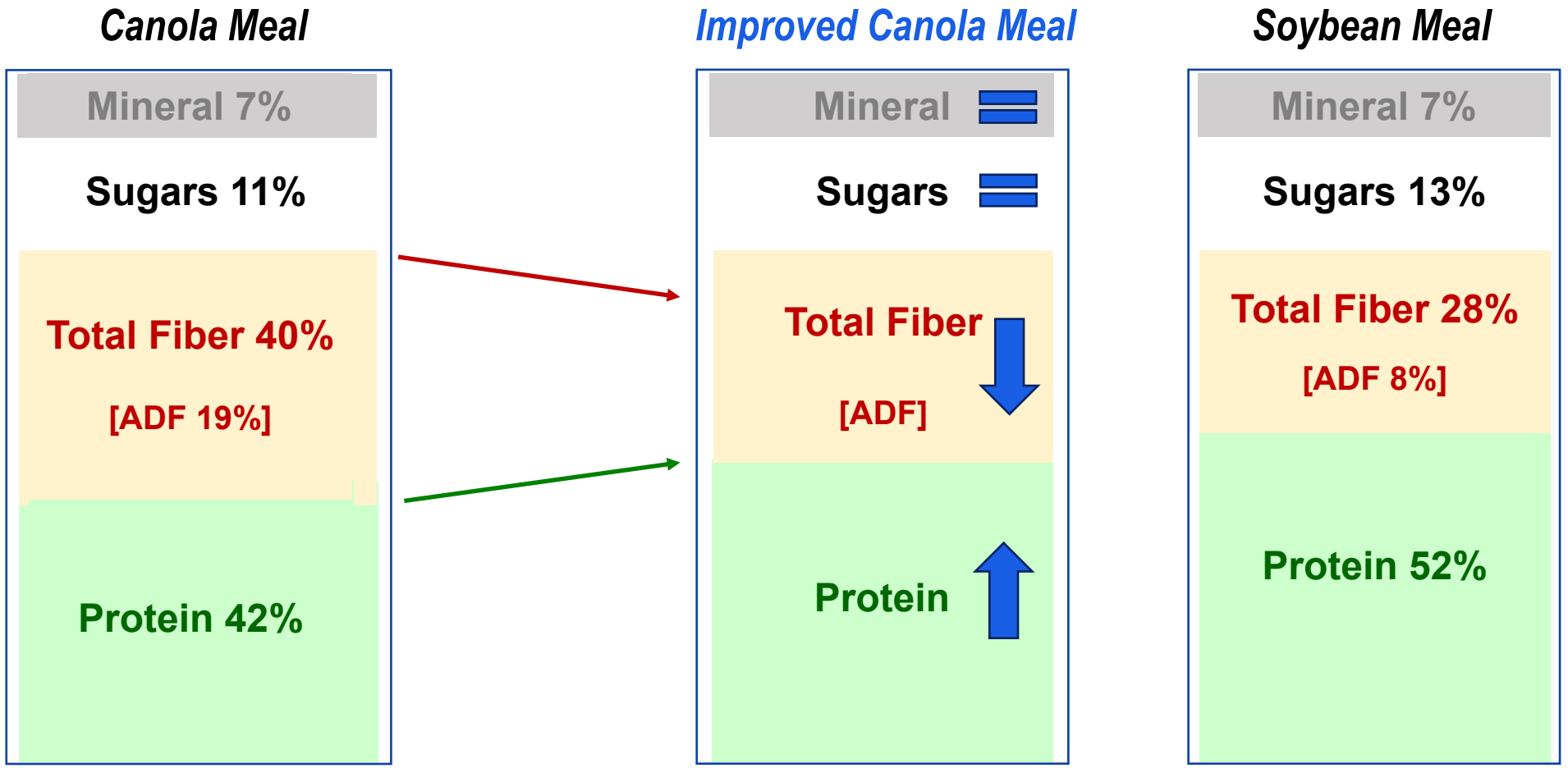
Excellent protein quality. Quantity and energy is diluted by fiber

USE:	PROTEIN	FIBER	ENERGY	GLUCS	MAXIMUM INCLUSION	COMMENTS:
Dairy					To formulation	RUP[1] a big plus, ruminant gets energy from fiber. Canola > Soy meal per unit protein due to RUP[2].
Beef					To formulation	Similar to dairy but RUP not big advantage. Canola = Soy[3].
Swine – Starter, Grow/Finish					10-30%	Higher inclusion with weanlings, lower for growing hogs & lactating sows. Protein & energy concerns limit to partial replacement. Canola < Soy meal[3]
Broilers – Starter, Grow/Finish					10-20%	Lower inclusion for starters. Protein & energy concerns and intake limit inclusion, limited replacement of Soy. Canola << Soy meal[3].
Turkeys					20%	Protein concerns, partial replacement of Soy. Canola < Soy meal[3].
Fish – Warm Water Species[4]					10%	Partial replacement of fish meal.

[1]RUP=rumen undigested protein. [2]Not issue with dry-toasted meal at current inclusion rates [3]On per kg of protein [4]Carp,Tilapia.

Objective: Increase the value of canola meal

How: Close value gap between canola meal and soybean meal by increasing CRUDE PROTEIN, reducing TOTAL FIBER, especially ADF (acid detergent fiber), and increasing ENERGY



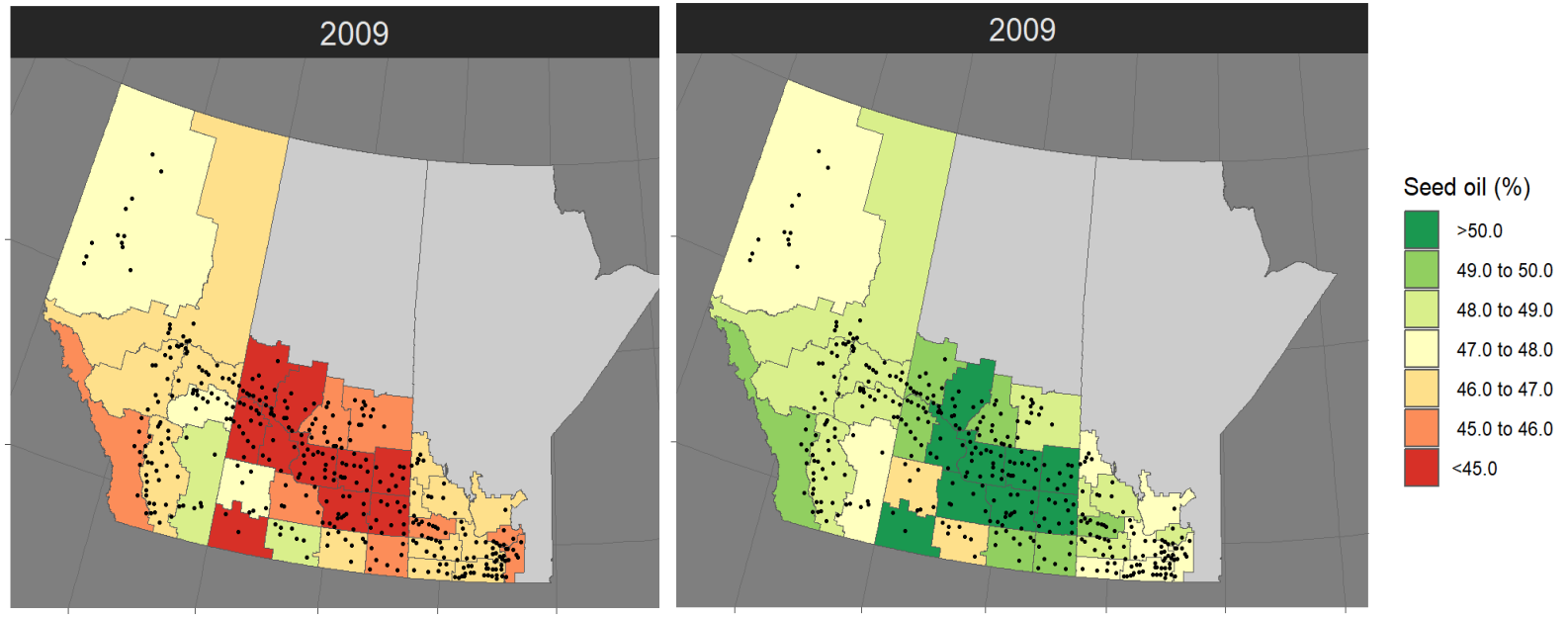
Dry matter basis

Understanding seed composition GxE

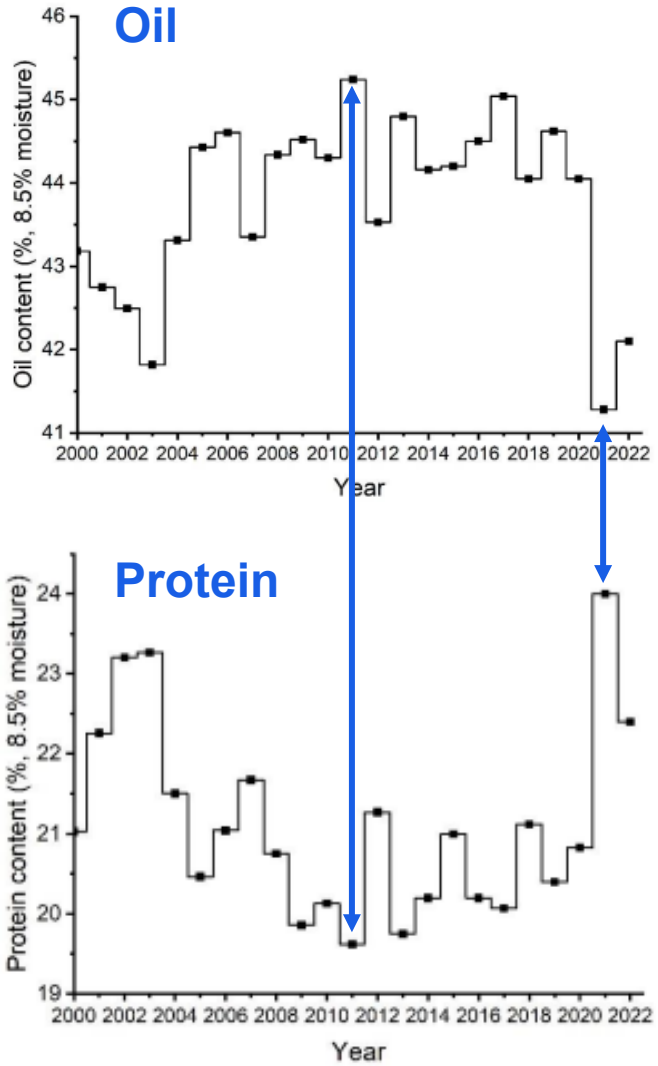
Correlation between oil and protein contents

Strong negative environment trait correlation

Protein **Oil**



Commercial canola grain samples submitted to Canadian Grain Commission, 2009-2022, database of ~10,000 records



https://www.grainscanada.gc.ca/en/grain-research/export-quality/oilseeds/canola/2022/pdf/quality-report-canola-2022.pdf

Protein content correlation with other traits

Negative genetic trait correlation with ADF is an advantage

Negative genetic trait correlation with yield is a challenge

Positive genetic trait correlation with maturity is a watch-out

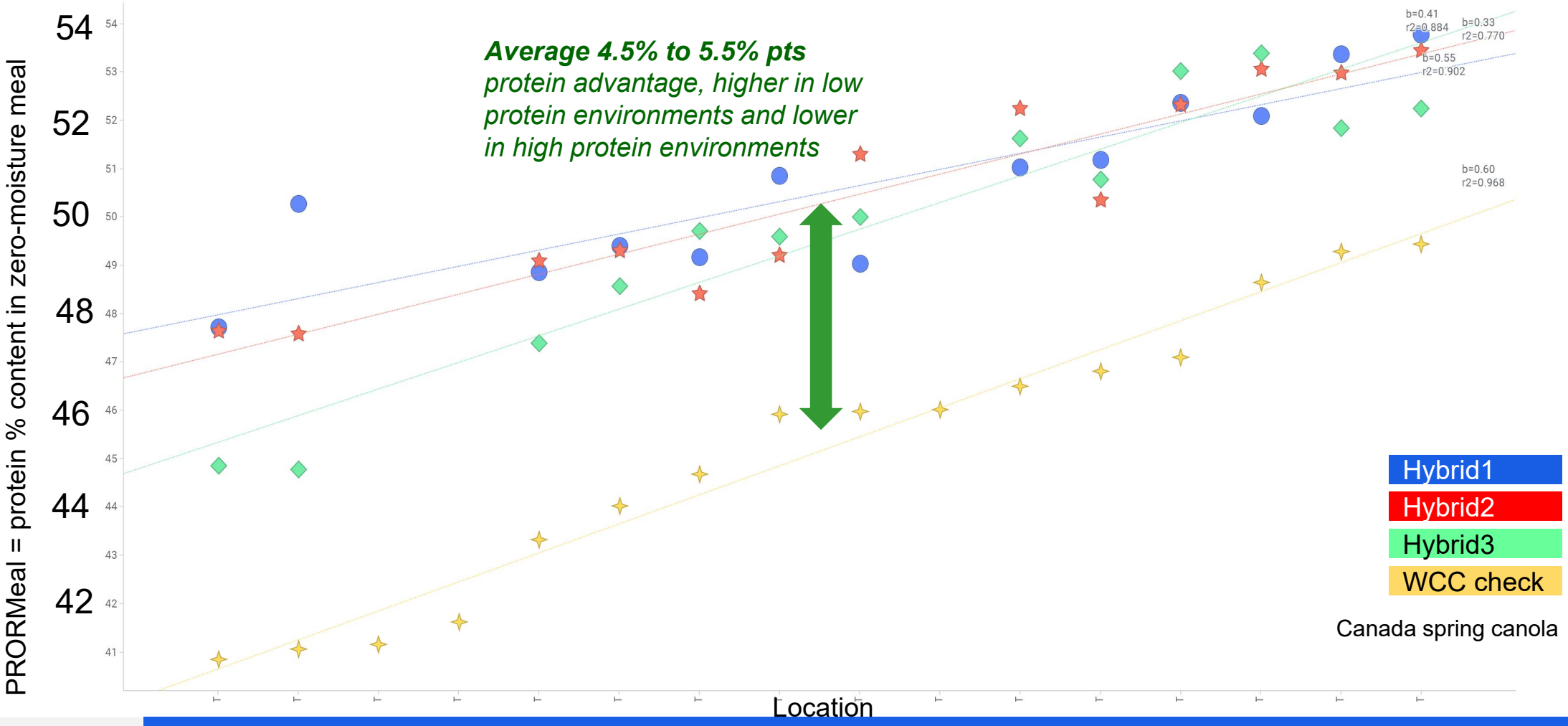
Protein % trait correlations in elite spring-type canola (Canada)

	Genetic Effect				Location Effect			
	2019	2020	2021	2022	2019	2020	2021	2022
Oil %	0.35	0.08	-0.01	-0.06	-0.71	-0.87	-0.84	-0.78
ADF %	-0.76	-0.67	-0.69	-0.49	-0.82	-0.93	-0.66	-0.89
Yield	-0.25	-0.28	-0.36	-0.36	0.27	-0.18	-0.06	0.14
Maturity	0.33	0.29	0.34	0.34	-0.17	0.33	-0.50	-0.22

Stable protein advantage across environments

3 high-protein hybrids compared to commercial checks

Checks ranged from 41 to 48% protein meal depending on site

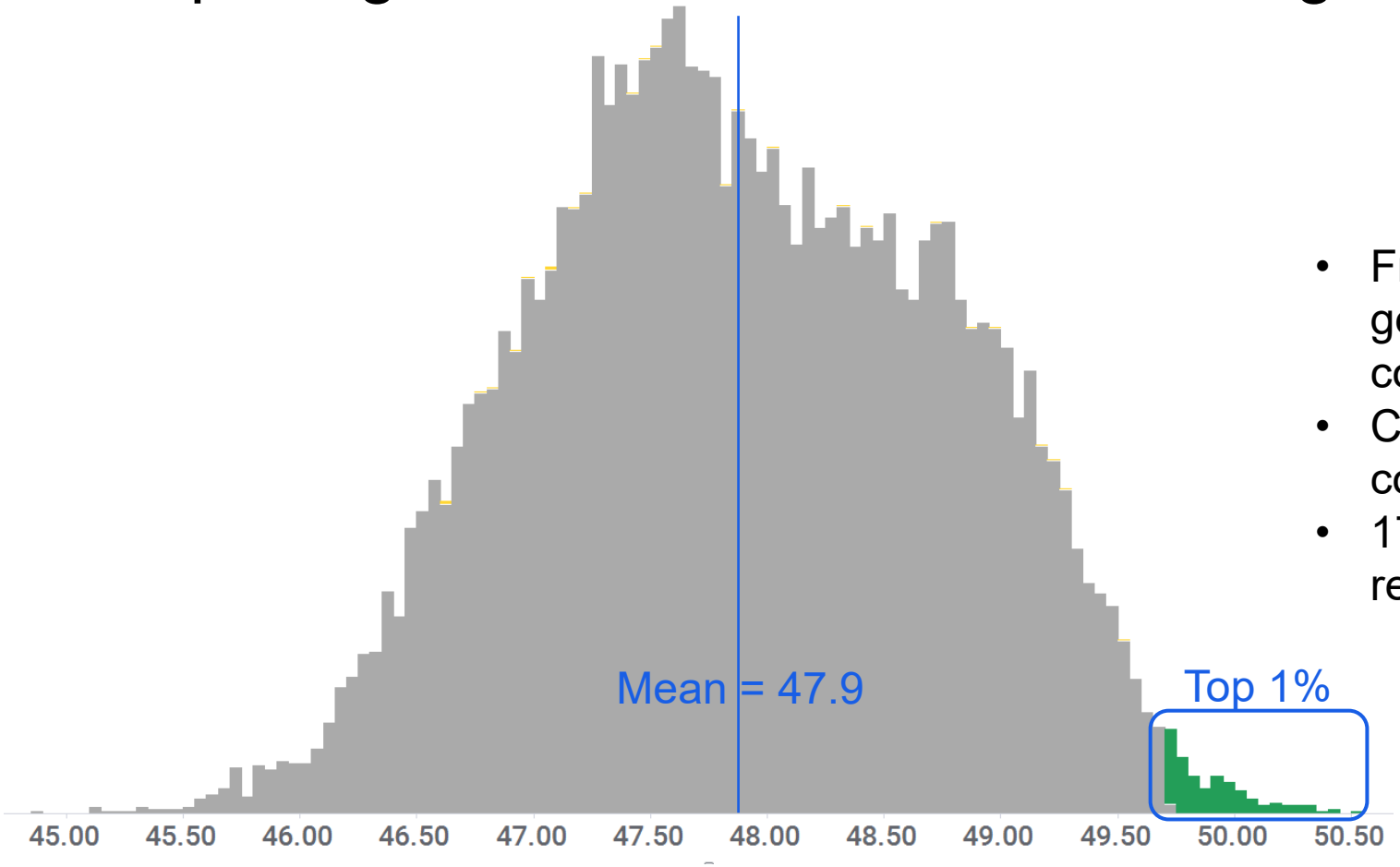


Increasing protein content

Using prediction to select high protein individuals

Protein content in multi-genic

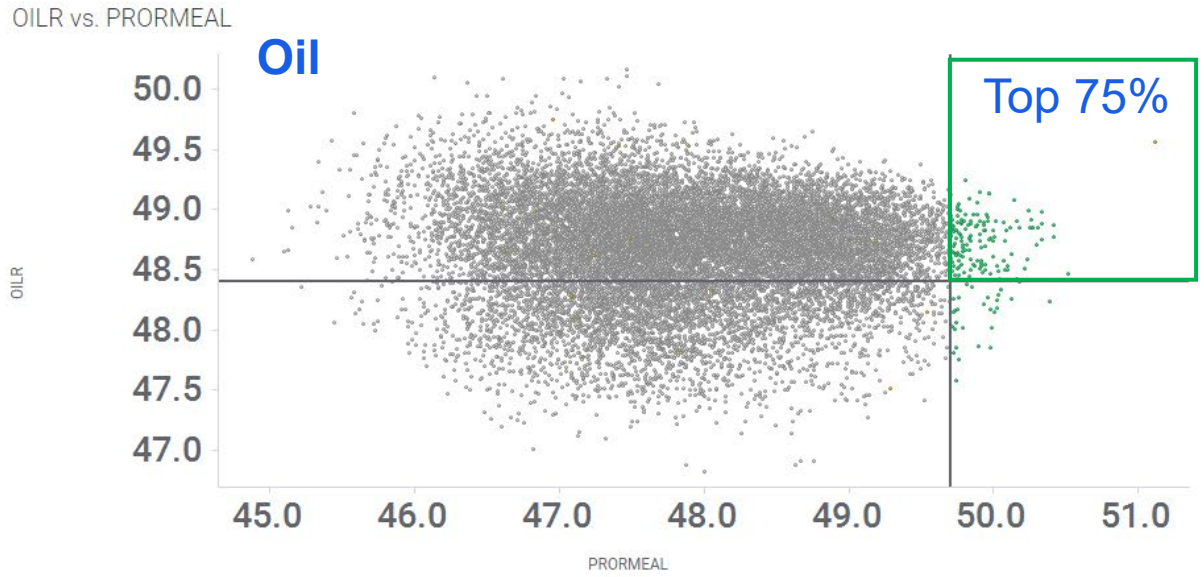
Adequate genetic variation exists in elite germplasm pools

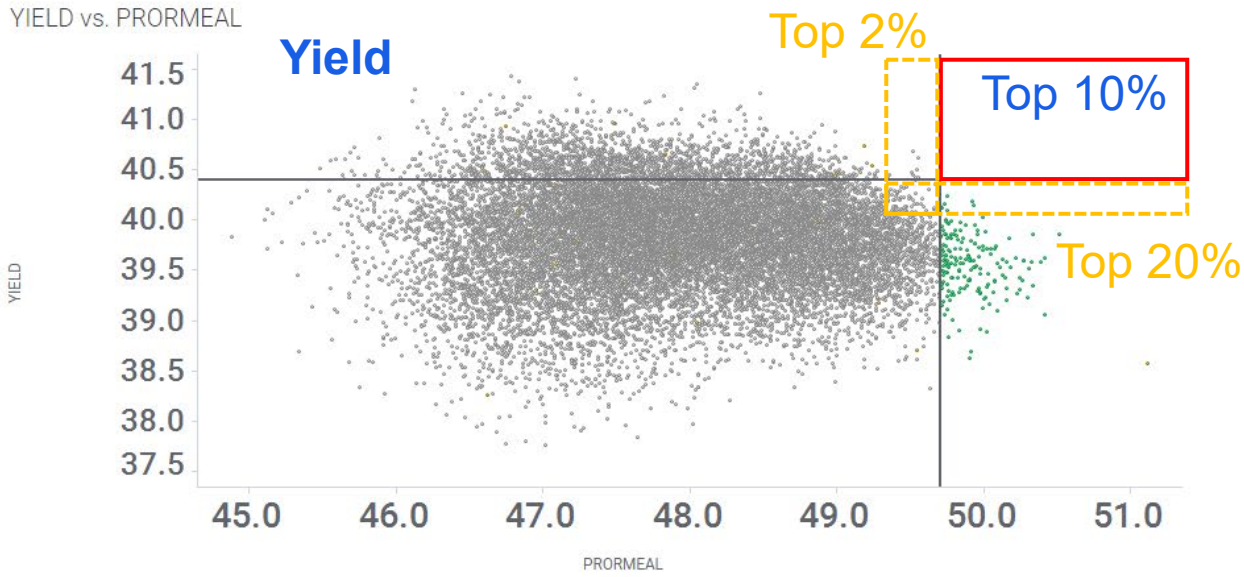


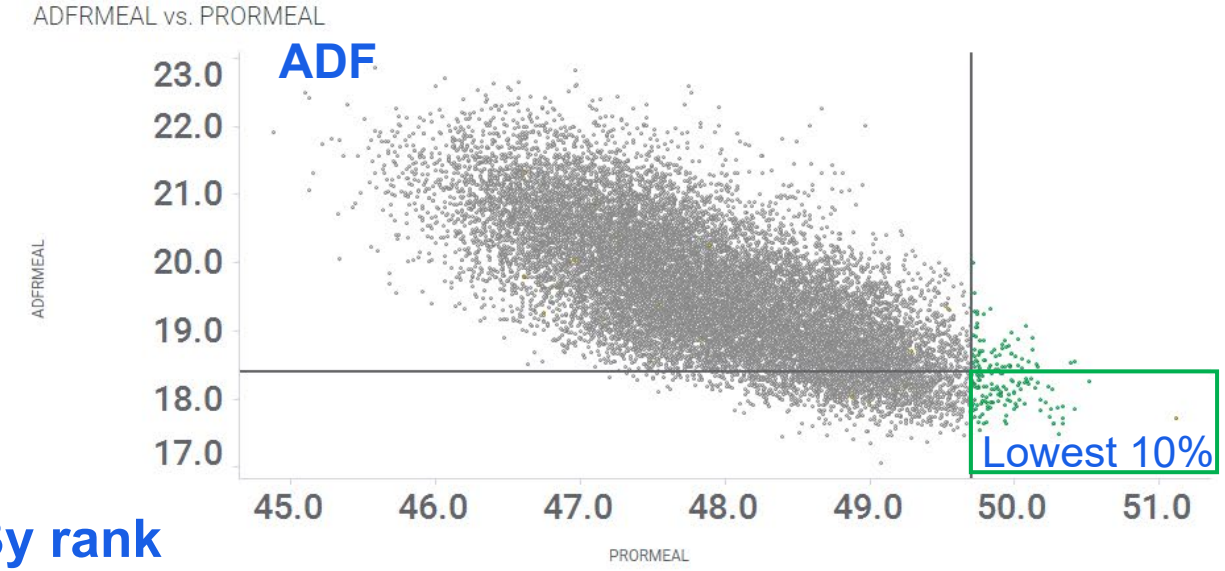
Predicted PRORMeal = protein % content in zero-moisture meal

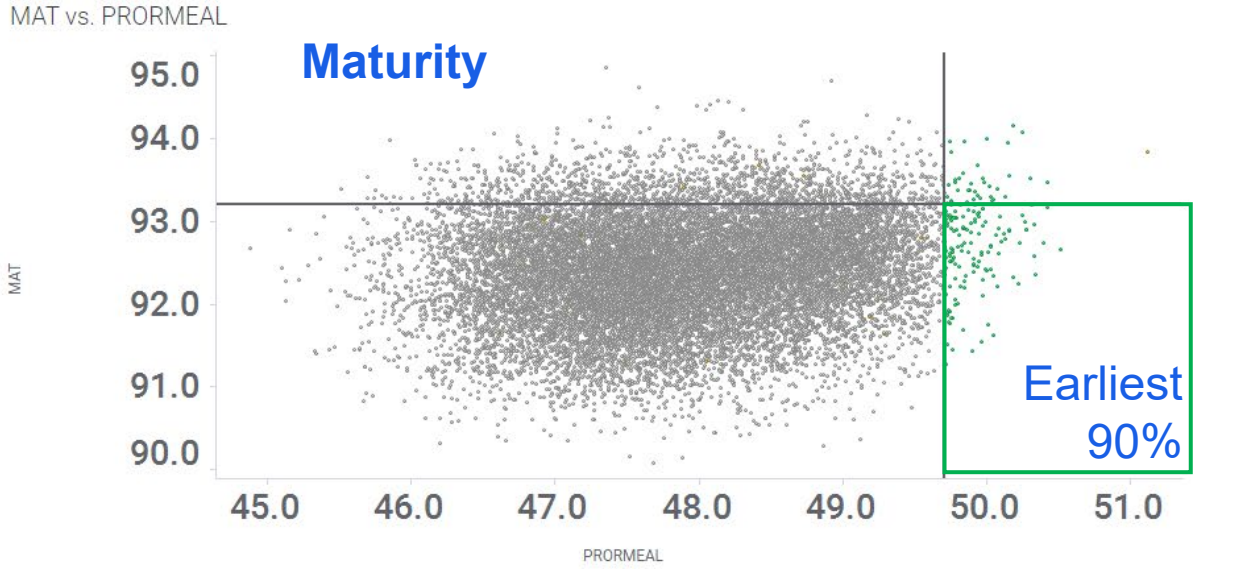
- Frequency histogram of whole genome predicted (WGP) protein content
- Canada spring canola elite commodity breeding pool – female
- 17,000 doubled haploid individuals representing 78 populations

Multi-trait threshold selection top 1% protein inbreds by rank









By rank

Decreasing fiber content

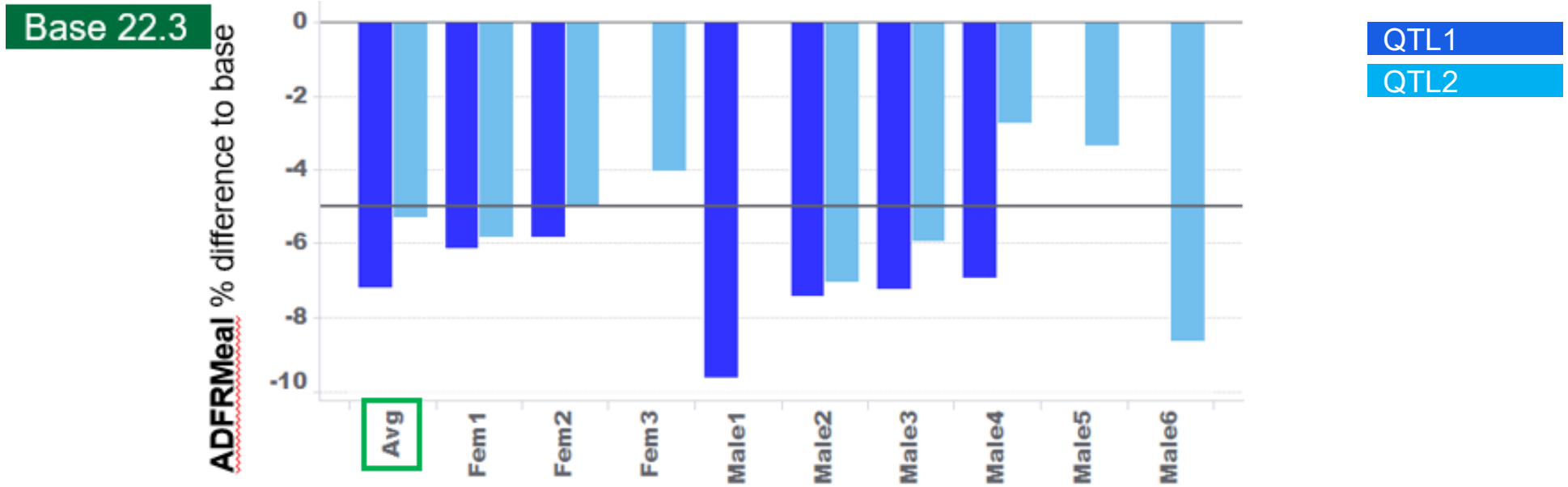
ADF – acid detergent fiber

Using major effect native QTLs to reduce ADF

Material decrease of 5-7 percentage points on average in meal ADF

Magnitude varies across base genetics

- 2 native QTLs identified, each on separate chromosomes
- QTLs individually introgressed into 3 females and 6 males by backcrossing and conversions selected for presence of QTL and >90% recurrent parent using molecular markers
- Bases (null) and BC2F3/BC3F3 converted parents grown in field and seed composition assessed
- Winter oilseed rape grown in France

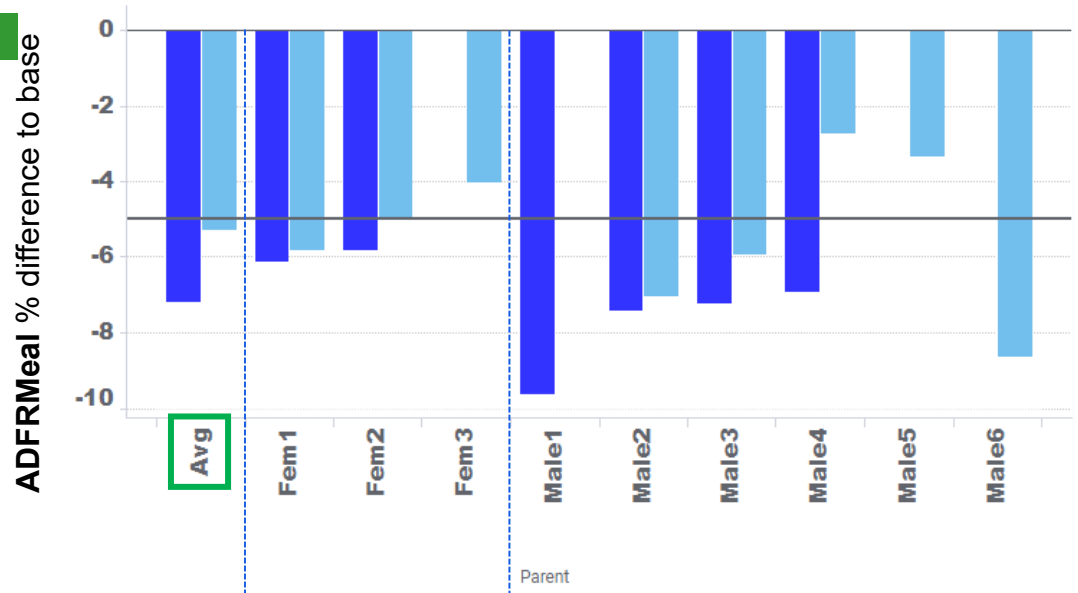


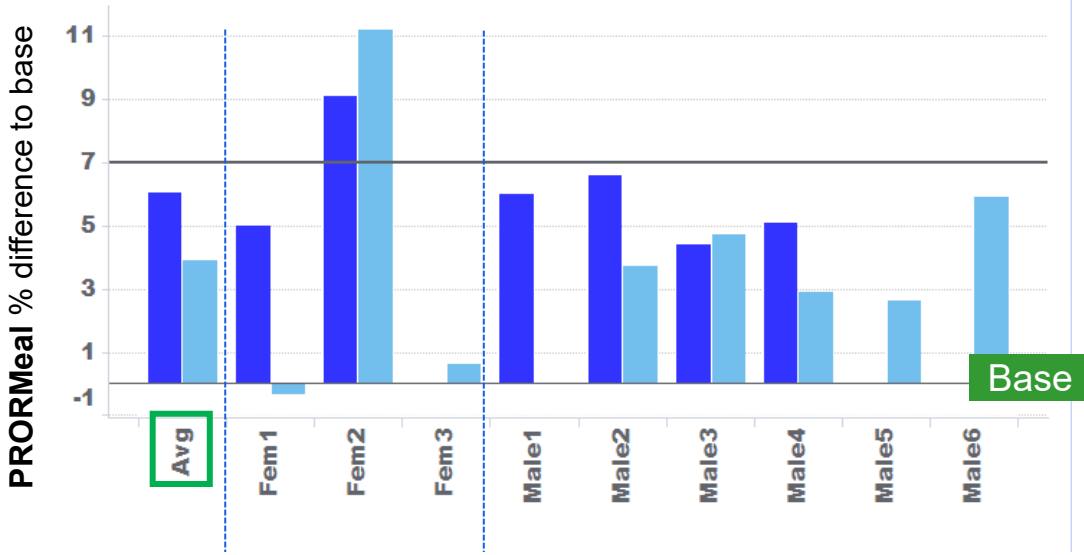
ADFRMeal = acid detergent fiber % content in zero-moisture meal

ADF reduction alters other seed components

QTL1
QTL2

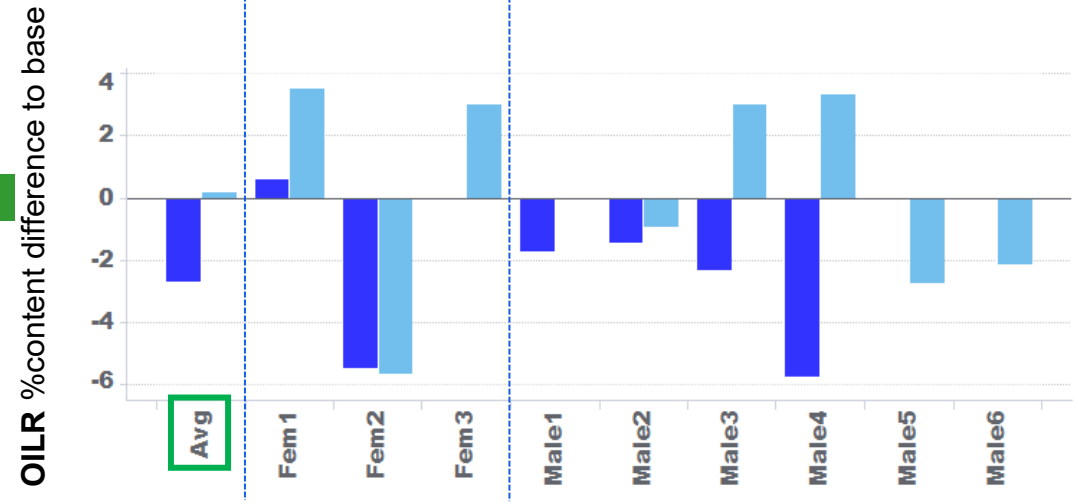
Base 22.3





Base 38.5

Base 47.6



- Decreased ADF drives higher protein content on a percentage basis
- Oil content less affected by QTL2 than QTL1
- Winter oilseed rape

ADFRMeal = acid detergent fiber % content in zero-moisture meal
PRORMeal = protein % content in zero-moisture meal
OILR = oil % content in whole seed

Improving feed energy value

Enhancing canola meal value

- **Soybean meal** is gold standard for protein, fiber & energy density. Goal is to drive increased canola meal inclusion in all feed sectors by closing the composition gap
- **Protein** – Quantity is key limitation, quality also a factor (lower lysine in soy meal)
- **Fiber** – Very high insoluble fiber dilutes energy, limits intake. Glycoprotein formation in processing reduces available protein
- **Energy density** – Limitation due mainly to high insoluble fiber content
- Well demonstrated that canola meal can be used in rations for non-ruminants. **Opportunity** is to drive increased inclusion rates in poultry, pigs and warm-water fish
- **Canola meal value is 25-30% lower per tonne vs. soy meal**. Increasing protein & reducing fiber will increase value/tonne. Actual price value of these improvements will be sorted out in the marketplace

Candidate hybrids for animal feeding studies

Australia:

Hybrid	Segment	Yield %Checks	Maturity 1-9 scale	Oil +/- Checks	Protein meal +/- Checks	ADF +/- Checks
Experimental	HOLL	82%	5.0	+ 0.7	**+ 3.9**	**- 6.3**
Competitor	HOLL	86%	5.1	Parity	+ 0.3	- 2.6
Check average	Commodity	100%	4.8	47.6%	42.6%	22.1%

Canada:

Hybrid	Segment	Yield %Checks	Maturity days	Oil +/- Checks	Protein Meal +/- Checks	ADF +/- Checks
Experimental	HOLL	97%	93	- 0.6	**+ 5.4**	**- 3.7**
Commercial	HOLL	89%	95	Parity	+ 0.3	- 2.6
WCC checks	Commodity	100%	91	48.4%	45.5%	19.2%

HOLL = High Oleic Low Linolenic specialty oil

Summary

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Objective: Increase the value of canola meal

1. Environment causes a strong negative correlation between protein and oil contents but there is not a genotype correlation (favorable)
2. Protein and ADF contents have strong negative correlations with genotype and environment (favorable)
3. Negative genotype correlations between protein content and yield & maturity are a watch-out
4. There is adequate genetic variation for protein content in elite germplasm heterotic pools to select for higher protein individuals without compromising oil content
5. Applying too much selection intensity on high protein content in the first breeding cycle can compromise yield potential
6. A single QTL can reduce ADF content by a material amount (and also increases protein content by default)
7. The value of altered canola meal composition ultimately needs to be validated in animal feeding studies

External Funding

- Protein Industries Canada
- Sofiproteol
- France 2030

Collaborations

- Canadian Grain Commission
- Botaneco
- Bunge
- National Research Council Canada
- Terres Innovia
- University of Manitoba

Authors

- **Steven King[1]**, Dave Charne[1], Chad Koscielny[2], Jean-Claude Pruvot[3], Ray Cowley[4], Igor Falak[1], Raju Jetty[5], Xiuqiang Huang[1], Ushan Alahakoon[6]

- [1] Corteva Agriscience, Caledon, ON, Canada
- [2] Corteva Agriscience, Carman, MB, Canada
- [3] Corteva Agriscience, Epuiseau, France
- [4] Corteva Agriscience, Wagga Wagga, Australia
- [5] Corteva Agriscience, Johnston, IA, USA
- [6] Corteva Agriscience, Saskatoon, SK, Canada