



Department of
Agriculture and Food



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Innovations Underpinning Yield Improvements in the Canadian Canola Industry



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Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada



Outline



- The Canadian and Australian canola industries share many of the same problems and have used each other's research to tackle them.

My talk will:

- Examine the changes in farmer canola yield and the forces driving them
- Talk about some of the new Canadian agronomy



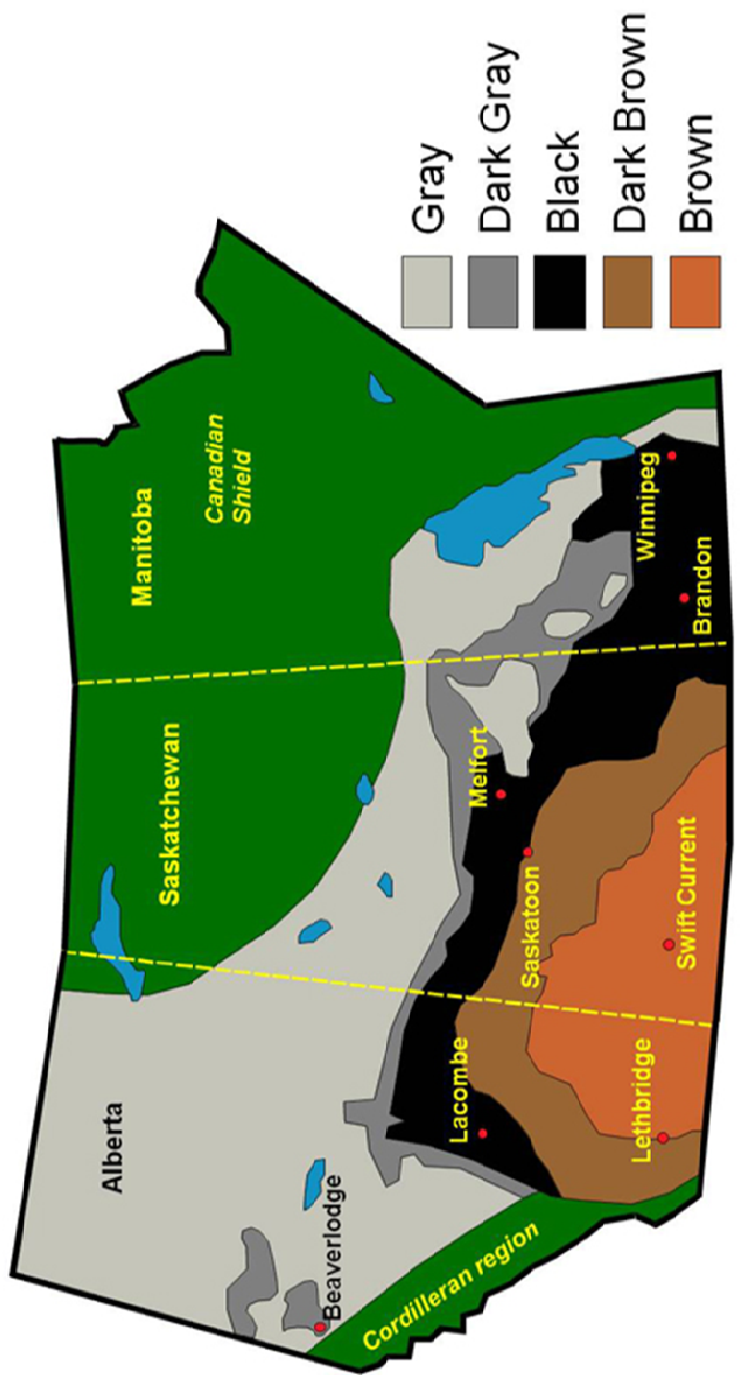


*Nearly one billion ha of land (998,467,000)
68 million ha of farmland 35 million ha crop land
81% of farmland in the Prairies, 13% Ontario and Quebec*

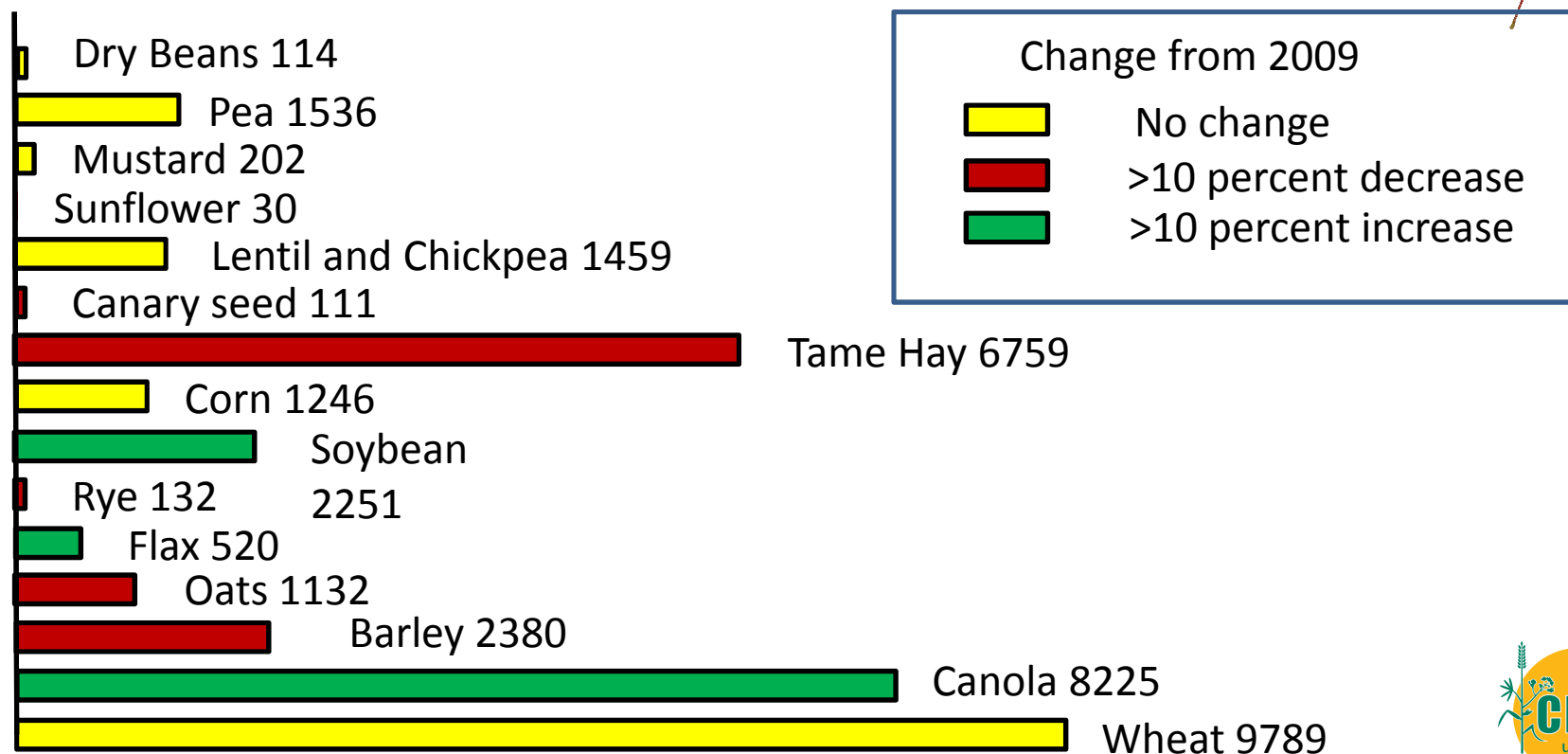




Major soil zones of the Prairie Region

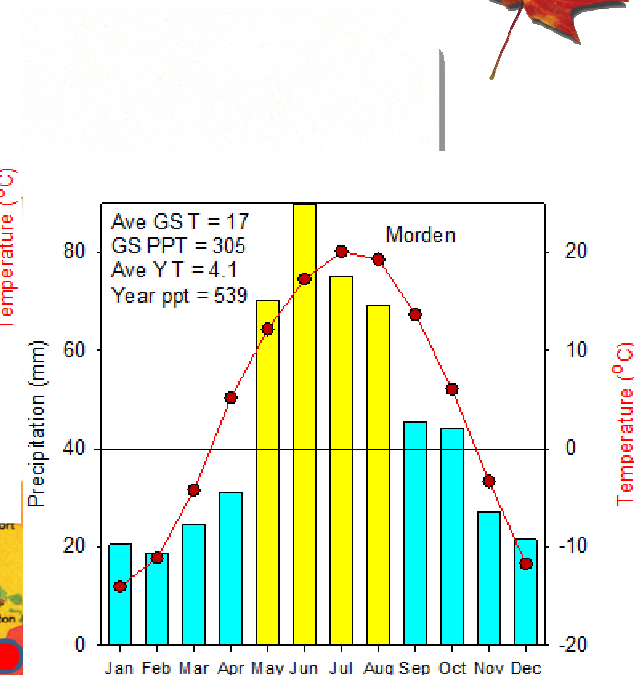
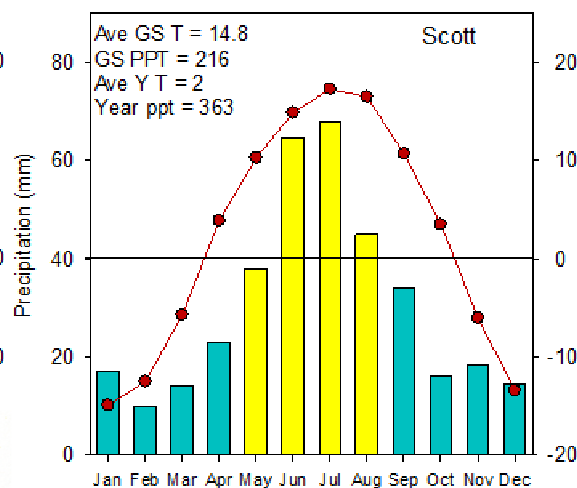
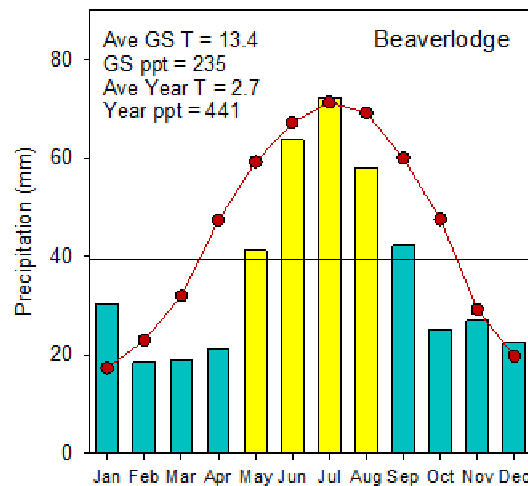


Canadian 2014 Field Crop Production '000 ha

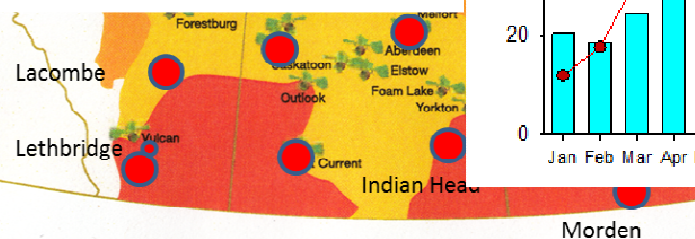




and sub-stations



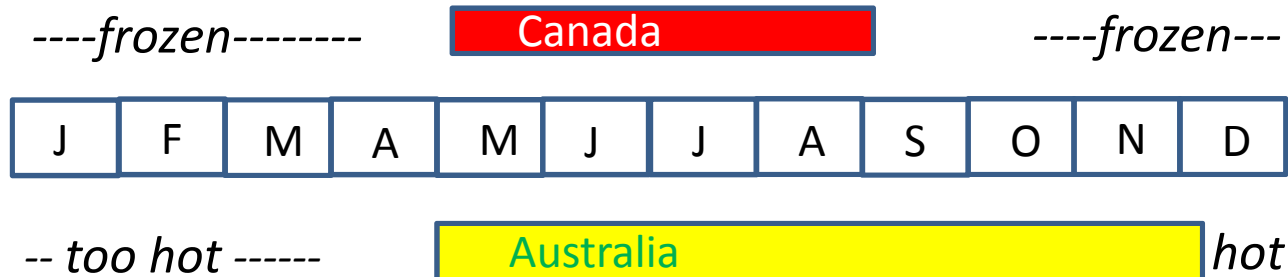
A total of 108 field scale trials
were approved this year:
AB=43, SK=50, MB=15



Canola growth in Canada and Australia



Canadian canola cultivars are 95 to 112 days in order to fit into the frost-free period for the Canadian Prairies. Planted in the spring and harvested in late summer



Australian canola takes nearly twice as long from seed to harvest. Planted in the fall and harvested in late spring.



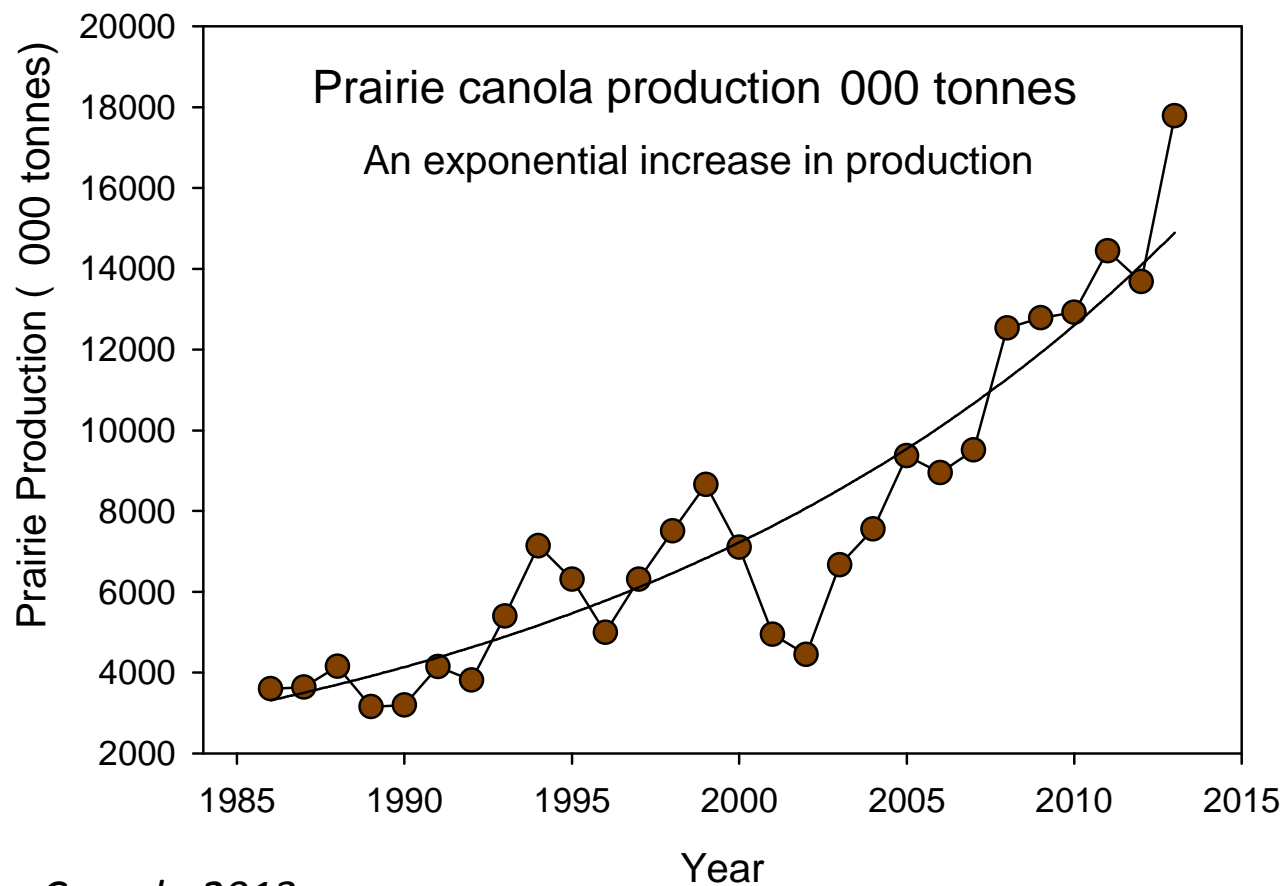
15 18 22 25 28 31 35 42 45 50

Days after Seeding



Canola Growth in Canada





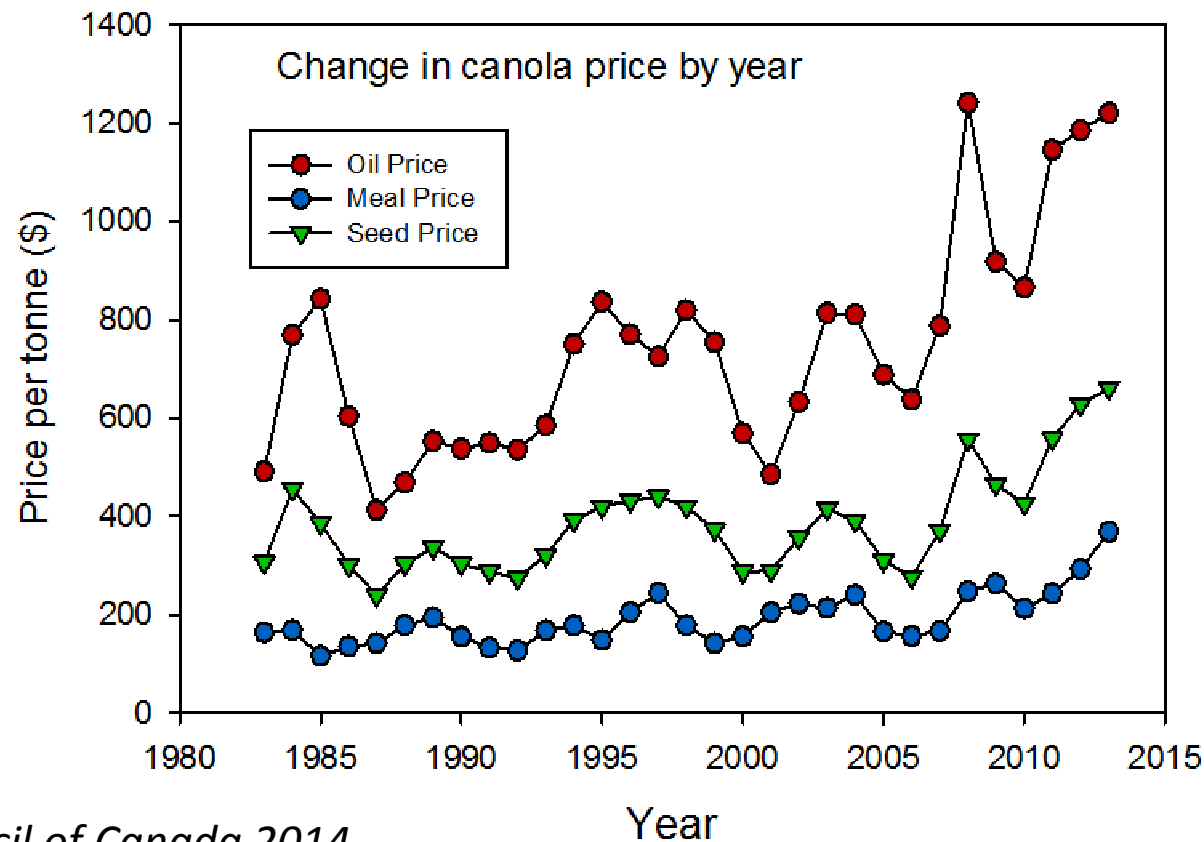
Statistics Canada 2013



New Target
26,000,000
tonnes
2025



Price has driven the increase in canola production



Canola Council of Canada 2014

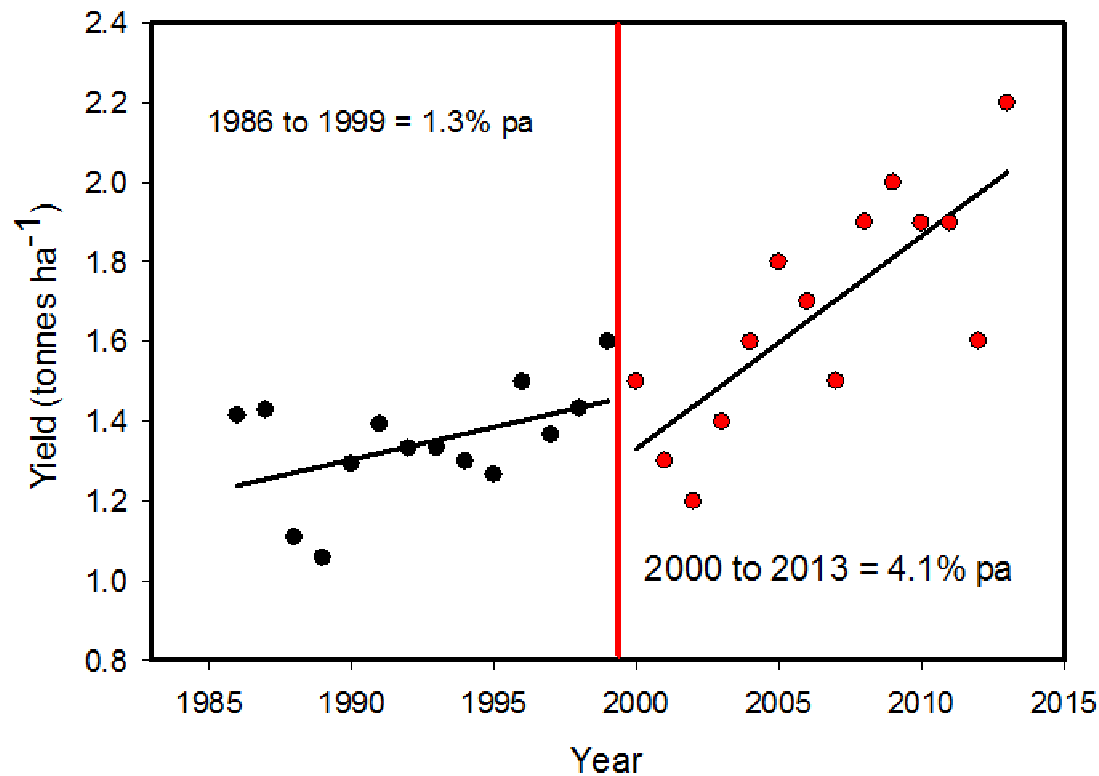


Prairie farmer canola yield (tonnes ha⁻¹)



1986 to 2013
yield increased
by 2.4 % pa
65%.

2000 to 2013
695 kg ha⁻¹
increase or 54
kg ha⁻¹ pa.
4.1 % pa.



Statistics
Canada 2013

What caused the yield increase?



Yield

Genotype :

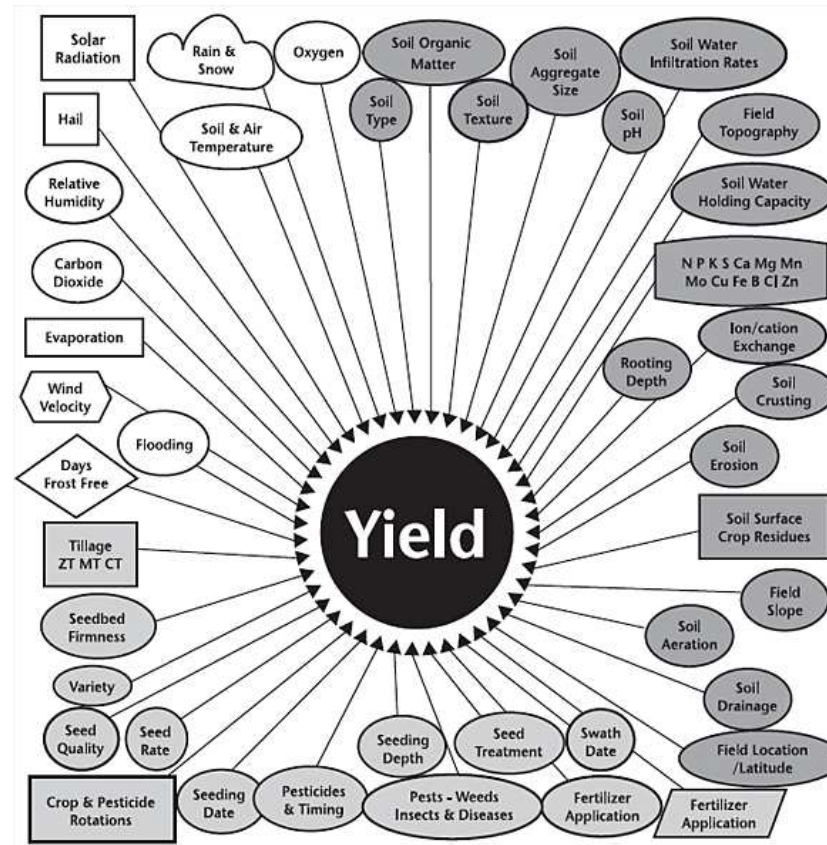
Variety, pest tolerance, stress tolerance, phenology, biomass production...

Environment :

weather, CO₂, oxygen, solar radiation, hail, wind...

Management:

Tillage, Planting, Fertilizer
Herbicides, Insecticides,
Fungicides, Soil, Rotations.
Harvest....

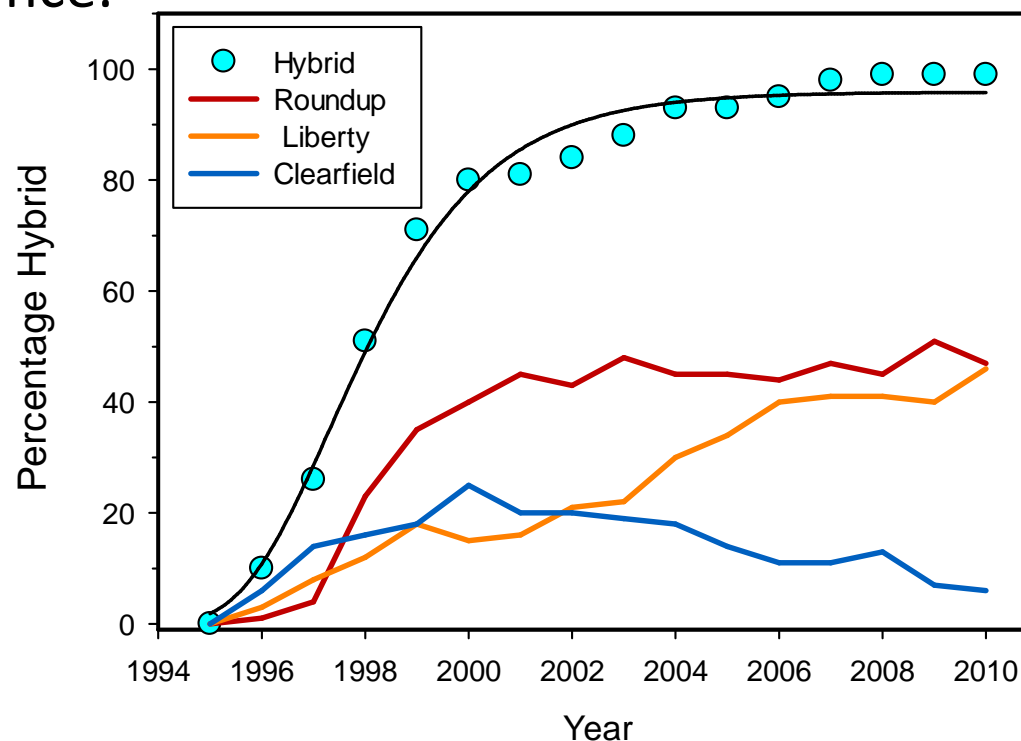


Genotype

Conversion from conventional open pollinated varieties to hybrid varieties with herbicide tolerance.



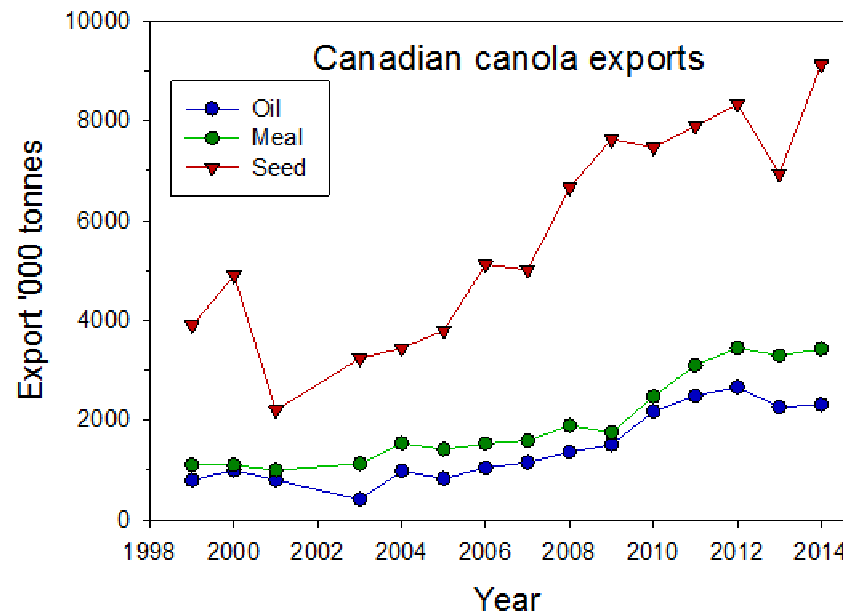
- 2014 >95% of canola is Hybrid with herbicide tolerance.



Genotype

Canadian canola exports have not decreased because of GM use.

Percent of Export Country	2003	2013
China	0	39
EU	5	1
Japan	0	1
Asia	2	3
USA	91	53
Other	2	3

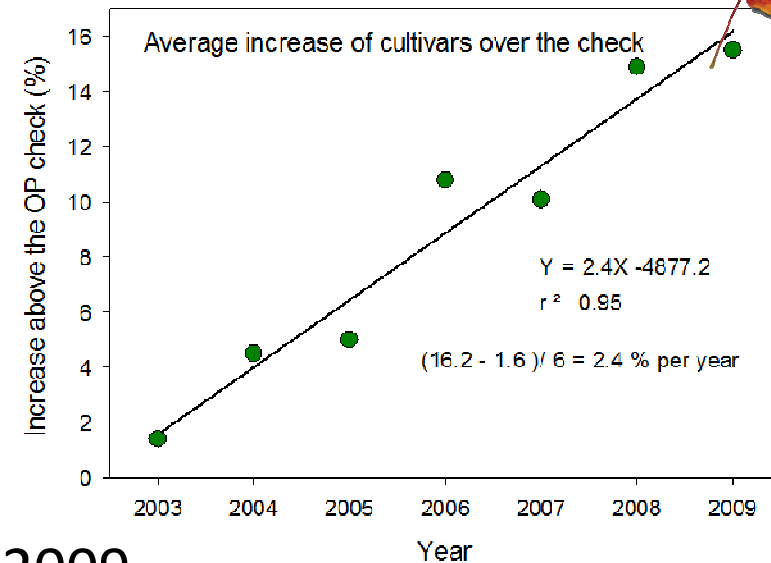
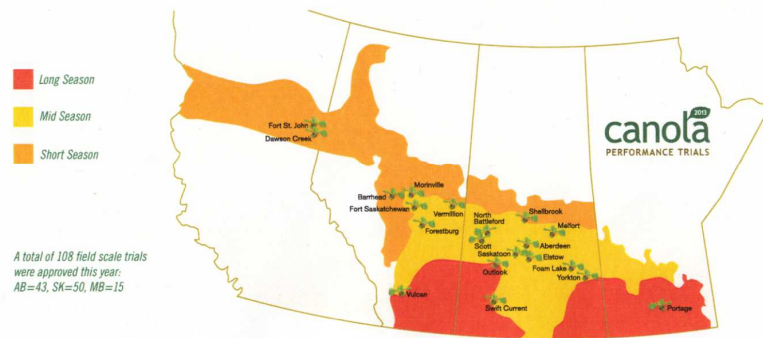


Bigger threats to exports on the horizon with canola-quality high oleic soybean oils.



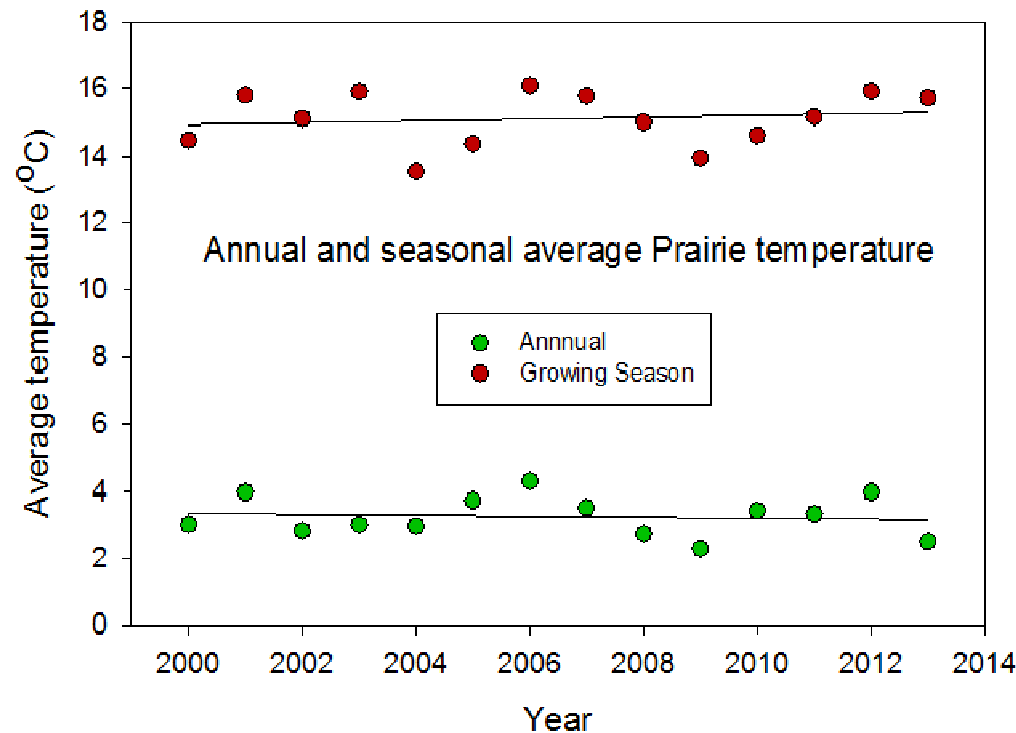
Genotype Estimating Genetic Gain

Small Plot Locations throughout Western Canada



- Performance data from 2003 to 2009
- Calculate the average % increase over the OP check for all locations and all varieties (RR, Clearfield, Liberty, conventional)
- Genetic Gain switching HY/HT= 2.4 % pa.

Environment Temperature



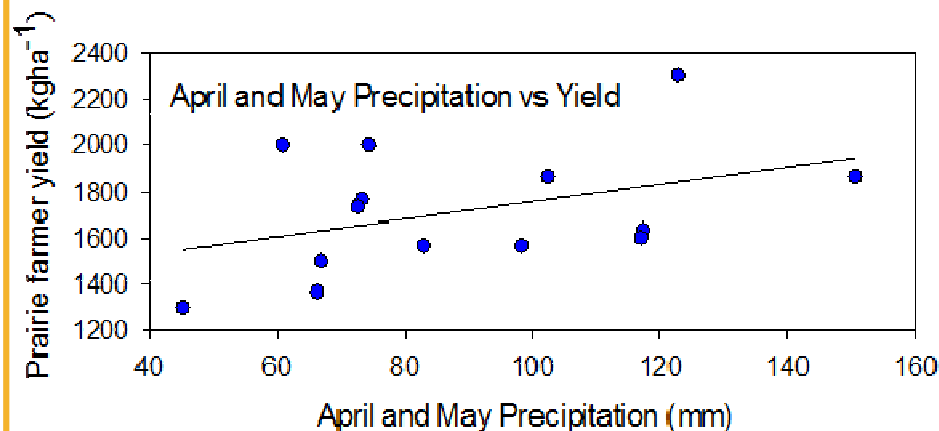
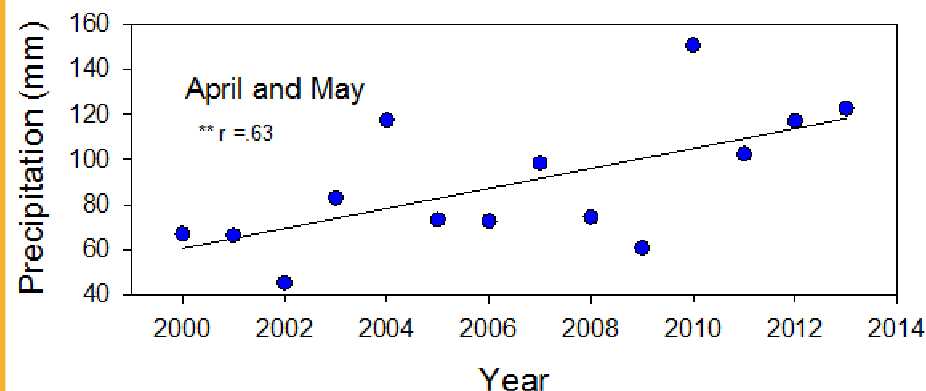
Averaged weather data from 10 Prairie sites.

No significant relationships between T and year.

No significant relationships between Stress T (heat or cold) and year.



Environment Precipitation



Precip from April and May increased
~4 mm per year

April and May precip increased
yield ~4 kg ha⁻¹ mm⁻¹

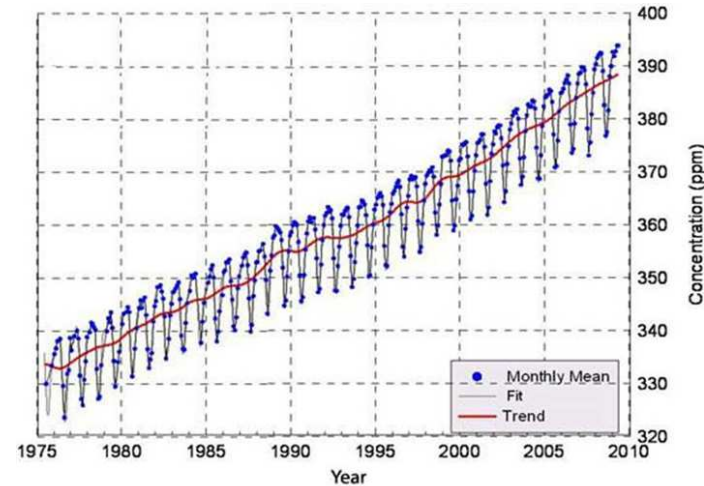
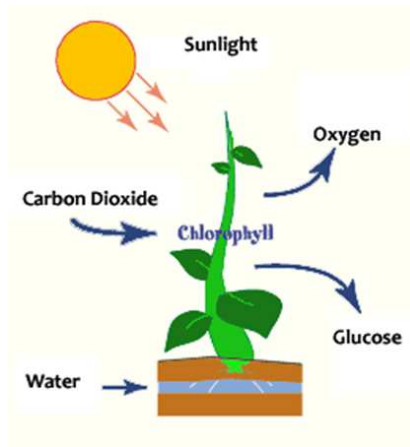
16 kg ha⁻¹ pa. due to more
precip

Precip + (P x G) + (P x M)
+ (P x G x M)



Environment Carbon Dioxide

Carbon Dioxide at Alert



- From 2000 to 2013 CO₂ increased from 370 to 395 ppm = 25 ppm or 1.9 ppm pa.
- Yield increases by 1.7 kg ha⁻¹ ppm⁻¹ CO₂ (Franzaring et al. 2008).
- Yield increased by (1.7 x 25) = 42.5 kg ha⁻¹ or 3.3 kg ha⁻¹ pa.



Genotype, Environment and Management

A Simple Balance sheet of Prairie Farmer Yield Gain



Factor	kg ha ⁻¹	% of total	% increase pa	kg ha ⁻¹ pa
Yield 2000 to 2013	695	100	4.1	54
Genotype (G)	416	59	2.4	32
Precipitation (E)	208	29	1.2	16
CO ₂ (E)	42	6	0.3	3
Management (M)	42	6	0.3	3

Why is the effect of management so small?



Why is the effect of Management so small?



- Many of the BMPs were in place before 2000 -- Fertilizer, Min-Tillage, seeding, herbicides, harvest etc.
- Not all prairie farmers implement BMPs.
- Interactions (M x G, M x E and M x G x E) are not easily determined.
- Management will need to keep pace with variety development

Cultivated
Stubble



Short Stubble
15 cm



Which inputs have the greatest impact on canola yield?

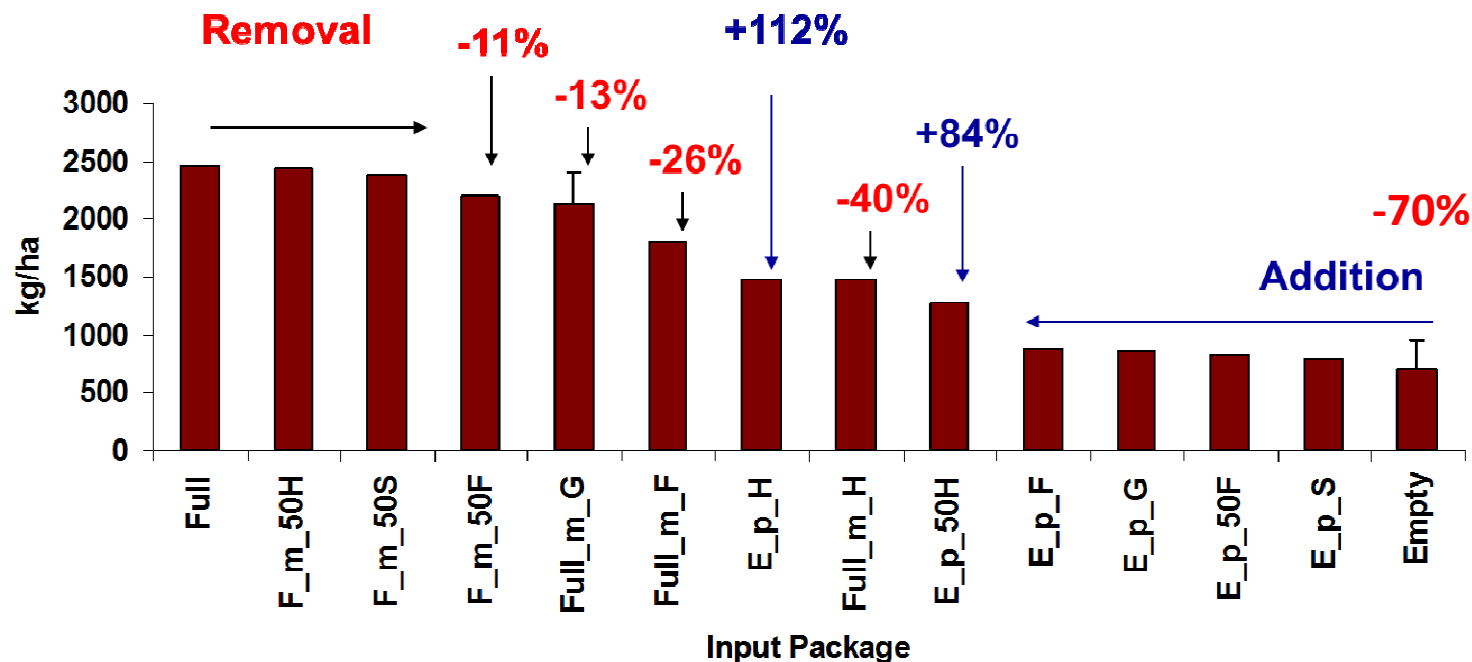
Bob Blackshaw (AAFC Lethbridge)



- Compared 'full' input package with 'empty' input package
- Removed inputs from full package or added them to empty package
- Four years, 6 Prairie sites = 24 location years, canola-barley.
- Genetics: hybrid or open-pollinated (OP) LL cultivars
- Seeding rate: 75 or 150 seeds/m²
- Fertilizer rate: 0, 50 or 100% of soil test recommendation
- In-crop herbicide rate: 0, 50 or 100% of registered rate Liberty



Input Removal and Addition Effects on Yield



Ranking of inputs: herbicide > fertilizer=genetics > seeding rate
Only herbicide improved the empty package.

Bob Blackshaw



Input Removal and Addition Effects on Yield



A combination of desirable inputs increased yield more than the sum of individual inputs:

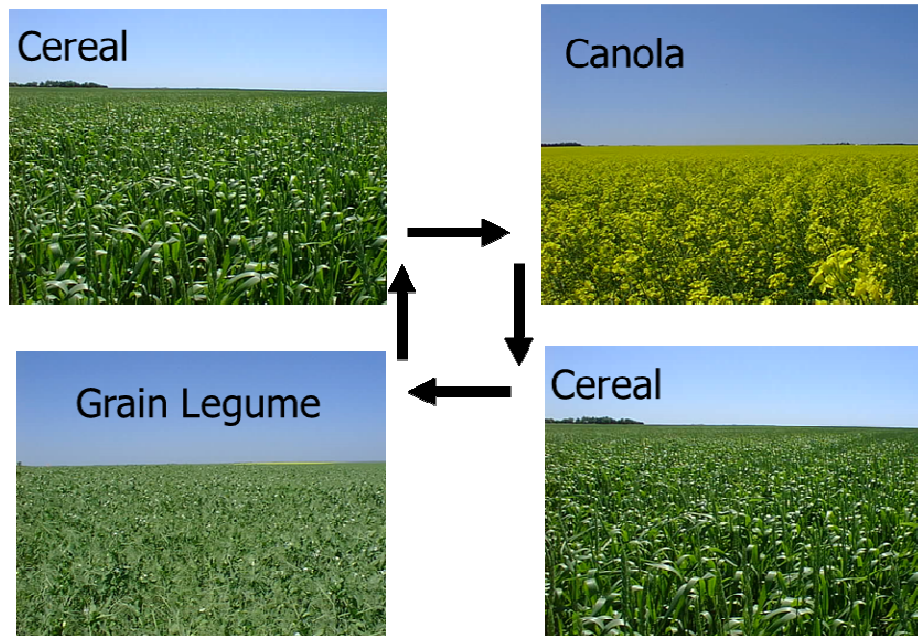
Interactions with environment

Bob Blackshaw

	Yield increase [kg/ha]
Component	Average
Genetics	179
Seed rate	90
Fertilizer	195
Herbicide	783
TOTAL	1248
Full	1764
Interaction	516



Crop Rotation:



Recommend a 4 year rotation with cereal and pulse crops to decrease disease and weed pressure. Crop Rotation is an integral aspect of integrated weed management

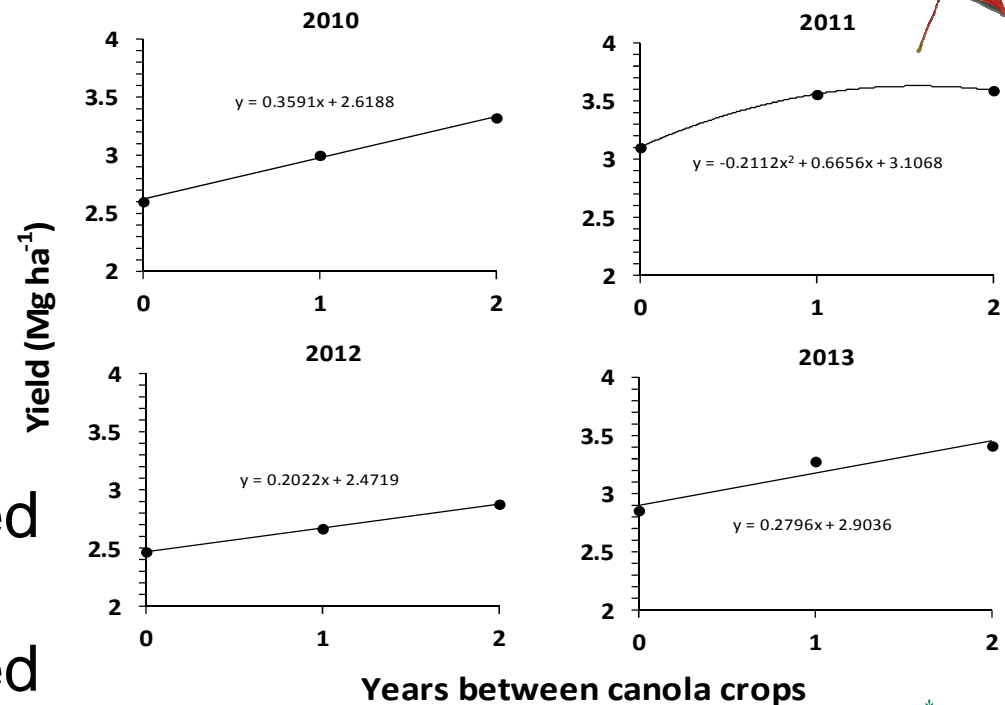


Herbicide tolerance and high economic returns have tempted farmers to shorten crop rotation cycle.
~70% use a 2-year rotation



Crop Rotation:

- 30 site-year experiment,
- HY canola grown 1, 2 and 3 years apart in No-till rotation with pea, barley or wheat.
- 2-year rotations increased canola yield by 9-14%
- 3-year rotations increased canola yield by 15-27%



Bob Blackshaw



Crop Rotation:

Increased disease and pest pressure partially explained reduced yields in shortened rotations

Black leg increased from 29, to 32 to 43 % for 3, 2 and 1 year separating canola.

Every 3rd year



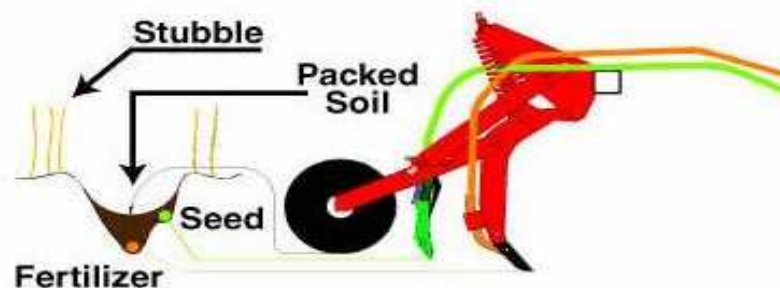
Every year



Nitrogen Fertilizer:



- Soil N tested in the fall before freeze-up or spring before planting
- Fertilizer applied once at seeding, -- banded beside and below the seed because placement influences germination.
- A 2012 Canola Council Canada survey - farmers apply N based on past experience, soil tests, general fertilizer guidelines, cost.
- Wheat after HY canola needs more N than after OP canola.



Nitrogen Fertilizer:



- Yields of HY were higher at 150% N rate. *Blackshaw et al. 2011.*
- Are Hybrids are more N use efficient than OP varieties
 - HY = 72 kg N/tonne , vs OP 87 kg N/tonne (*Karamanos et al. 2005*).
 - HY = OP @ 56 kg N/tonne (*Karamanos et al. 2007*)
 - HY = 66 kg N/tonne, OP = 55 kg N/tonne (*Cutforth et al. 2009*).
- Experiments need to be redone with newer hybrids.





Polymer coated urea (ESN) with the seed = less emergence damage than regular urea. *Neil Harker*



Up to 60 kg of PCU can be applied with the seed.

Qin 2014





Variable rate application

Can we apply the right amount of fertilizer
based on what the crop tells us it needs?

Chris Holzapfel and Guy Lafond

Indian Head Agricultural Research Foundation and AAFC

Nitrogen Fertilizer: VRA

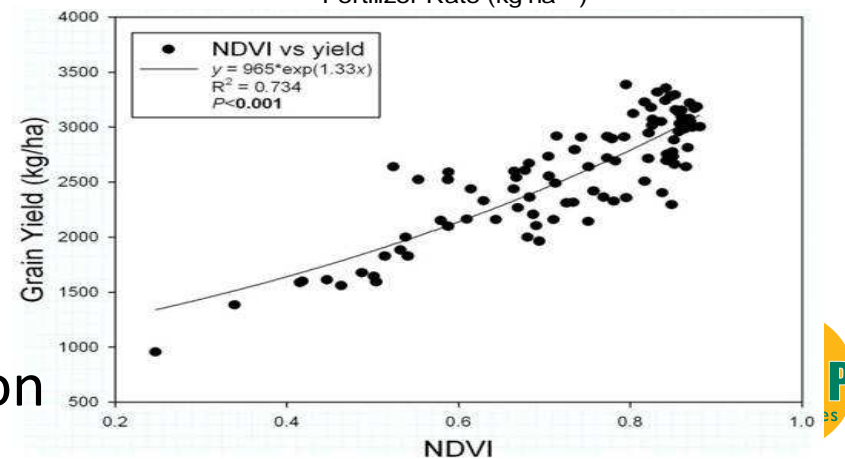
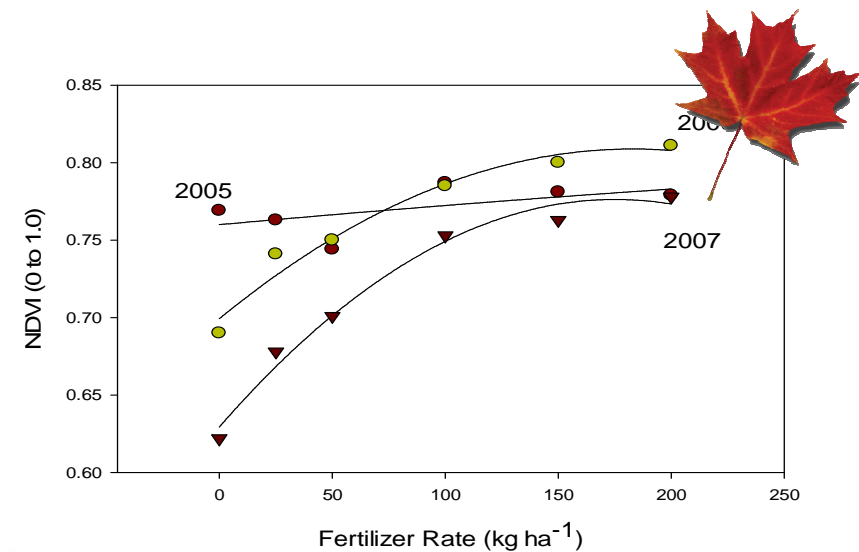


0 kg N at bolting

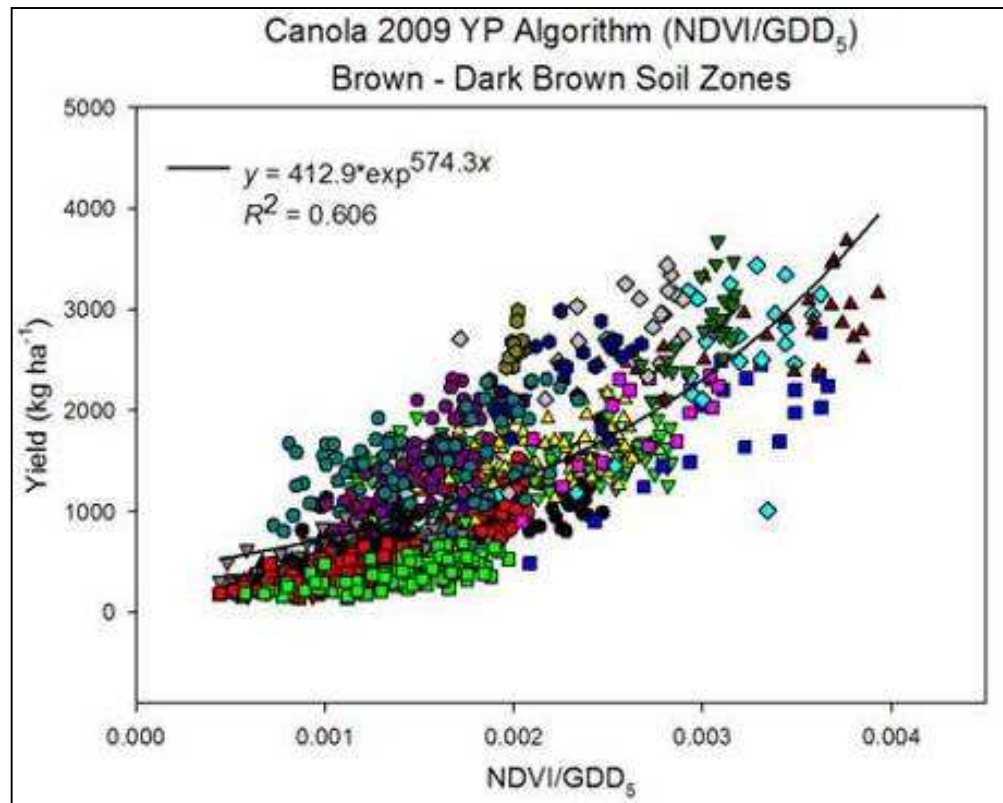


200 kg N bolting.

Greenseeker™
measures canopy
green colour =
nitrogen concentration



Nitrogen Fertilizer: VRA



Relationship between N
Rate NDVI and Yield

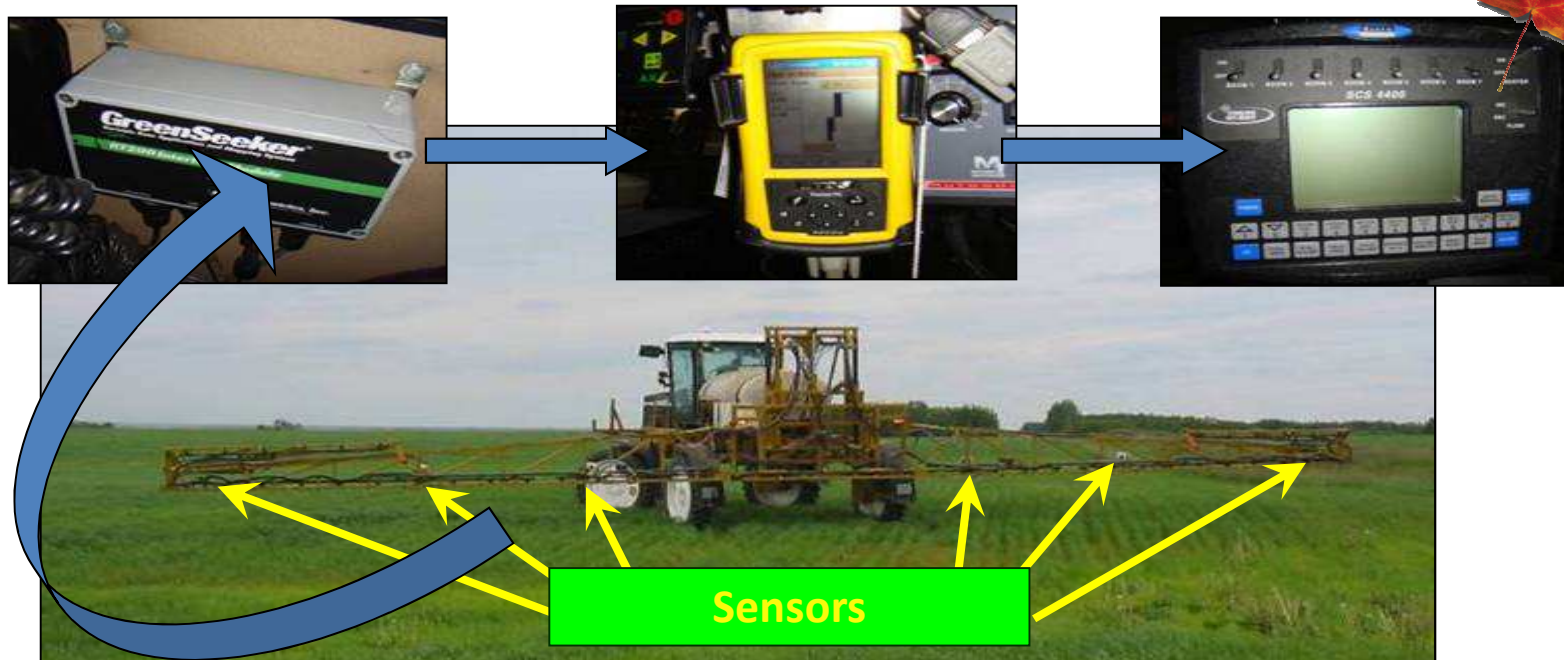
Normalized over many
locations

Used to adjust VRN

Chris Holzapfel



Nitrogen Fertilizer: VRA

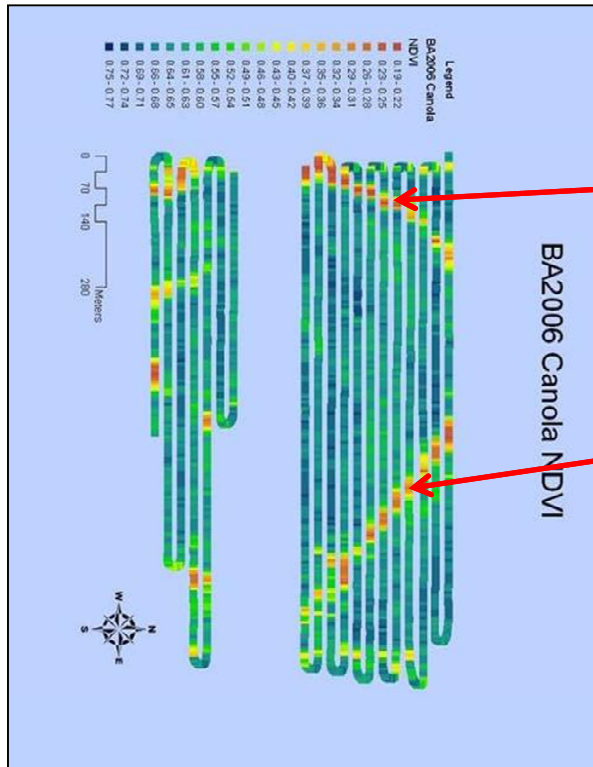


- In the RT200™ VRA system, post-emergent N rates are based on the mean NDVI of 6 boom-mounted sensors

Chris Holzapfel



Nitrogen Fertilizer: VRA



NDVI Scan at bolting



Aerial photo at mid flower

Greenseeker
mapped
farmers field

Chris Holzapfel



Nitrogen Fertilizer: VRA in practice



- Compared Farmer Practice (FP = 100% N @ seeding) to VRA = 66% N @ seeding and the rest with the Greenseeker Algorithm @ bolting.
- 6/9 fields used less N with VRA.
- No fields yielded less with VRA than FP.
- Economically VRA produced \$4.63 per ha more when everything factored in.
- Problems: A narrow window of application, algorithms may change with cultivars. Not used extensively.

Chris Holzapfel



Population Density

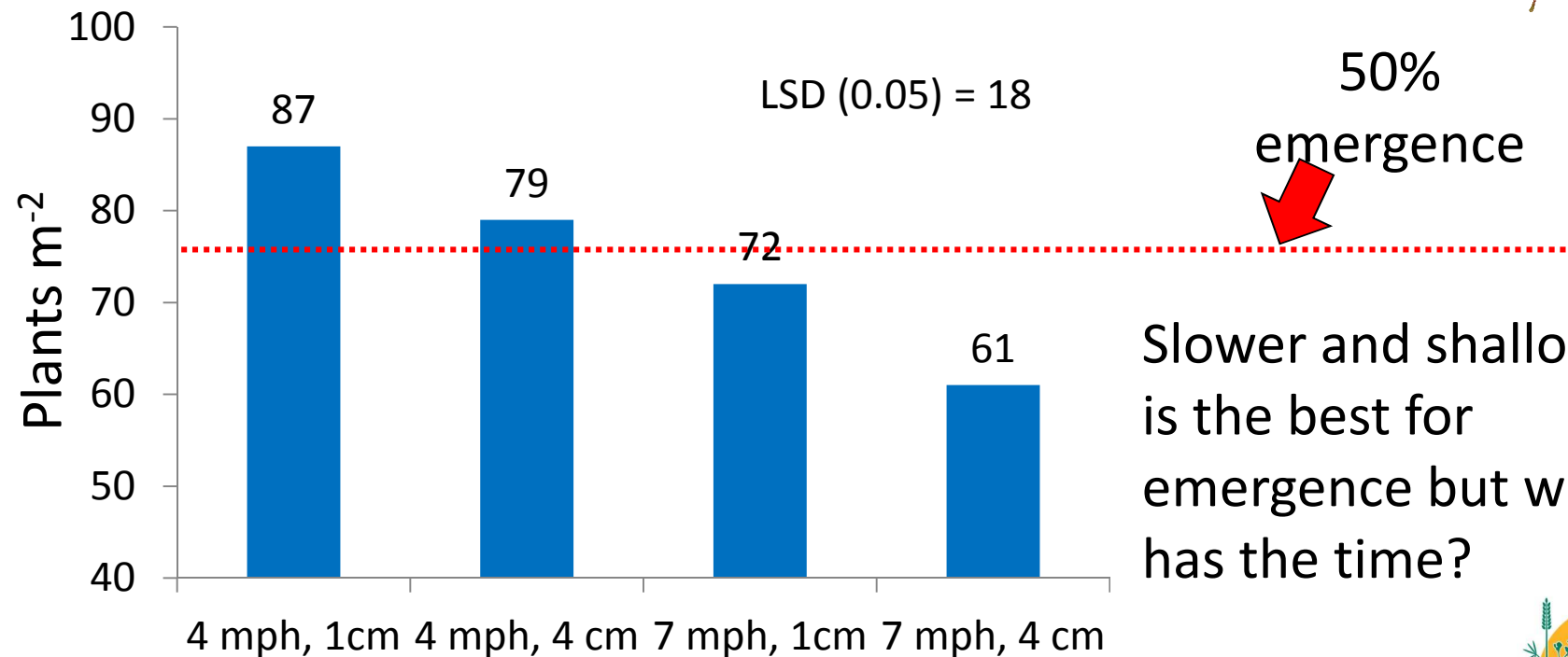
- Hybrid seed costs more than open pollinated seed –farmers ask if they can reduce planting density?
- Uniform emergence improves yield, optimizes harvest and seed quality.
- Even with high germination rate seed and good conditions only 50 to 60 % of the sown seed emerges





Seeding depth and speed effect on emergence

Cultivar = 71-45 RR, seeding rate 150 seeds m⁻²



Slower and shallower is the best for emergence but who has the time?

Neil Harker



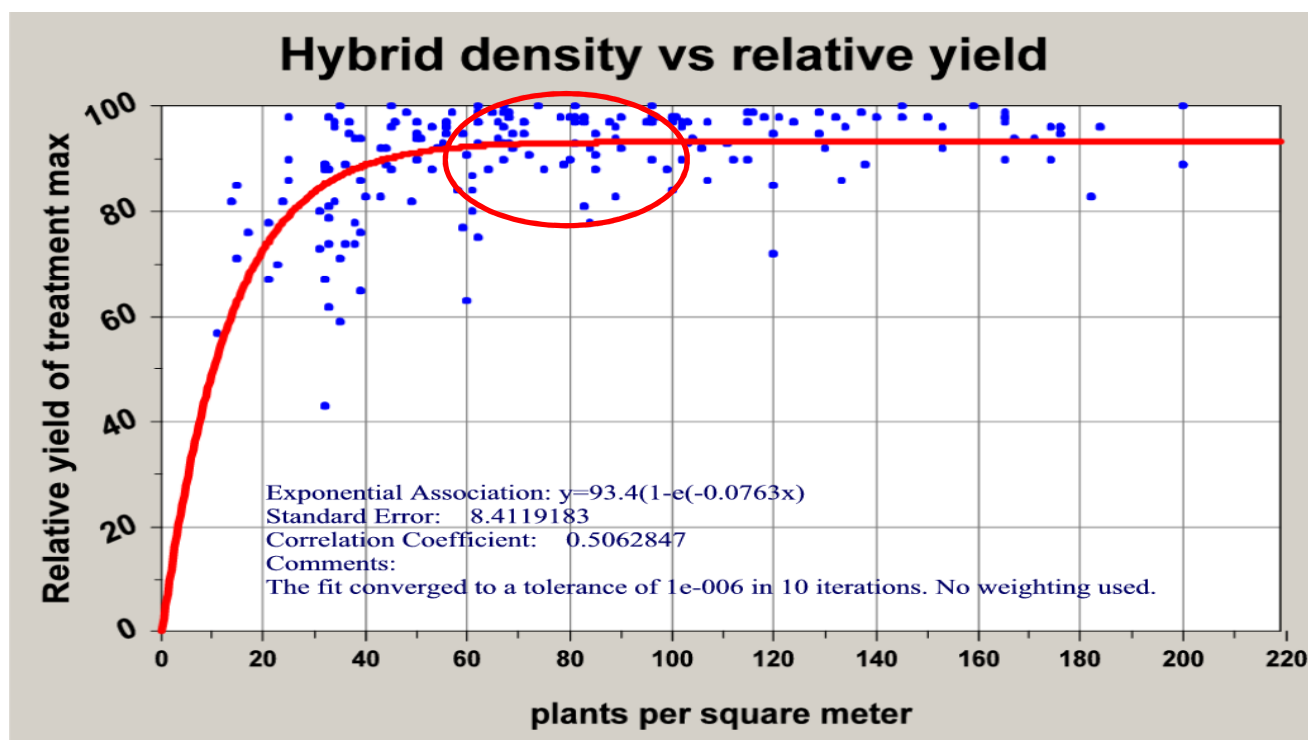
Seeding depth and speed effect on emergence



Neil Harker



Population Density



Meta Analysis:
60 to 100 pl m⁻²
increases the
frequency of
achieving max
yield.

Murray Hartman and Neil Harker



Summary



- Prairie yield gain of 4 % pa has been made primarily with the development and adoption hybrid varieties with herbicide tolerance.
- Hybrid seed is purchased every year -- is treated with fungicide and insecticides. Good seed = good yield
- Management will need to be revised for new hybrid varieties.
- How high can hybrids yields go? -- Corn = 5 fold increase since 1930s

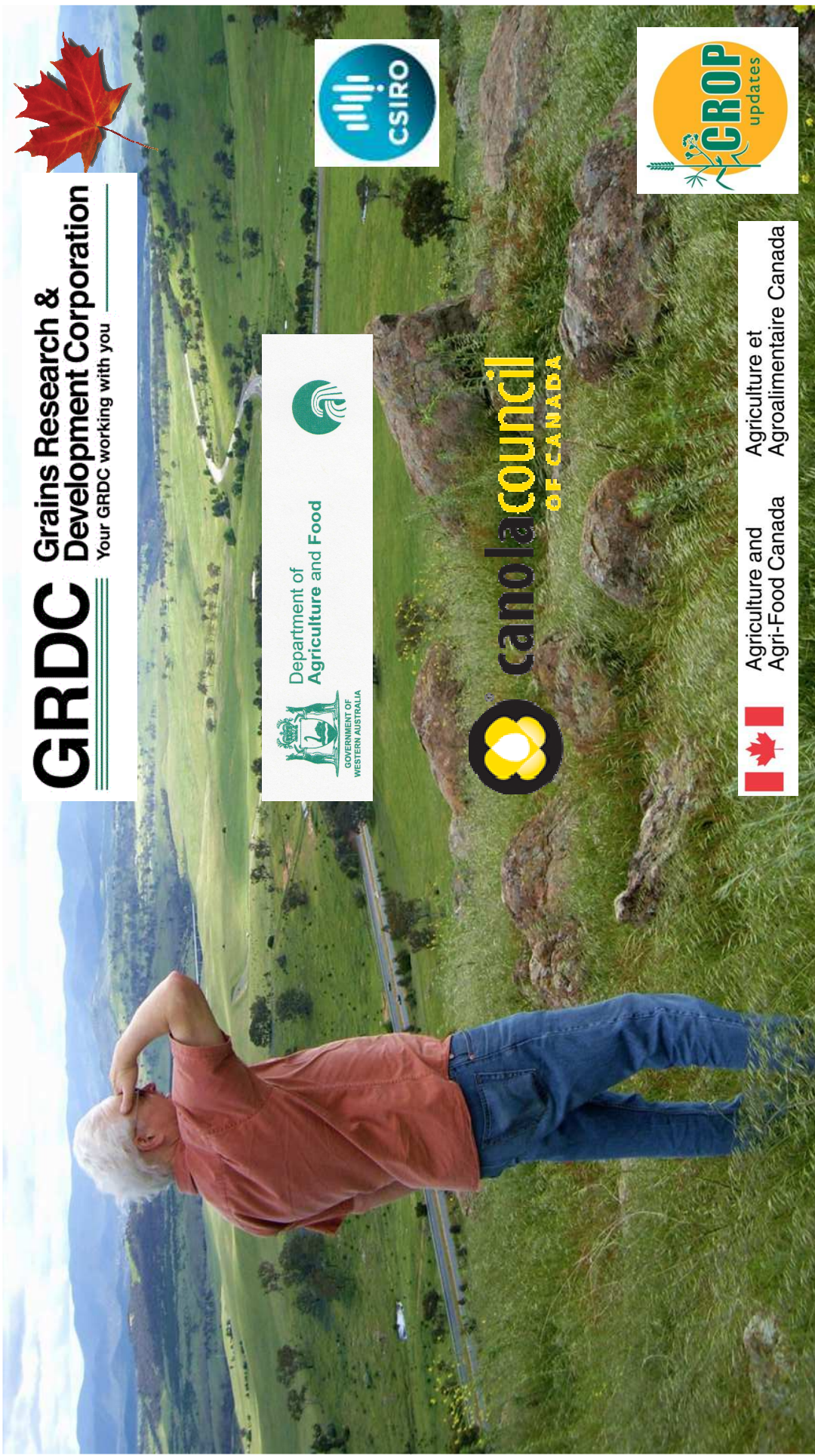
	Kg/ha
Average 2000-2013	1767
2013	2150
Great	4560
Max	???



Summary


- Nature helped farmers yields with higher spring precipitation.
- Variable rate N application works but, timing is tricky, not widely adopted by farmers.
- Ideal plant population to improve the chances of best yield = 80 plants m^{-2} achieved with 150 seeds m^{-2} .
- Seed placement at 1cm better than deeper. Slower better than faster





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Thank you
Technical Questions?

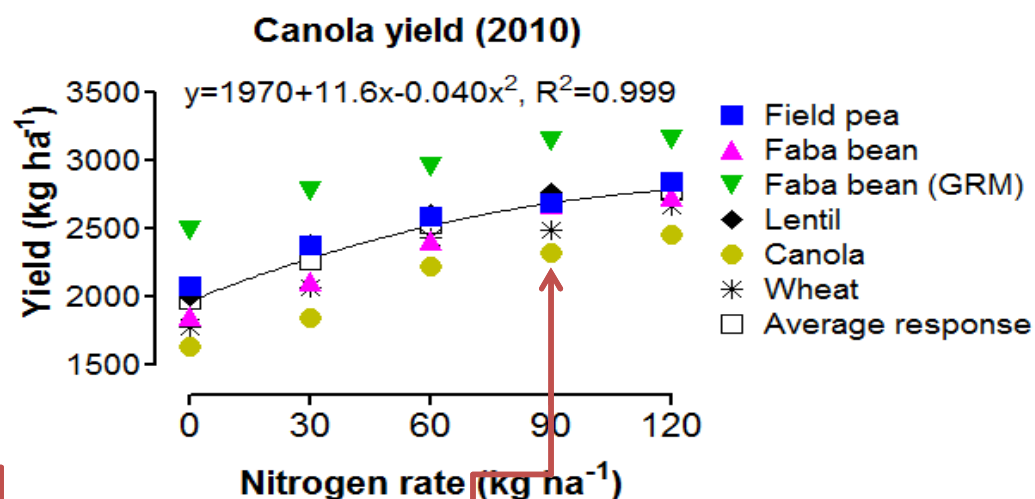


Crop Rotation: Using grain legume in the rotation



2009: Grew field crops at 6 locations. **2010:** Hy HT seeded into the residue and urea applied at 0, 30, 60, 90, 120 kg ha⁻¹

2009 Crop residue	2010 Canola Yield (kg ha ⁻¹)
Wheat	2289
Faba bean GM	2906 (27%)*
Faba bean SD	2346 (NS)
Field Pea	2517 (10%)*
Lentil	2521 (10%)*
Canola	2097 (-8%)*



10% increase in canola yield after grain legumes compared to after wheat. 25% less fertilizer N after grain legume

John O'Donovan



Emergence and seed size



- 2013, 9 Sites, 4 Seed Sizes (4.0, 4.6, 4.8, 5.7 g 1000 seed⁻¹)
-
- Seed size had no effect on emergence, yield and seed quality.
 - Large seeds had increased vegetative biomass and 1000 seed weights.

