Agriculture and Agri-Food Canada
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Canada

Dethroning a king: Canola's rise to supremacy and what it could mean to the atmosphere

Lemke, R., Baron, V., Liu, L., MacWilliam, S and Farrell, R.

- Canola has become the most valuable cash crop in Canada generating > $19 billion CAD in 2013
- About 40% of canola seed is exported primarily to China, Japan, Mexico and the USA
- About 60% of seed is crushed in Canada
- 80% of canola oil and meal is exported primarily to the USA and China but also Korea, Japan, Malaysia and other countries
- Emerging uses include bio-diesel, plastics, protein isolates, adhesives and sealants

Virtually all canola production in Canada is grown in the three prairie provinces of Alberta, Saskatchewan, and Manitoba

GDD < 1000 (base 5°)
MAP 400 mm
FFD 115
M. Deficit 200 mm

GDD 1600 (base 5°)
MAP 250 mm
FFD 125
M. Deficit > 450 mm

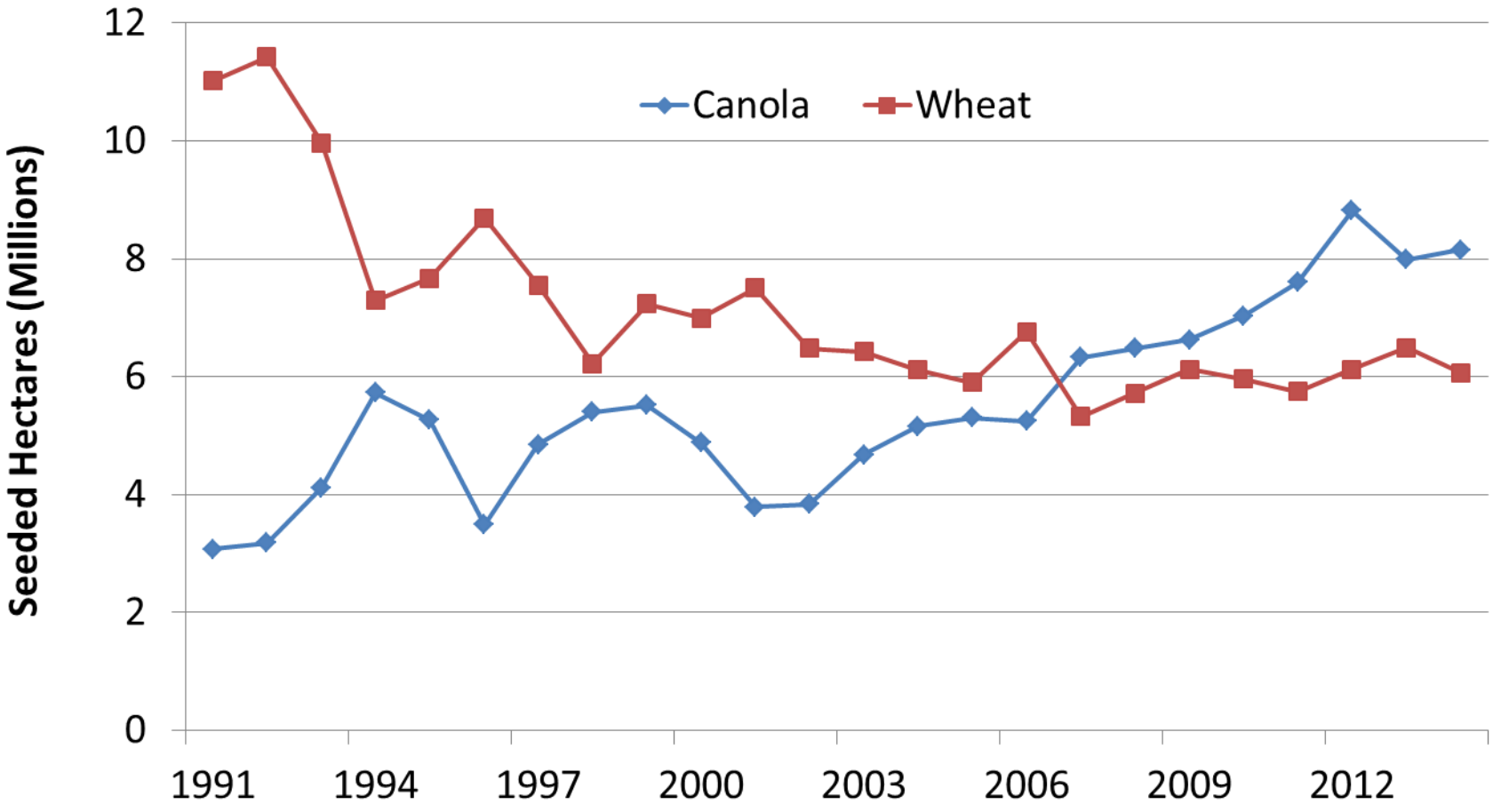
GDD - 1650(base 5°)
MAP – 700 mm
FFD – 135
M. Deficit - 200 mm

- 1908 - 60% of seeded acreage in spring wheat
  30% oats
  10% barley

- 1958 – 30% wheat (~ 100% Canadian Western Red Spring)
  24% oats and barley
  40% summerfallow

- 2008 – 35% spring wheat (~ 6 classes)
  12% oats and barley
  31% canola, 3% flax, 1% mustard,
  12% pulses (lentil, field pea, chickpea)
  7% summerfallow

Seeded Hectares of Canola and CWRS Wheat: Prairie Provinces

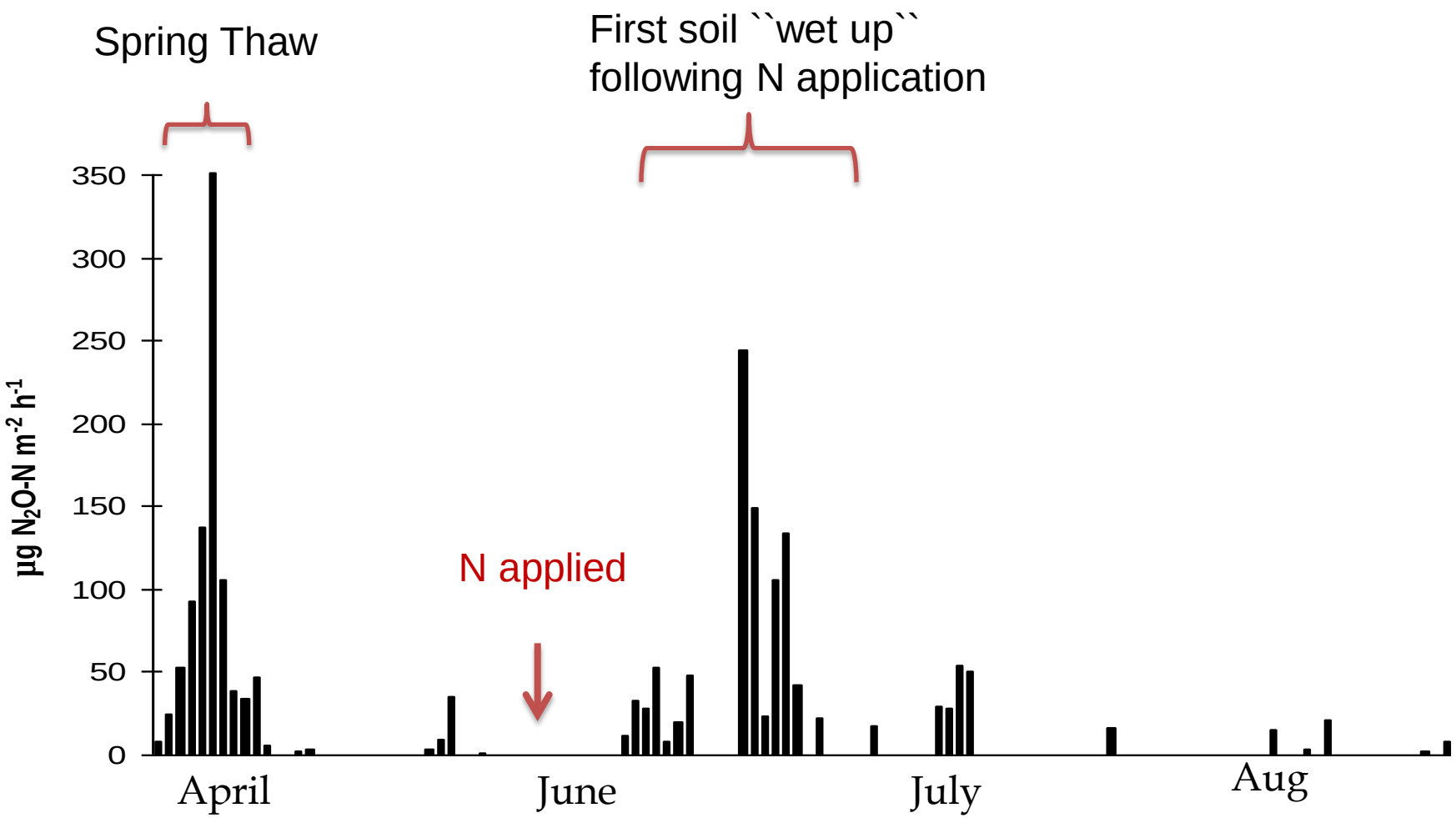


Source: Statistics Canada

Typical field scheduling

- Last frost in mid/late May; first frost in late Sept
- Soils deeply frozen Nov – March (- 20ºC @ 10 cm)
- Seed in late April – mid May; Harvest Aug – early Sept.
- Common crop sequence in recent years:
    - Oilseed-Cereal
    - Oilseed-Pulse-Cereal
- All fertilizer (N,P,K,S) requirements applied in “one-pass” seeding system; alternatively early spring or late fall banding of N
- Nitrogen N rates ranging 50 – 150 kg N ha^{-1}

Seasonal Pattern of soil-emitted N_2O



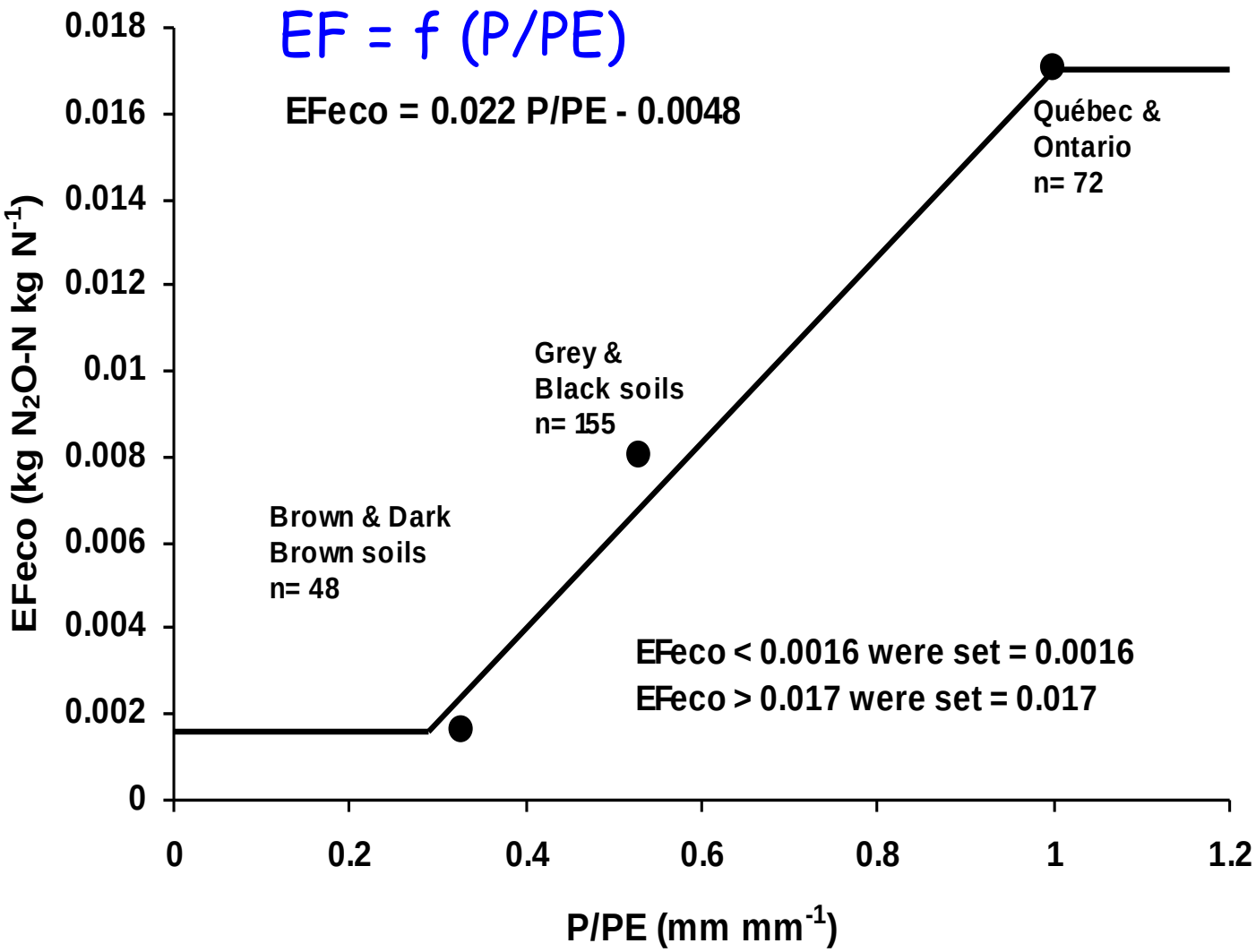
Source: Lemke et al. 1998

Percentage of fertilizer N lost as N_2O averaged across soil zones in western Canada

Soil Zone (Great Group)	% N lost as N_2O Minimum	Maximum	Mean	number of studies
Brown	0.0	0.4	0.2	3
Dark Brown	0.0	0.4	0.2	3
Black	0.2	1.9	0.9	4
Grey/Dark Grey	0.1	1.0	0.4	2

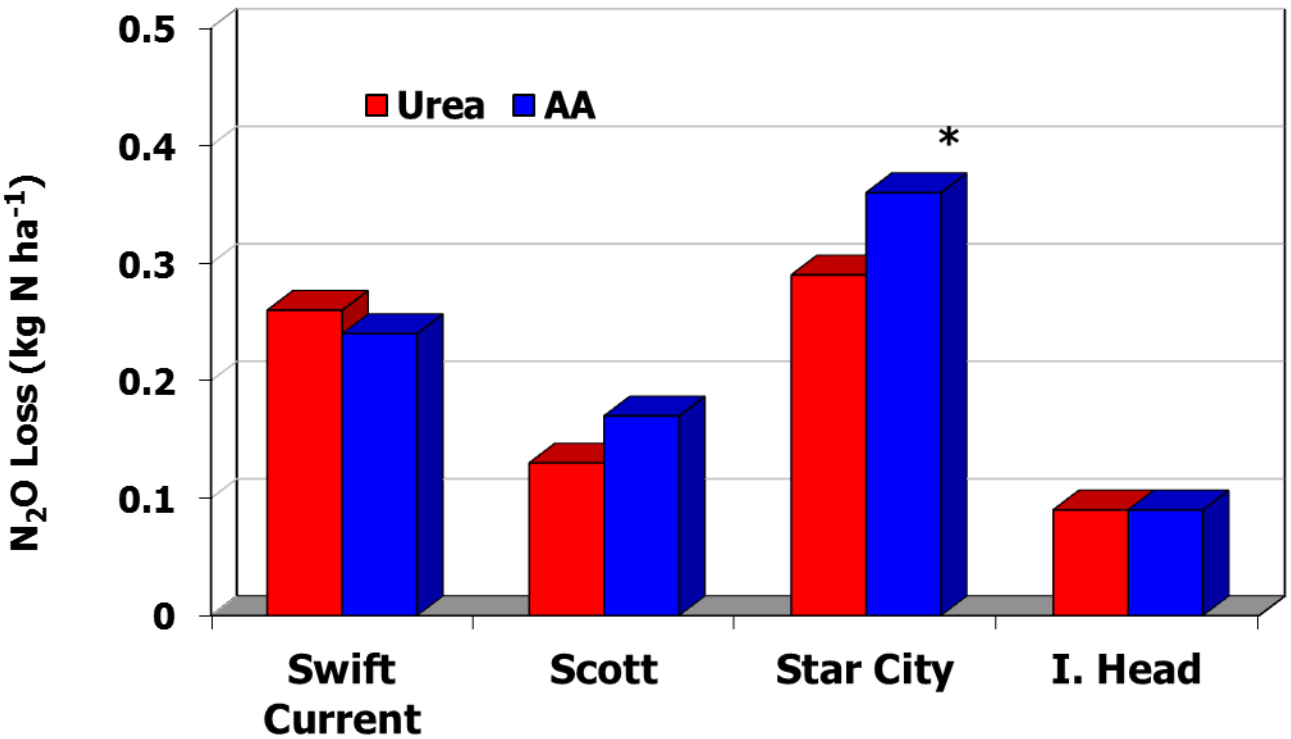
(sources: Burton et al. 2003; Farrell et al. 2003; Lemke et al. 1999 & 2003)

Emission factor as a function of local climate



(Source: Rochette et al., 2008)

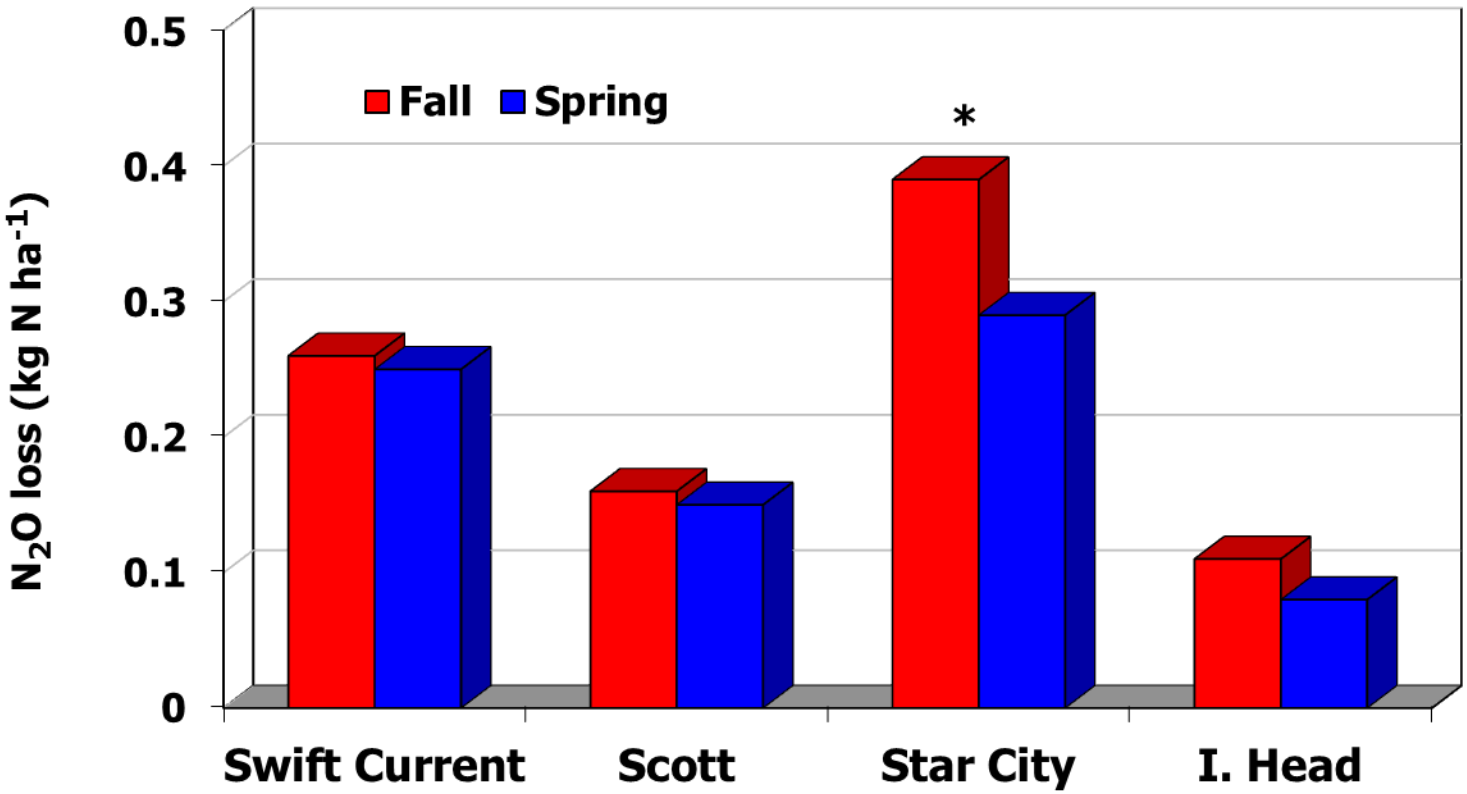
Estimated N_2O loss (3-yr mean) from N applied as urea or anhydrous ammonia at four sites in Saskatchewan, Canada



* = $p < 0.05$

(Source: Lemke unpublished data)

Estimated N_2O loss (3-yr total) from N applied in fall or spring at four sites in Saskatchewan, Canada



* = $p < 0.05$

(Source: Lemke unpublished data)

Annual estimated N_2O loss from selected crop-residue combinations at Scott, Saskatchewan, Canada

Residue Type (previous crop)	Crop	2008/09	2009/10	2010/11	3-year cumulative
		g N_2O-N ha^{-1}			
Wheat(-N)	Wheat (-N)	515 abc	160 d	380 b	1110 bc
Wheat (+N) †	Wheat (+N) †	570 ab	310 ab	540 ab	1360 b
Pea	Pea	400 cd	160 cd	430 b	990 c
wheat	Pea	340 d	170 cd	610 ab	1120 bc
Pea	Wheat (+N)	330 d	430 a	510 ab	1270 bc
Wheat (+N) †	Canola (+N) ‡	400 bcd	460 a	580 ab	1440 b
Canola (+N) ‡	Wheat (+N)	810 a	380 ab	930 a	2120 a

† Wheat received 65 kg N ha^{-1}

‡ Canola received 75 kg N ha^{-1}

(Source: Lemke & Farrell unpublished data)

Nitrous oxide emissions from selected crop residues and urea incubated at 50% WFPS

Treatment	Total Emissions	Residue Derived Emissions	Residue Derived Emission Factor
	—— mg N_2O-N ——		%
Control	0.02	-	-
Urea	0.04	0.01	0.07 c
Wheat	0.07	0.02	0.07 c
Pea	0.18	0.06	0.12 b
Flax	0.08	0.02	0.08 c
Canola	0.23	0.10	0.16 a

(Source: Farrell & Lemke unpublished data)

Nitrous oxide emissions from selected crop residues and urea incubated at 70% WFPS

Treatment	Total Emissions	Residue Derived Emissions	Residue Derived Emission Factor
	—— mg N_2O-N ——		%
Control	0.07	-	-
Urea	0.84	0.09	0.82 c
Wheat	2.66	0.26	1.07 c
Pea	4.26	0.95	1.97 bc
Flax	6.79	0.93	3.02 b
Canola	10.89	3.11	4.91 a

(Source: Farrell & Lemke unpublished data)

GHG calculations for this LCA

- Direct N_2O emissions calculated using IPCC Tier 2 methodology (Rochette et al. 2008)
- Indirect emissions calculated using IPCC Tier 1 methodology
- N content of crop biomass as presented in Janzen et al., 2003.
- Emissions related to LUC and LMC were provided by Can-AG-MARS system.

Approach to the GHG calculations for this LCA

- Conceptualize as a “Cropping Landscape” upon which all agricultural crops (annual and perennial) are grown.
- Cropping landscape excludes “unimproved/native” pasture
- Current emissions from that “Cropping Landscape” are a reflection of both current and historical farming activities
- Emissions were calculated for entire “Cropping Landscape” and assigned to all crops on a proportional basis
- Emissions associated with farming activities specific to a specific crop were calculated and assigned to that crop

CO_2-footprint Canola production on the Canadian Prairies: circa 2010

Soil Ecozone		Production	Land Use Change	Land Management Change	Net
		Emissions kg CO_2eq tonne^{-1} Canola			
Grey		580	320	-100	680
Black		515	-30	-230	260
D.Brown/Brown		475	-110	-290	80
Canadian Prairies		525	10	-210	330

LUC = conversion of grassland or forest land to cropland.

LMC = net change in tillage practices, area of land in summerfallow, and conversion of perennial to annual cropping

(Source: MacWilliam, Lemke, Baron unpublished data)

Summary

- Canola is now a major component of the annual crop mix on the Canadian prairies

- Nitrous oxide emissions on the Canadian prairies are driven by external N applications and governed largely by moisture regime

- Nitrous oxide emissions during the canola phase of rotation related to fertilizer N management in a way similar to wheat

- Constraining N_2O emissions will be related to our ability to fine tune fertilizer N management strategies

Summary continued….

- Indications of an interaction between canola residue and fertilizer N application in the following crop year
- Displacing wheat with canola in cropping systems on the Canadian prairies will likely result in a modest increase in overall N_2O emissions
- Life-Cycle analysis indicates a low CO_2 footprint for canola production on the prairies

Thank You for Your Kind Attention!