Nitrogen cycling and budget in crop rotations as influenced by preceding crops and N fertilization

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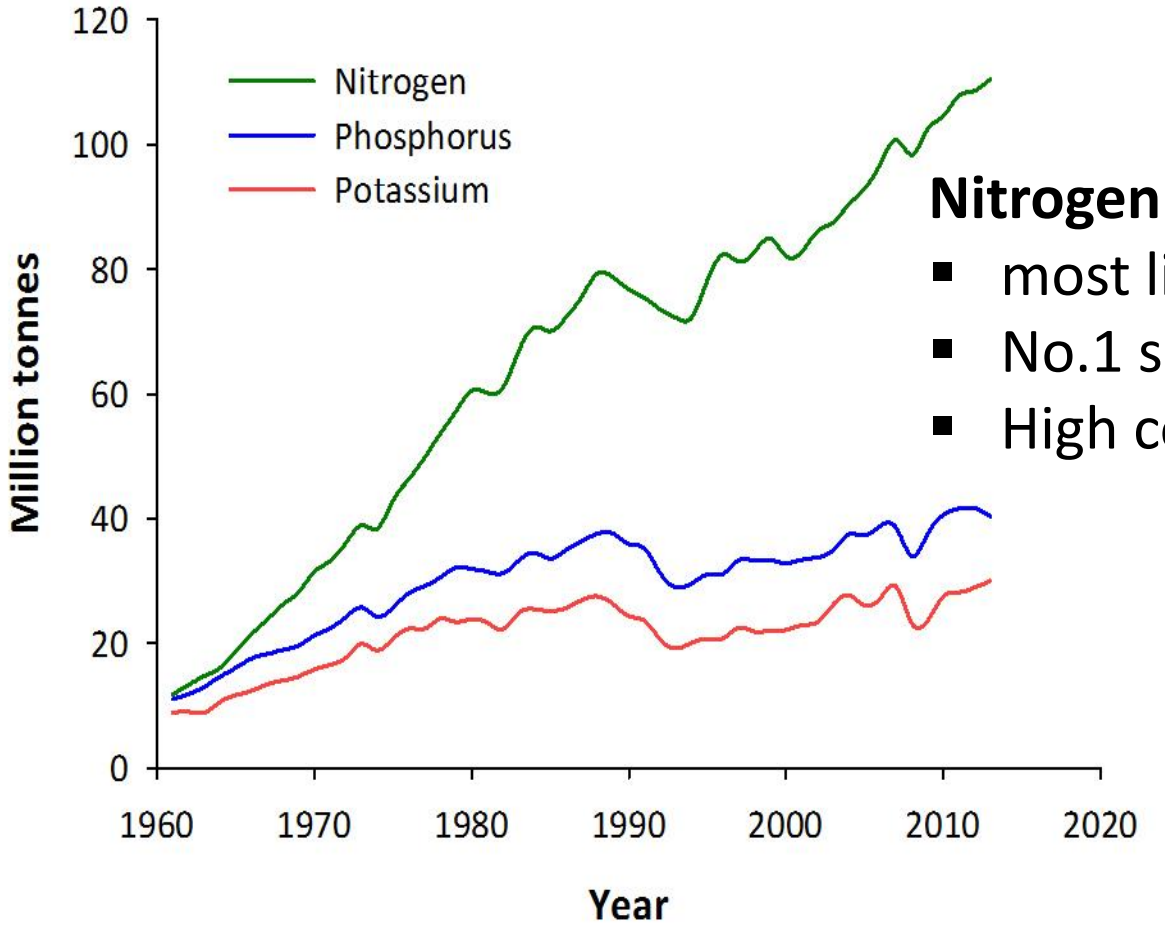
Global Fertilizer Consumption

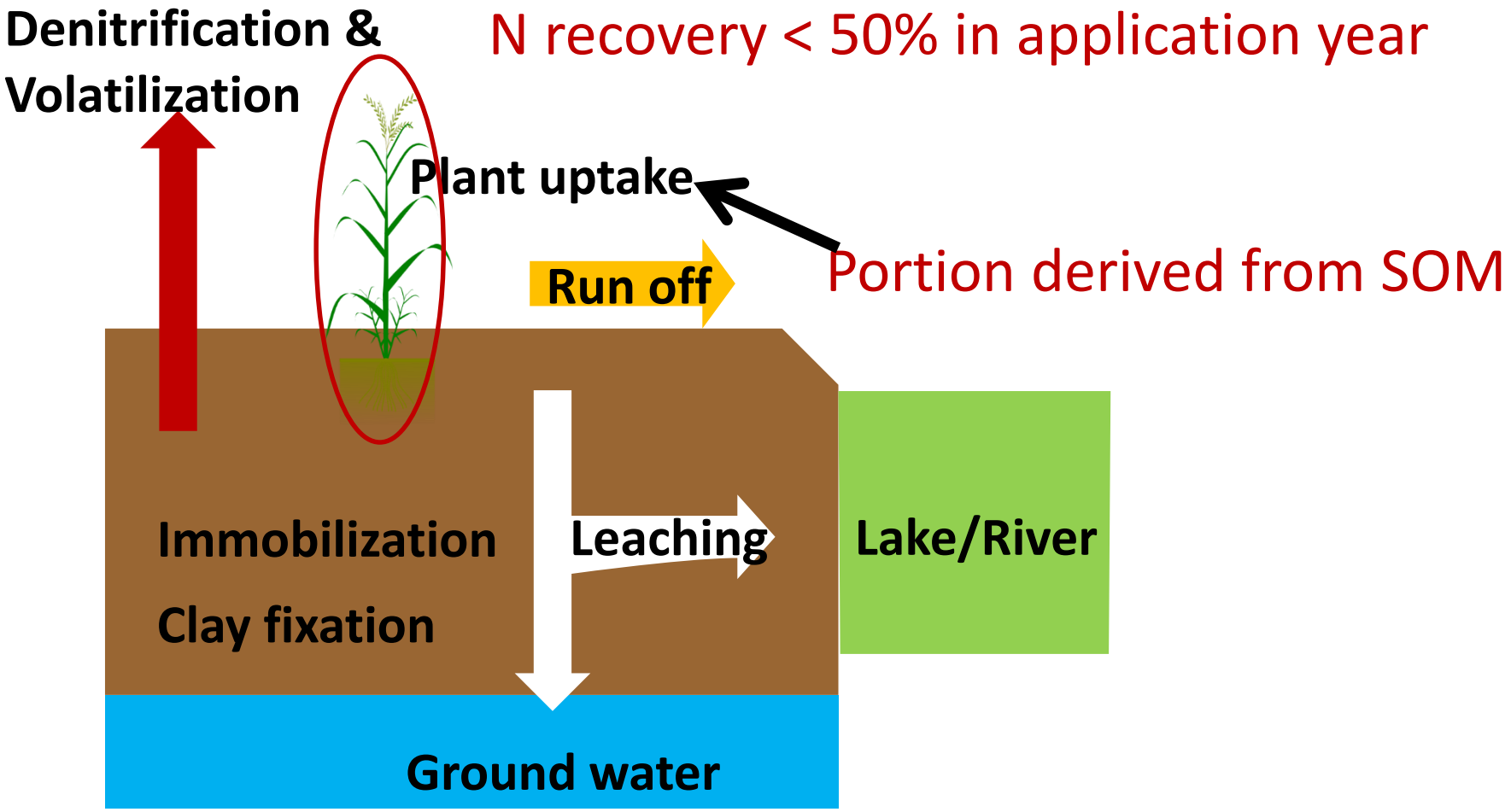


Nitrogen:

- most limiting nutrient
- No.1 source for N_2O emissions
- High cost associated

Source: International Fertilizer Industry Association

Fate of Added N Fertilizer



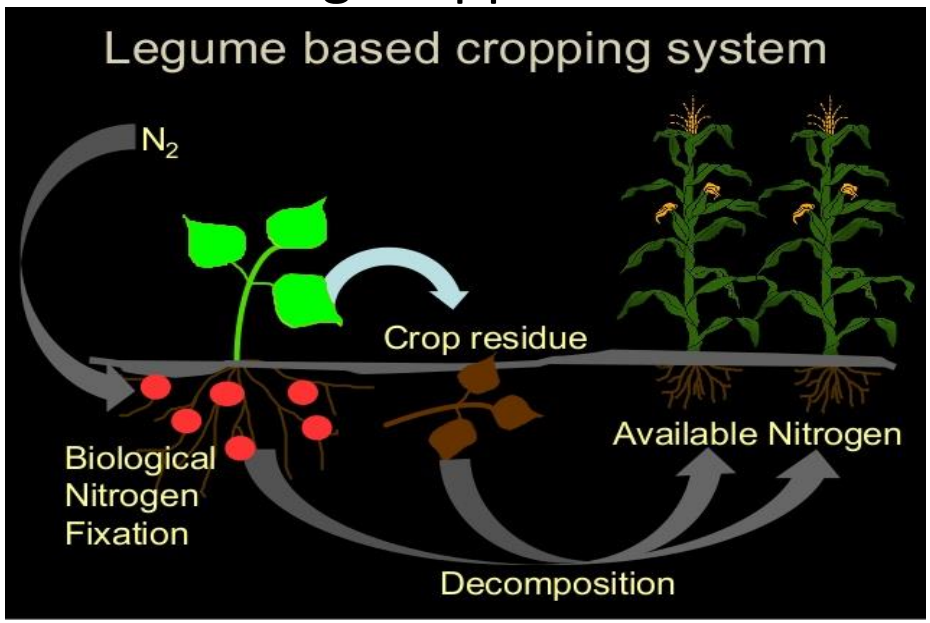
In Canada, 40% of N is either lost or accumulated within the system

Smil 1999; Janzen et al. 2003

Sustainable Production Systems

Alternative and sustainable approaches:

- Crop rotation with pulses & retaining of crop residues
- Matching N application with crop demand in space and time



Pulses	Walley et al. 2007	Hossain et al. 2017
	kg N ha^{-1}	
Faba bean	189	68
Field pea	83	55
Lentil	72	49
Dry bean	34	9
Chick pea	33	52

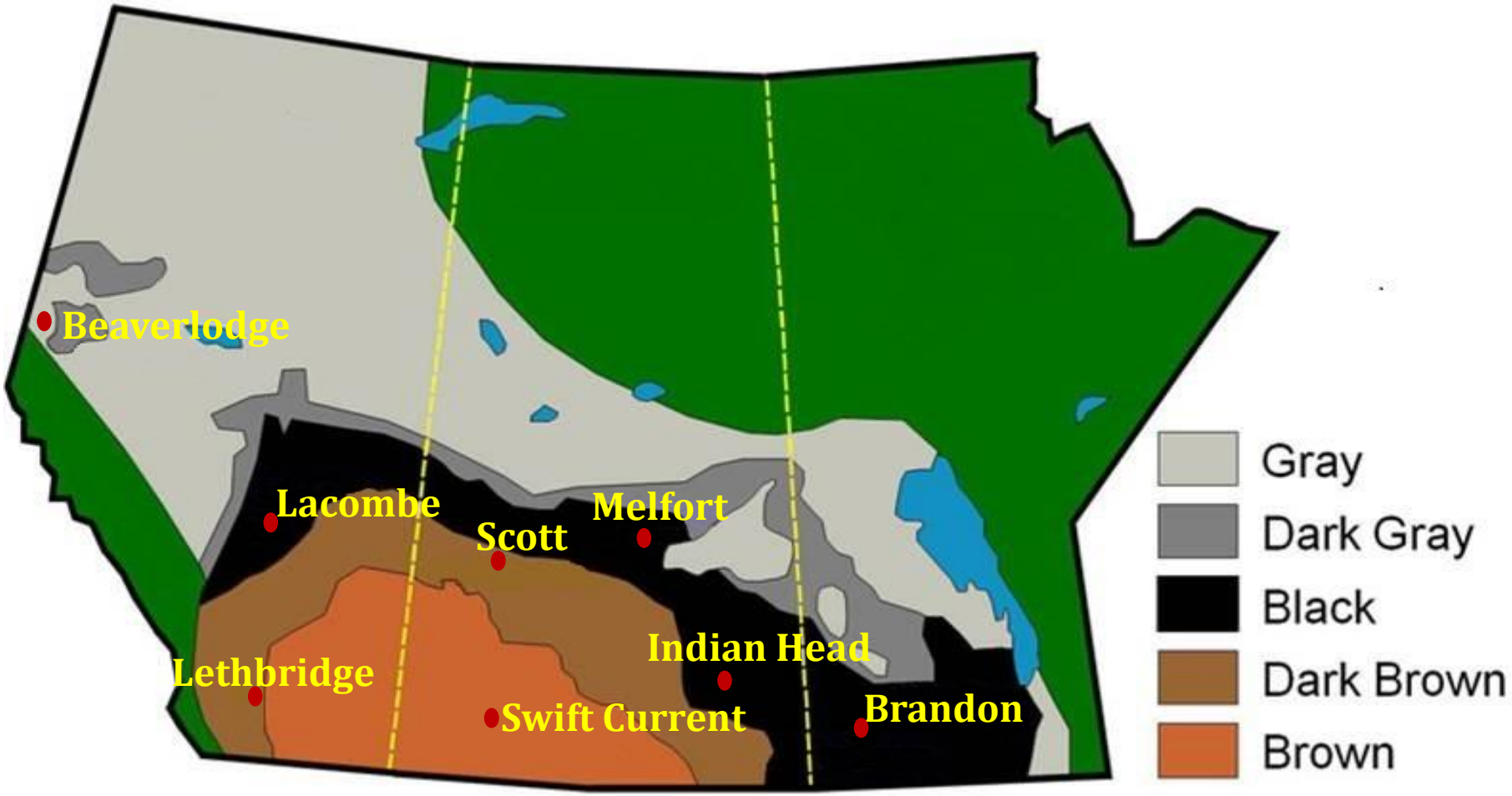
How does crop rotation & N fertilization interact to influence N cycling under varying soil & climatic conditions?

Source: University of Minnesota

Study Objective

To examine the interactive effects of preceding crops and N fertilization rates on soil N cycling in canola and wheat cropping systems in western Canada

Materials and Methods



Materials and Methods

Split-plot experimental design

Main plots (established in 2010):

- Canola (45H73) grown for seed
- Faba bean (Snowbird) grown for seed
- Faba bean (Snowbird) grown as green manure
- Field pea (CDC Golden) grown for seed
- Lentil (CDC Imperial) grown for seed
- Wheat (CDC Imagine) grown for seed
- Field pea (CDC Golden) grown as green manure at one site

Sub-plots (N rates in 2011 when **wheat** was the test crop):
0, 30, 60, 90 and 120 kg N ha^{-1}

Materials and Methods

Measurements

- Crop N uptake
- Spring and harvest soil NO_3-N (0 - 60 cm)
- Apparent in-crop N mineralization (ANM, kg N ha^{-1})=
  (N uptake + Harvest NO_3-N) – (N fertilizer + Spring NO_3-N)
- Apparent N fertilizer recovery (ANFR, %)=
  (N uptake_F – N uptake_C / N fertilizer applied) *100%
- Economic optimum N rate (EONR, kg N ha^{-1})

N budget = Input – Output (based on some assumptions)

Input: Spring NO_3-N + ANM + N fertilizer

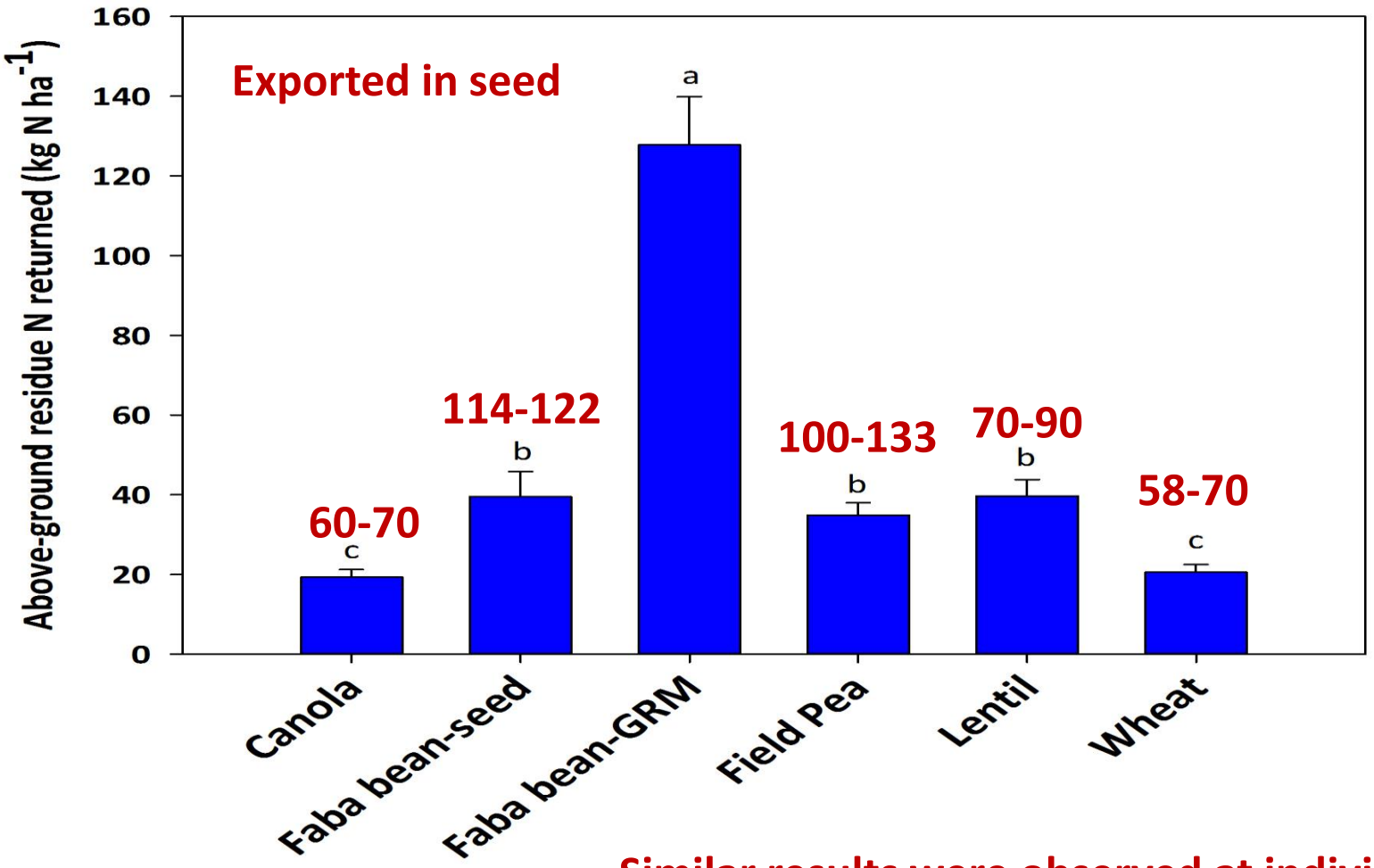
Output: Above-ground crop N uptake

Materials and Methods

Statistical Analyses

- Proc Mixed of SAS was used
- Analysis was conducted for individual sites and across all sites
- Differences were considered statistically significant at $P < 0.05$

Above-Ground Residue N Returned



Similar results were observed at individual sites

Adapted from St. Luce et al. 2016

Spring Soil NO_3-N in 2011

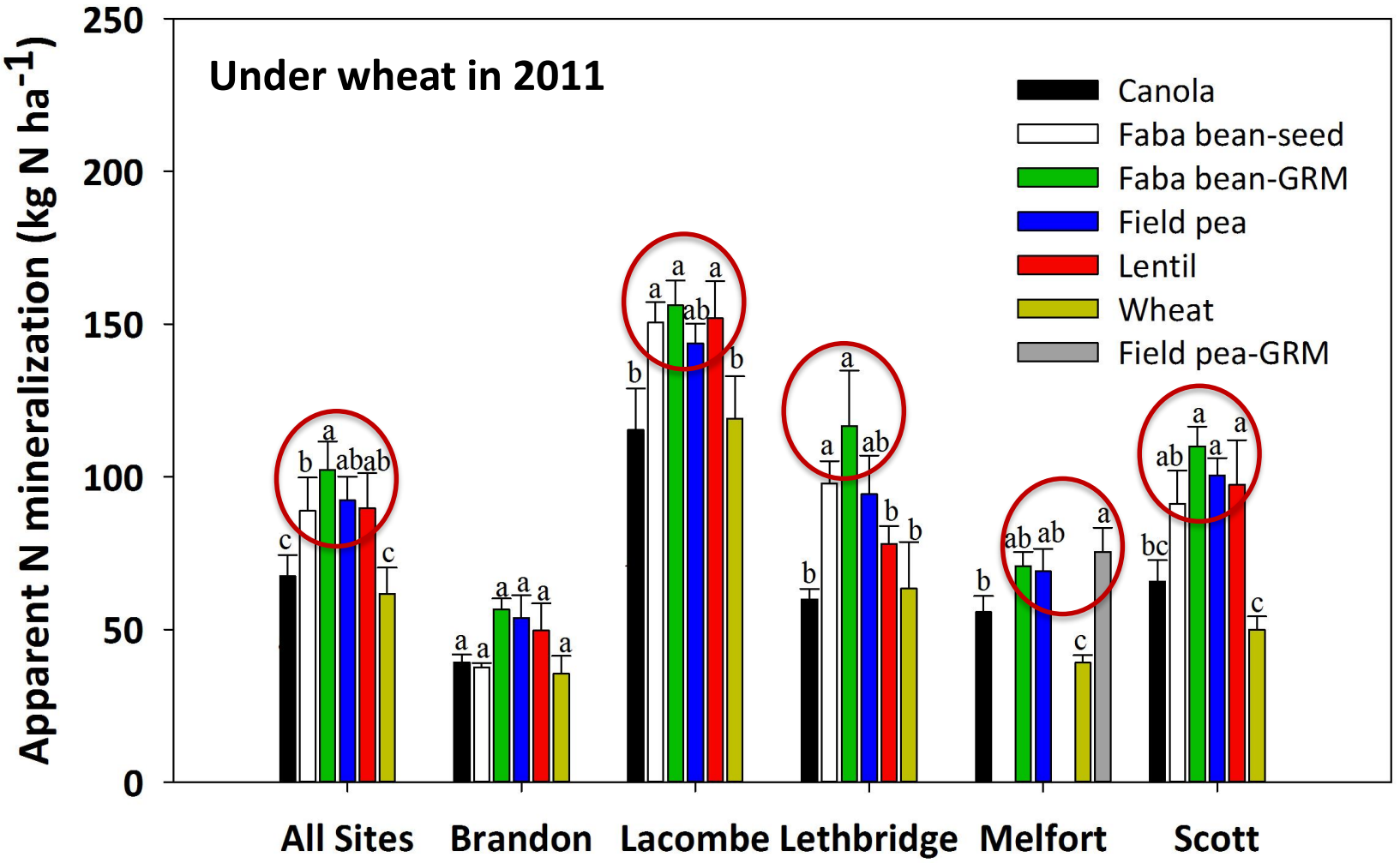
Preceding crop	Brandon	Indian Head	Lacombe	Lethbridge	Melfort	Scott	All sites
	kg N ha^{-1}						
Canola	12.0b	19.9	24.1c	15.7	7.1	21.2	16.7c
Faba-seed	13.1b	19.3	19.7c	20.3	----	18.8	18.2bc
Faba-GRM	19.5a	19.1	38.7ab	27.4	11.3	31.2	24.5a
Field pea	24.4a	15.7	28.4bc	18.1	11.3	27.8	20.9ab
Lentil	19.1a	21.2	40.5a	20.2	----	33.6	26.9a
Wheat	10.7b	11.3	23.9c	17.8	11.2	19.9	15.8c
Field pea-GRM	----	----	----	----	11.0	----	----
P value	0.002	NS	0.004	NS	NS	NS	0.0007

At 0-60 cm before wheat was planted in 2011

Values followed by the same letter within a column are not significantly different

St. Luce et al. 2015

Apparent N Mineralization

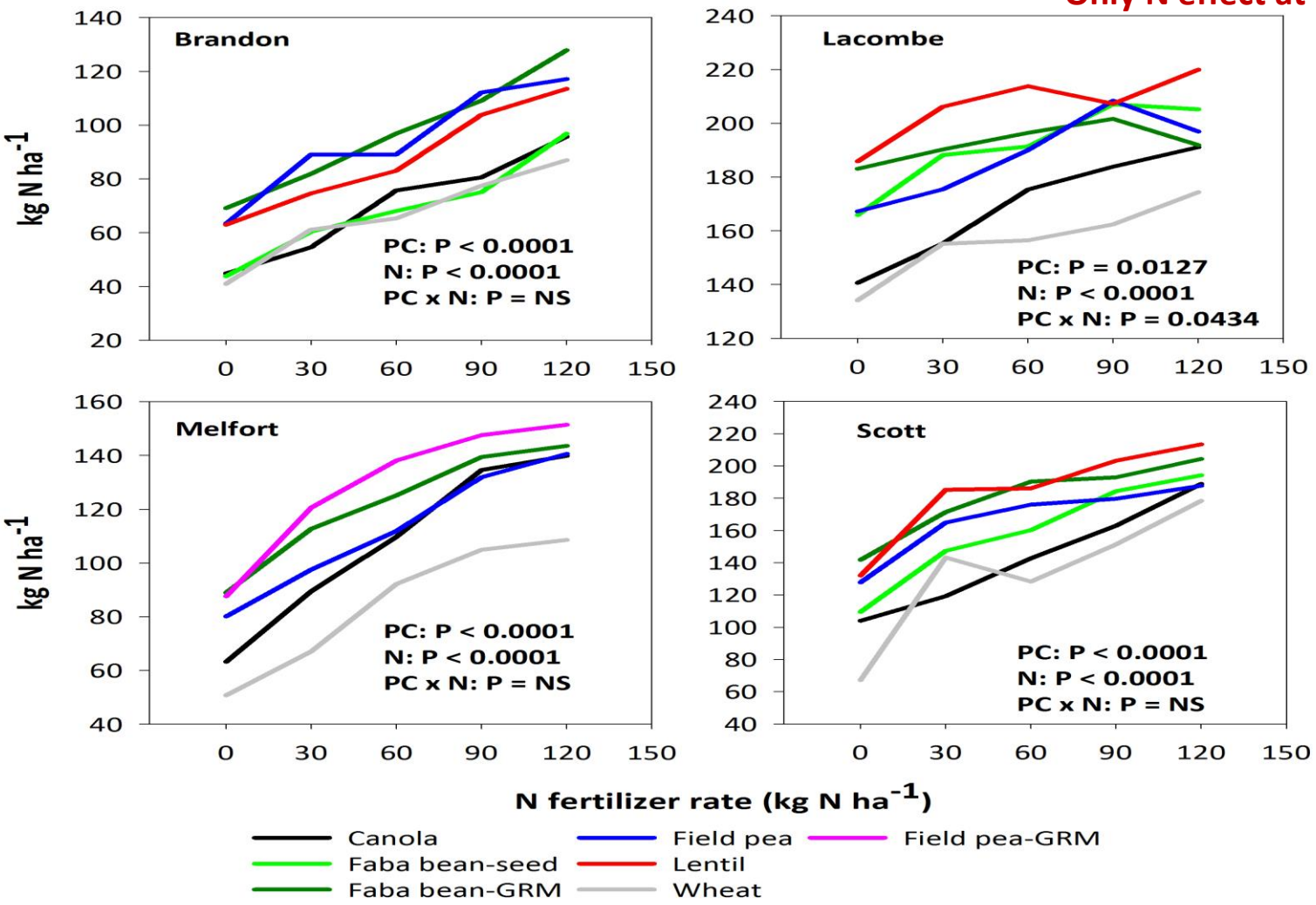


Bars with the same letter for each site are not significantly different

St. Luce et al. 2016

Wheat N Uptake

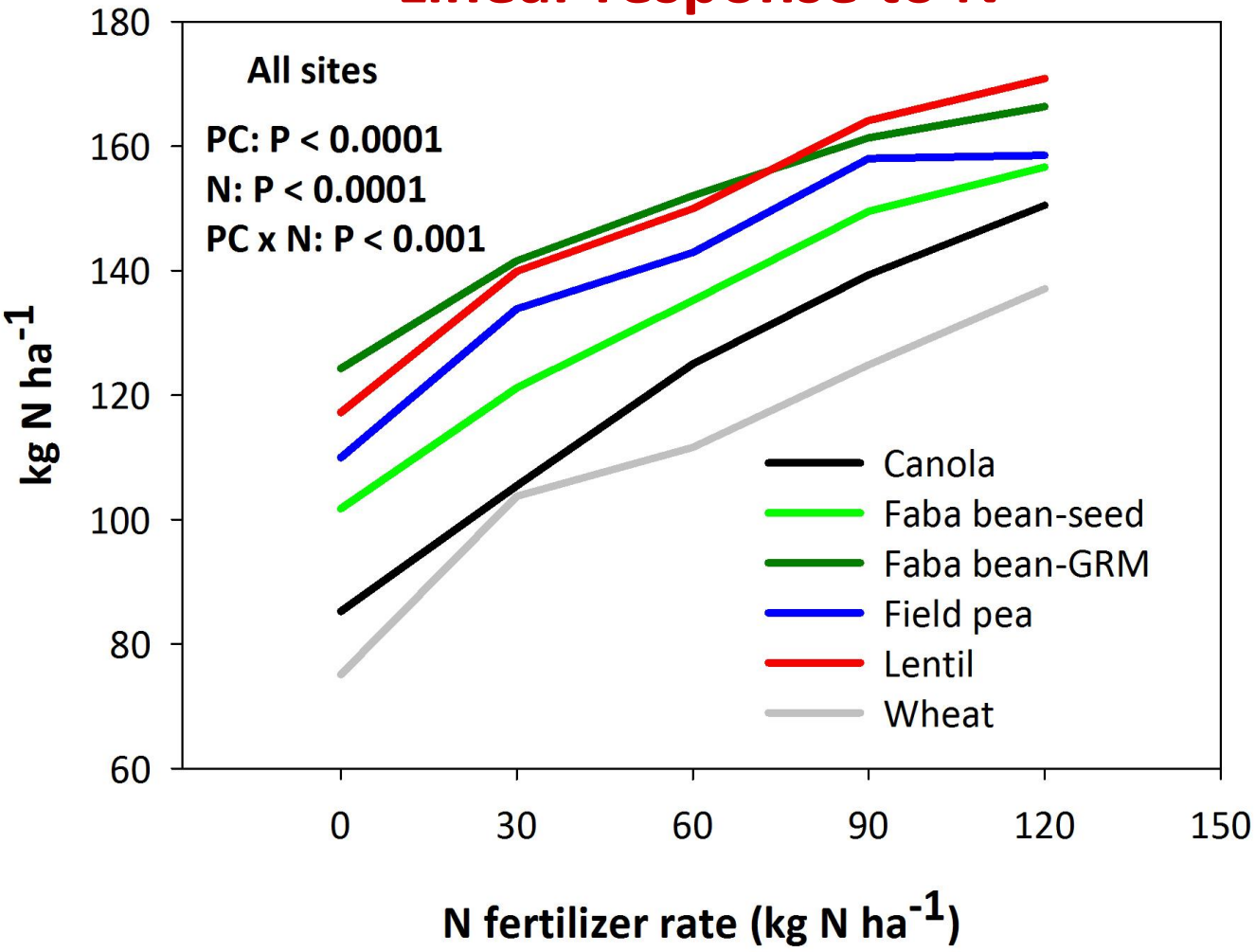
Only N effect at Lethbridge



St. Luce et al. 2016

Wheat N Uptake

Linear response to N



St. Luce et al. 2016

Wheat N Uptake

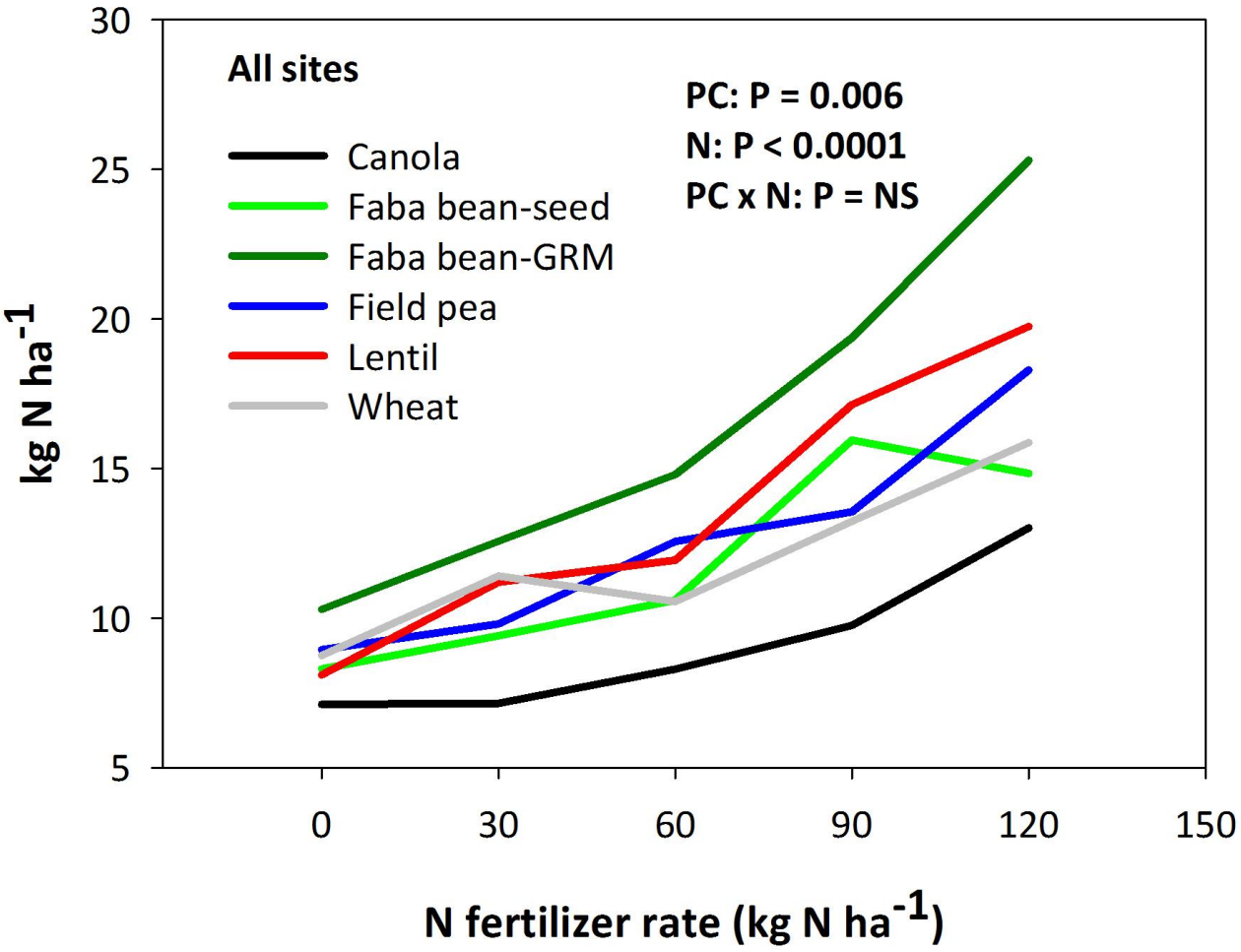
Linear response to N across sites

Preceding crop	Intercept	Slope	R^2
Canola	88.2bd	0.55a	0.26
Faba bean-seed	106.3c	0.44abc	0.13
Faba bean-GRM	128.4a	0.35c	0.12
Field pea	116.4b	0.40bc	0.16
Lentil	123.1ab	0.43abc	0.12
Wheat	81.9d	0.48ab	0.21

All intercept and slope values were significant ($P < 0.05$)

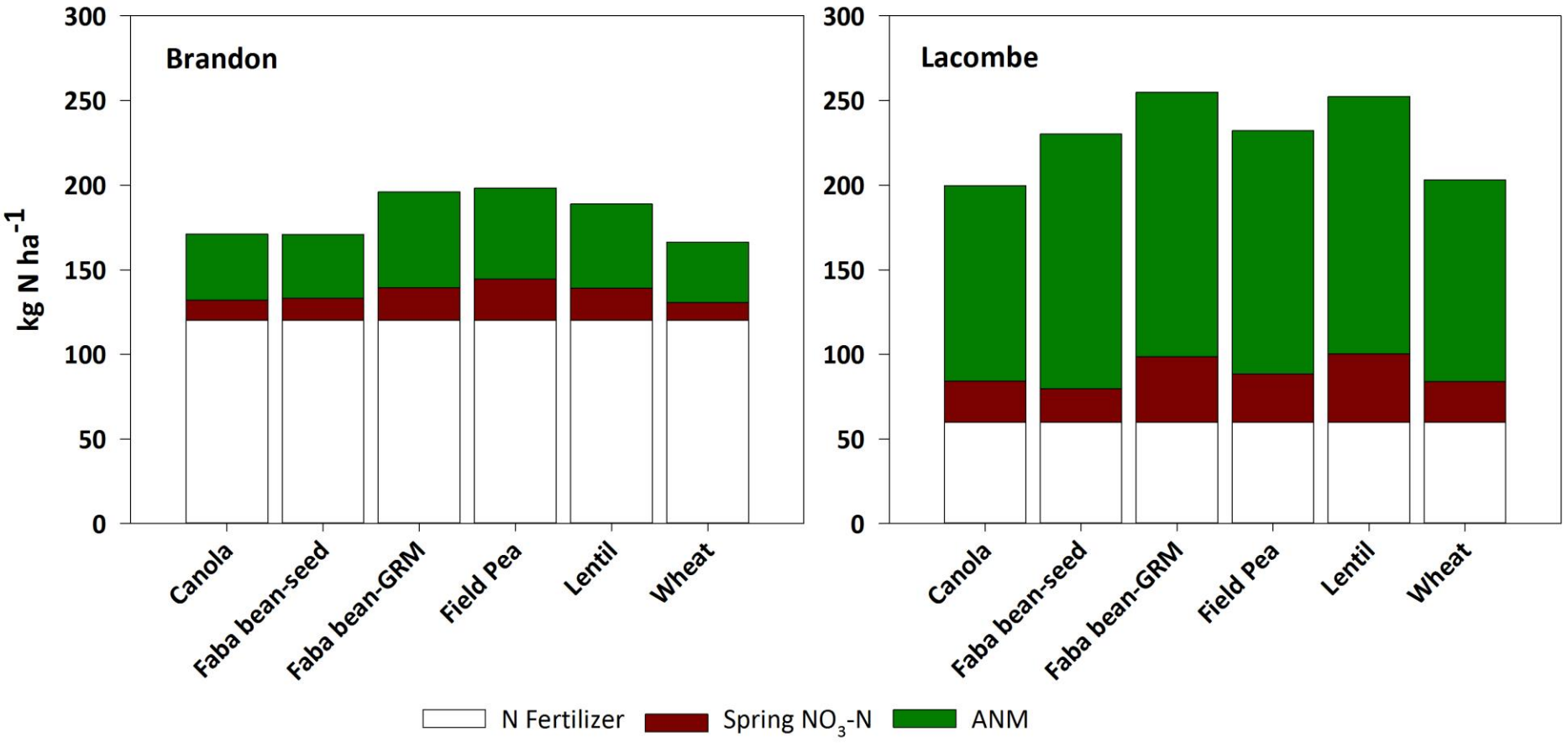
St. Luce et al. 2016

Fall Soil NO_3-N in 2011



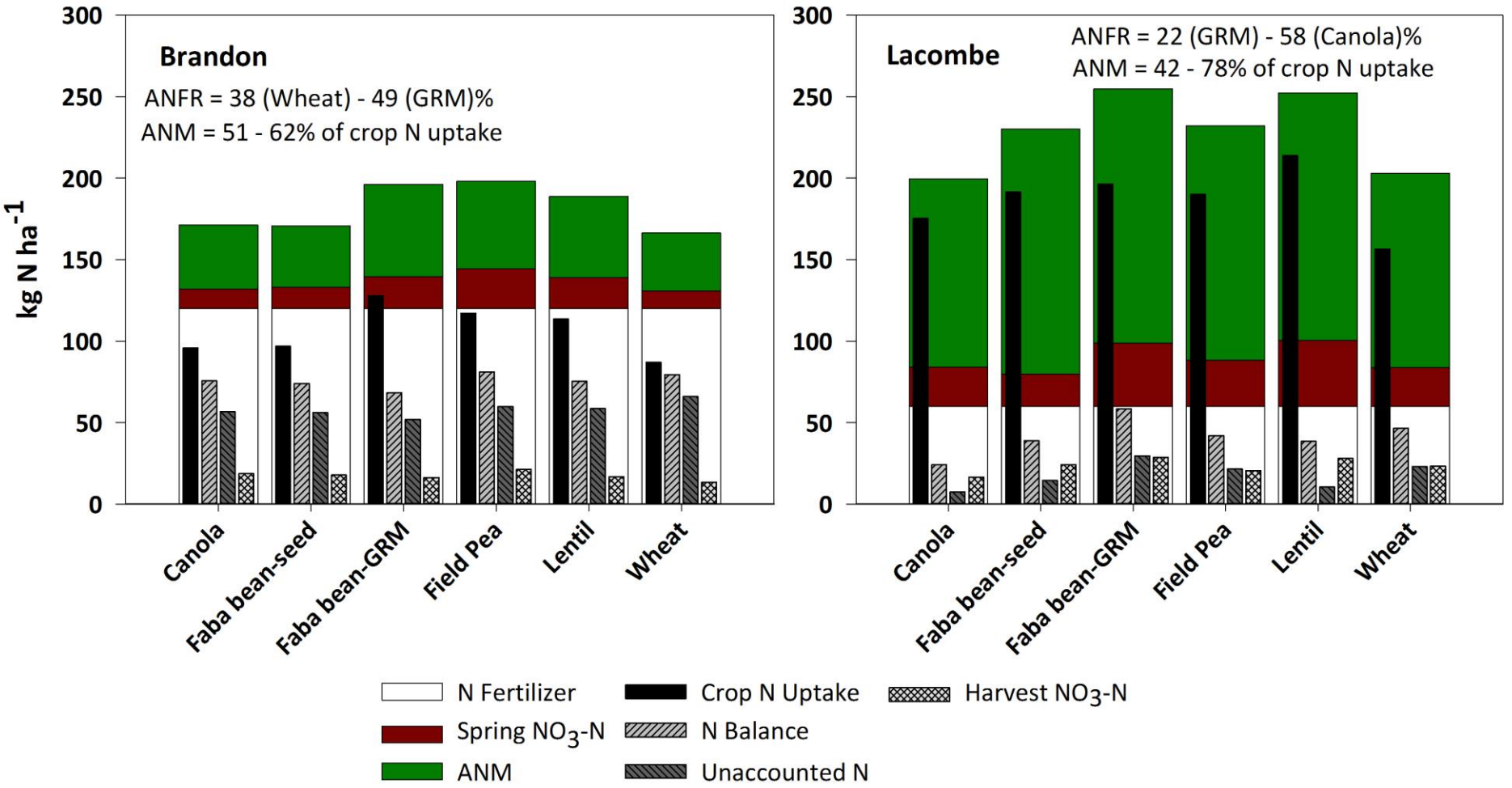
At 0-60 cm after wheat was harvested in 2011

Nitrogen Budget



Adapted from St. Luce et al. 2016

Nitrogen Budget



On average, ANM accounted for 40-60% of crop N uptake;

N balance & unaccounted greater after pulses

Adapted from St. Luce et al. 2016

Summary

- Pulses can increase soil fertility and enhance soil N cycling
- Pulse benefit depends on species, seed vs. green manure, and site-specific conditions
- Faba bean-GRM, field pea and lentil can increase pre-plant soil NO_3-N content, ANM and reduce reliance on N fertilizer inputs
- Up to 78% of crop N uptake may be derived from N mineralized from SOM and crop residues (high labile SOM content)
- N fertilizer recommendations should consider potential N availability; critical for reducing N surplus and N losses

Acknowledgements

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Thank you!

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