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Controlled release nitrogen fertilizer use in potato production systems of eastern Canada

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Canada

General introduction

- Potato is the fourth most important crop worldwide after rice, wheat, and maize (He et al. 2012).
- In 2008, nearly 151,100 ha of potatoes were harvested in Canada (Statistics Canada 2015).

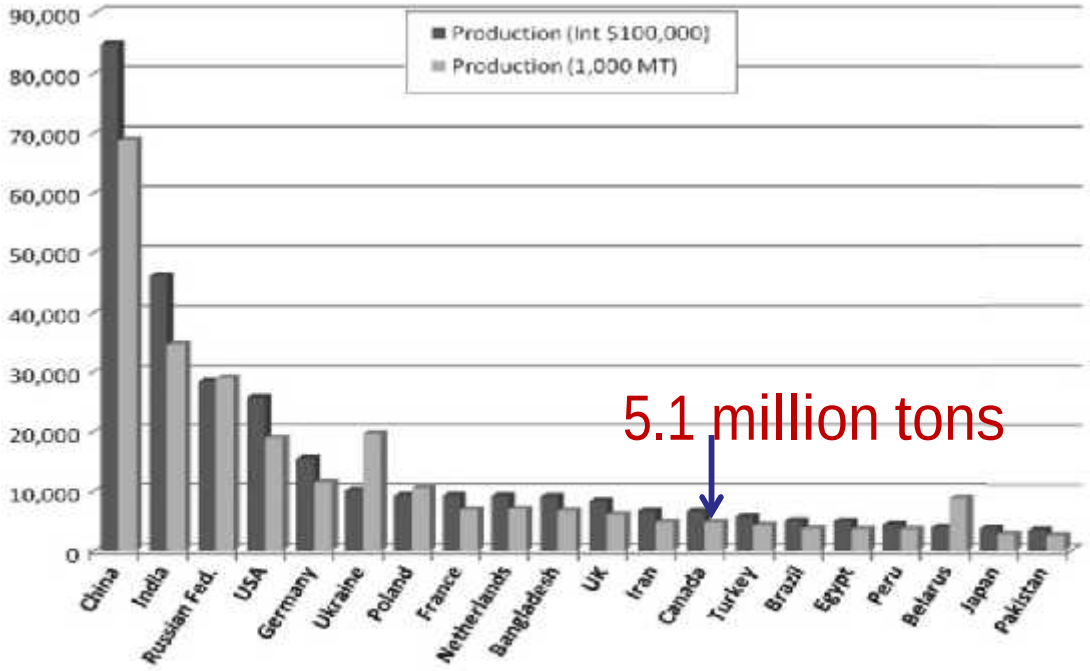
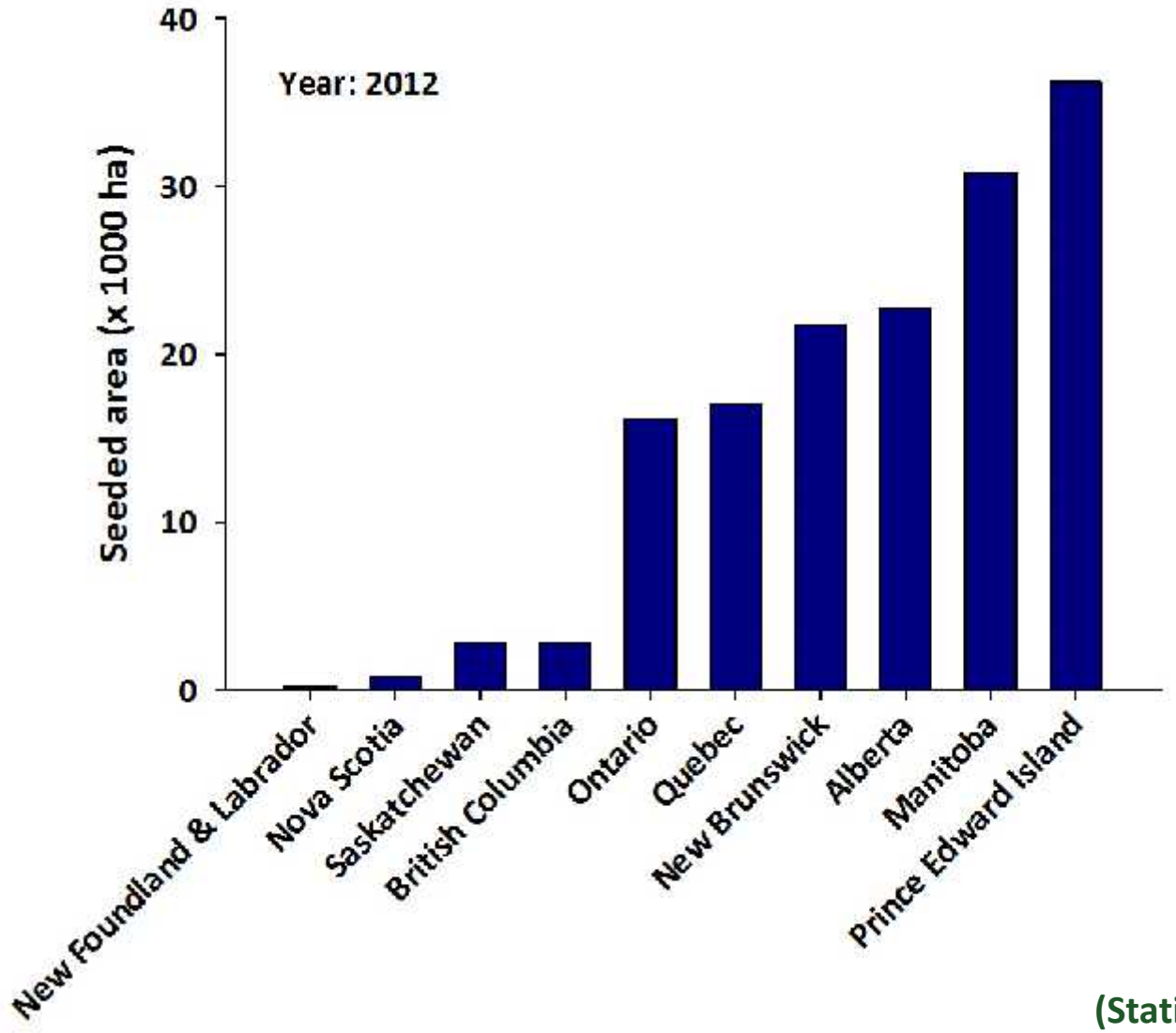
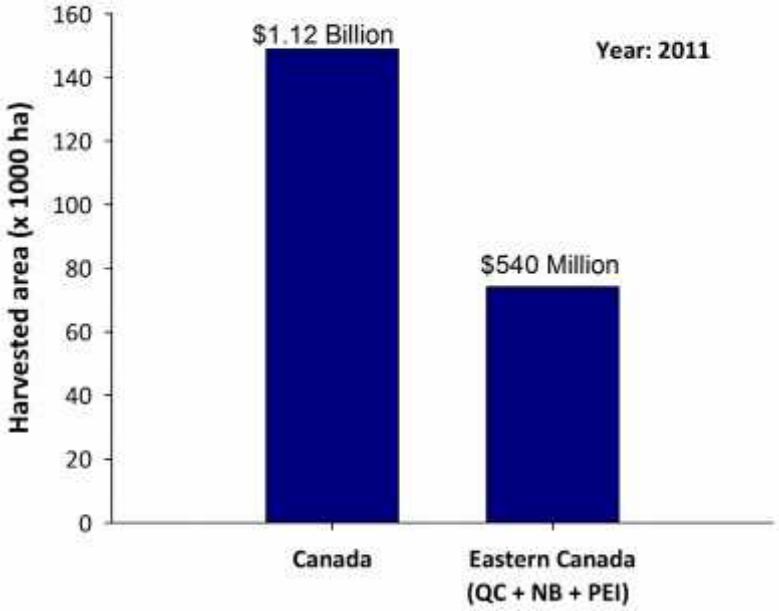


Fig. 1.1 Summary of the top 20 potato-producing nations (2008) comparing valuation in international dollars (Int) with quantity in metric tonnes (MT or Megagrams, Mg) (FAOSTAT 2011)

Potato Production: Economically Important



(Statistics Canada)



(Statistics Canada)

Context

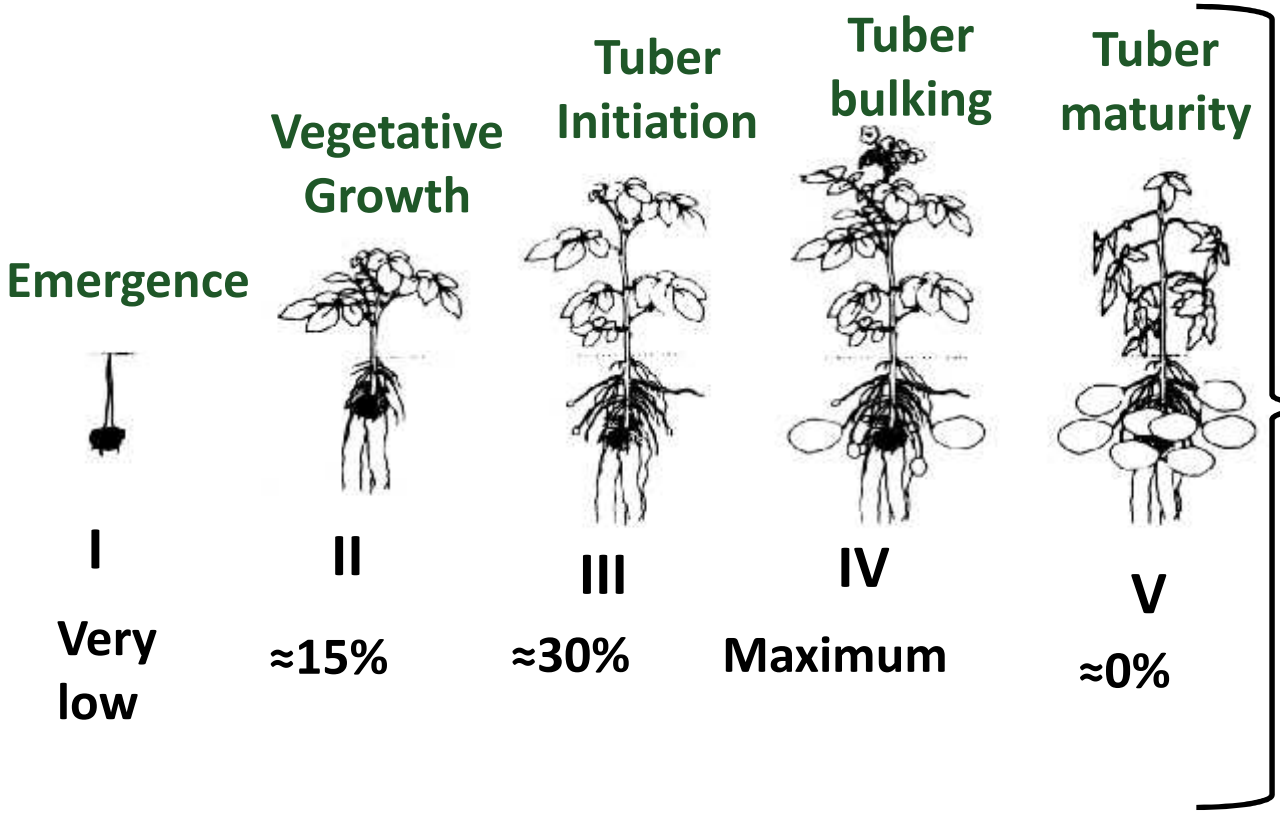
Nitrogen use efficiency of potatoes < 50% (Zebarth and Rosen, 2007).

Cultivated in soil highly susceptible to N leaching and low water retention capacity.

Shallow roots.

Just Enough N: Equilibrium between "too much" and "too little"

Nitrogen Uptake by Potatoes

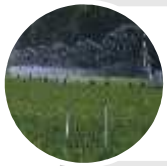


- Nitrogen uptake pattern varies with growth stage (Zebarth and Rosen, 2007)
- Timing of N fertilizer application, growth stage, climatic conditions and irrigation (40%) can influence N use efficiency (Cambouris et al. 2008)

Nitrogen Best Management Practices

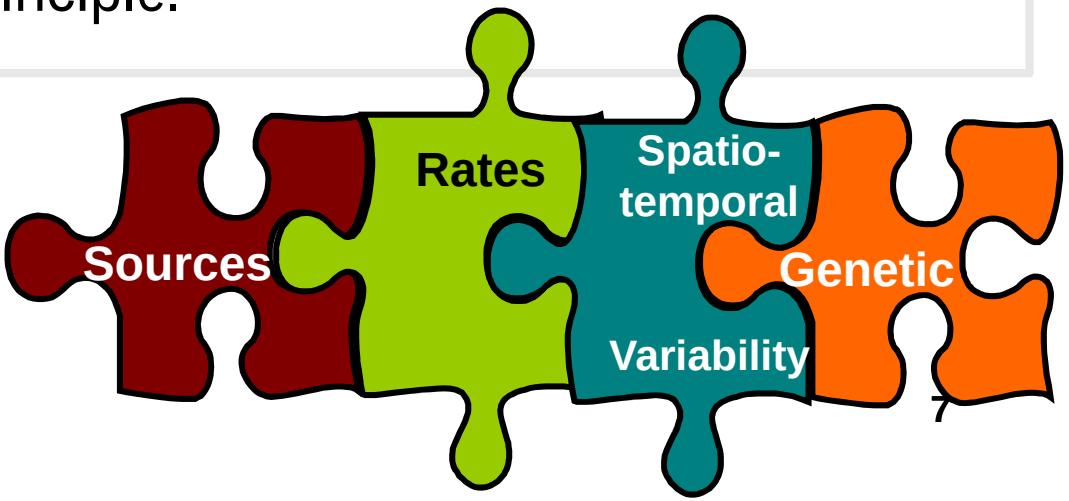
Goal: achieve good marketable yields (size and quality) while minimizing losses to the environment.

↑Yield by ↑NUE.



Synchonization of plant needs with N availiabitily.

Simple but elusive principle.

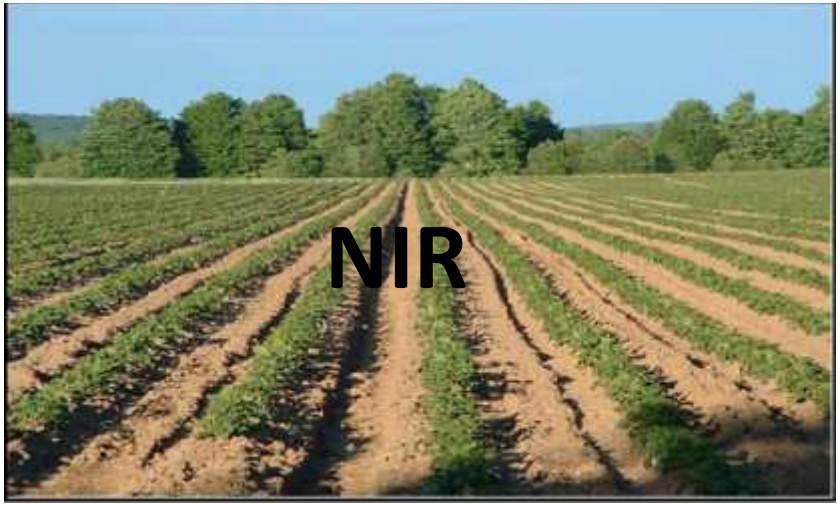


Nitrogen Fertilization in Potatoes

- **N recommendations in eastern Canada: 125 – 200 kg N ha^{-1}.**
- **Prince Edward Island and New Brunswick: Banded at planting.**
- **Quebec: Split N application (sandier soils); at planting and 30 DAP (at first or final hilling).**

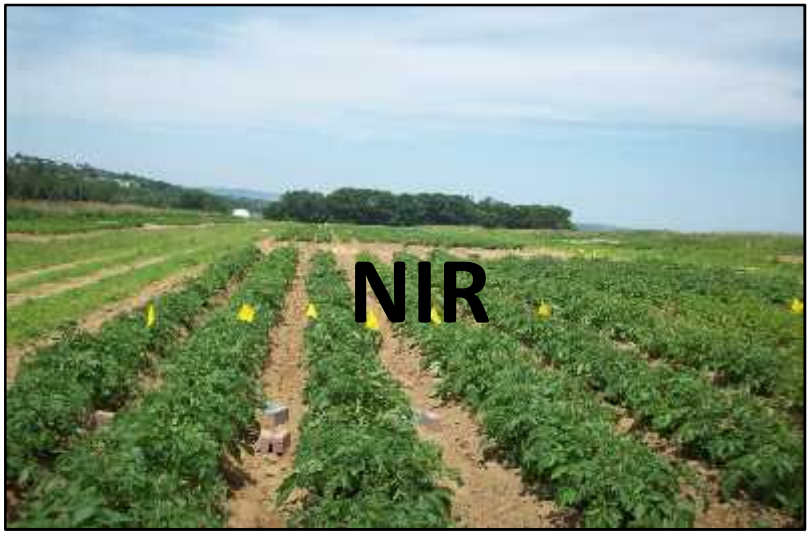
Results from Three Studies in eastern Canada

St. Ubalde, Quebec



Ste-Catherine-de-la-Jacques-Cartier, Quebec

Fredericton, New Brunswick



Study 1: 2006 – 2008 (3 yrs)

- Site: farm in St. Ubalde, Quebec
- Sandy loam soil
- Potato cultivars: Chieftain and Goldrush
- Treatments:
  - Control (no N fertilizer added)
  - Calcium ammonium nitrate (CAN) (150 and 200 kg N ha^{-1})
  - PCU* (150 kg N ha^{-1})
- N was applied only at planting.
- Randomized complete block design with 3 replicates.
- New experimental area each year to avoid residual N effects.

*PCU: Environmentally Smart Nitrogen, Agrium Inc.

Ziadi et al. (2011)

Study 1: 2006 – 2008 (3 yrs)

- **Marketable yield (MY) and specific gravity**
- **Nitrogen use efficiency (NUE, kg tubers kg^{-1} N):**

  MY of N treatment – MY of control/ N applied
- **Anion exchange membranes: NO_3 availability**

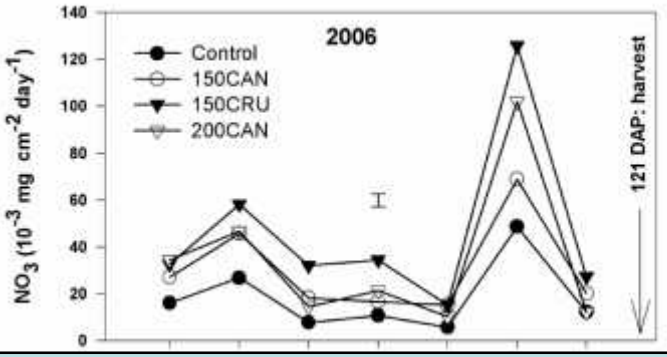
Ziadi et al. (2011)

Study 1: 2006 – 2008 (3 yrs)

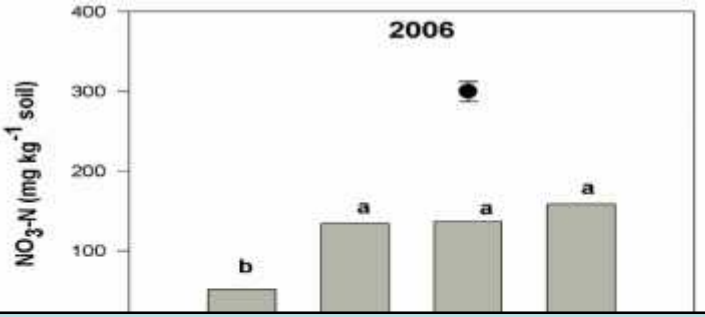
Treatment	Marketable yield (Mg ha^{-1})	Specific gravity	NUE (kg tuber kg^{-1} N)
Control	17.2c	1.070	
150CAN	26.0b	1.070	55.3b
150PCU	29.3a	1.066	84.8a
200CAN	26.3b	1.070	44.6c
Cultivar			
Goldrush	22.5	1.068	49.7b
Chieftain	26.8	1.070	73.5a
ANOVA			
Treatment (T)	< 0.001	0.14	< 0.001
Cultivar (C)	0.48	0.86	< 0.001
T x C	0.20	0.44	0.46

Ziadi et al. (2011)

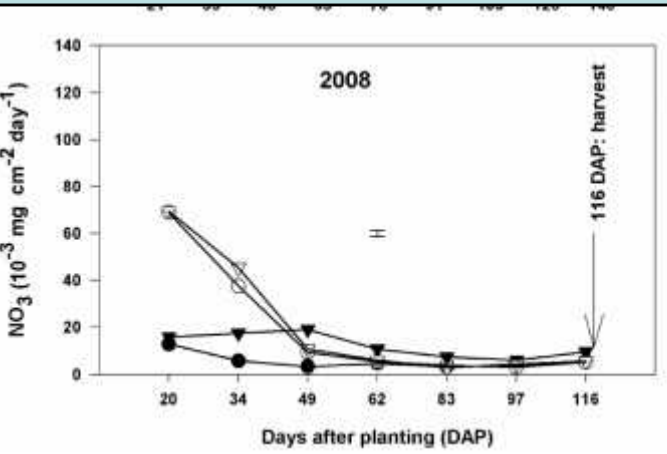
Study 1: 2006 – 2008 (3 yrs)

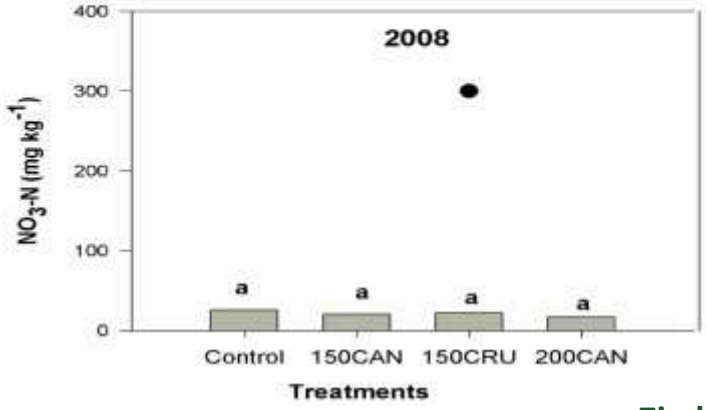


Residual NO_3-N



- CRU (PCU) is promising N source for increasing tuber yield and NUE: better synchrony between N demand and N release.
- However, PCU did not reduce residual soil NO_3-N at harvest compared to CAN.





Ziadi et al. (2011)

Study 2: 2008 – 2012 (5 yrs)

- Farm in Ste-Catherine-de-la-Jacques-Cartier, near Quebec City
- Sandy loam soil with supplemental irrigation
- Potato cultivar: Russet Burbank
- Factorial of 3 sources and 4 N rates + control
  - N sources : AN, AS and PCU* + unfertilized control
  - N rates: 60, 120, 200 and 280 kg N ha^{-1}
- N timing
  - AN and AS: 40% at planting and 60% at hilling
  - PCU 100% at planting
- Randomized complete block design with 4 replicates

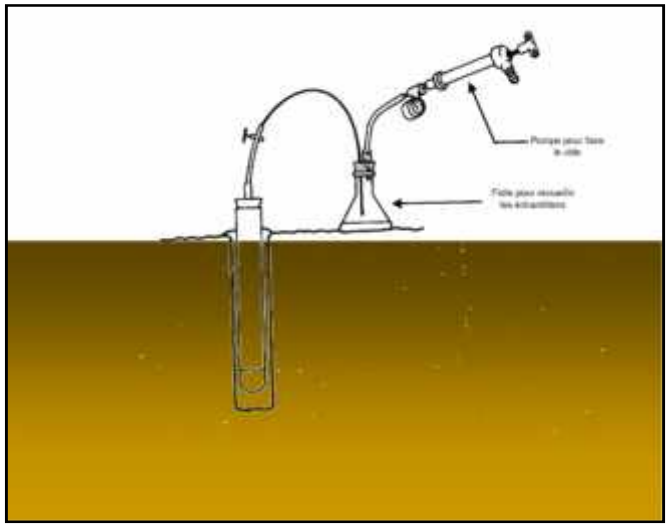
*PCU: Environmentally Smart Nitrogen, Agrium Inc.

Cambouris et al. (2016)

Study 2: 2008 – 2012 (5 yrs)

- **Total and marketable tuber yield, tuber specific gravity and total N uptake**
- **In-season NO_3-N leaching (soil water) with suction lysimeters**
- **Apparent N fertilizer recovery (ANR, %):**

  Plant N uptake in treatment – plant N uptake in control / N rate applied



Cambouris et al. (2016)

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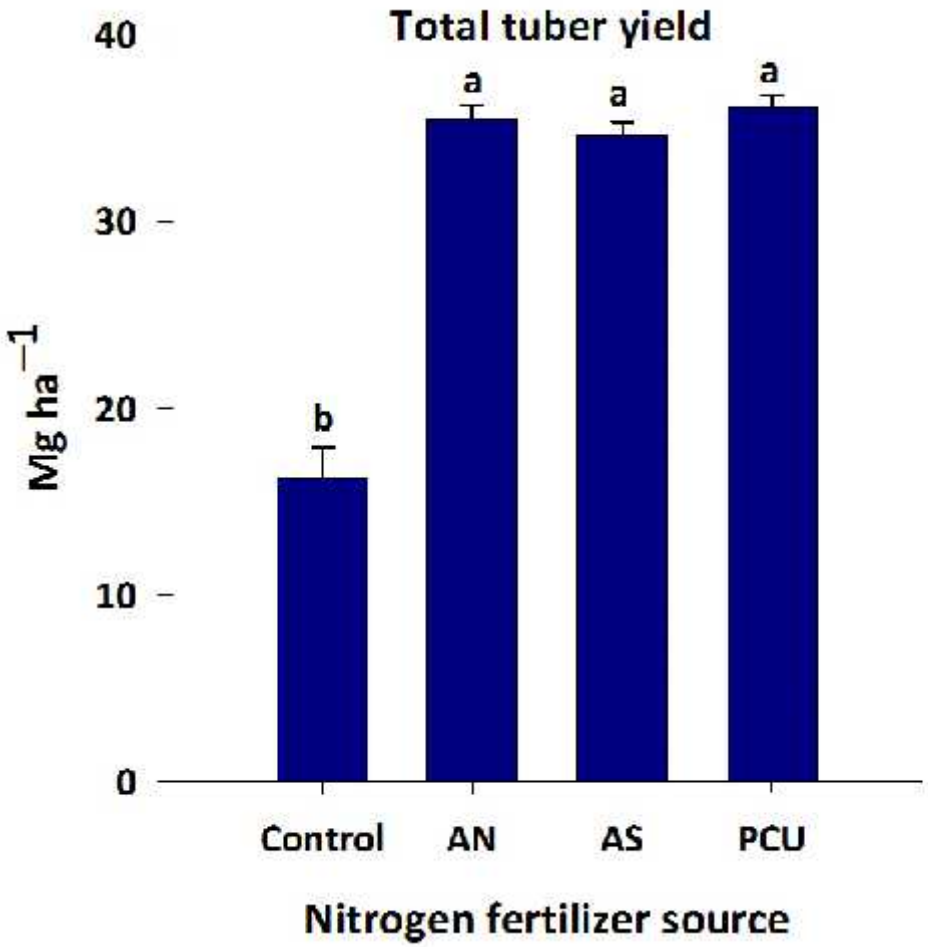

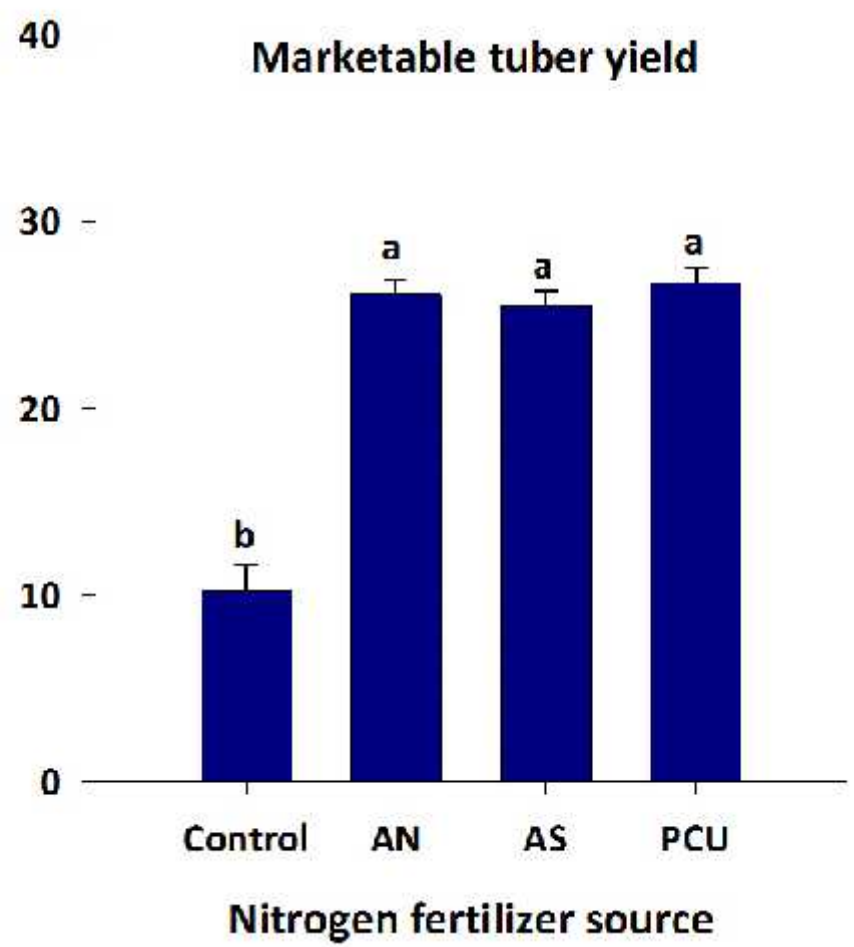

Cambouris et al. (2016)

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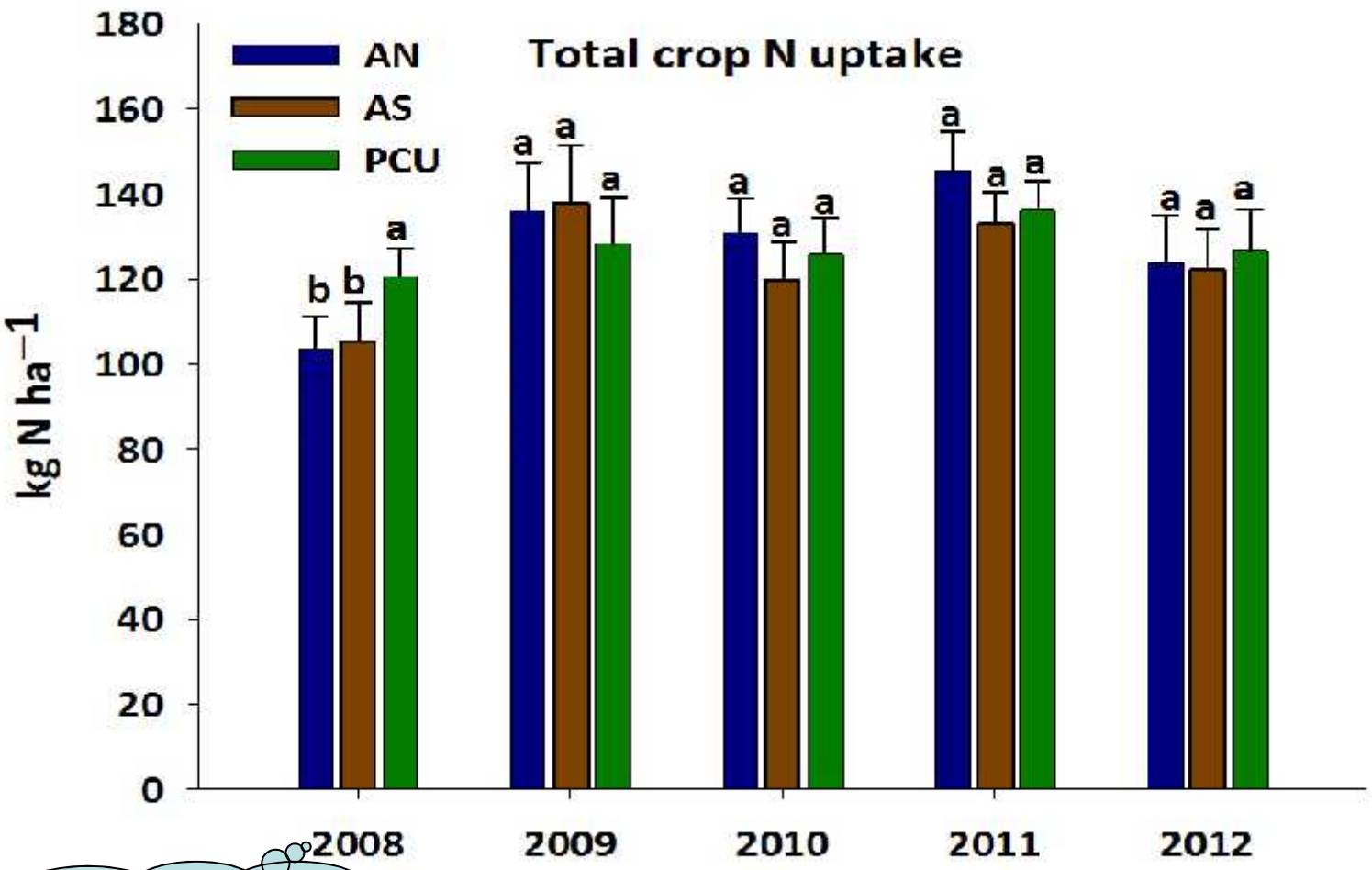
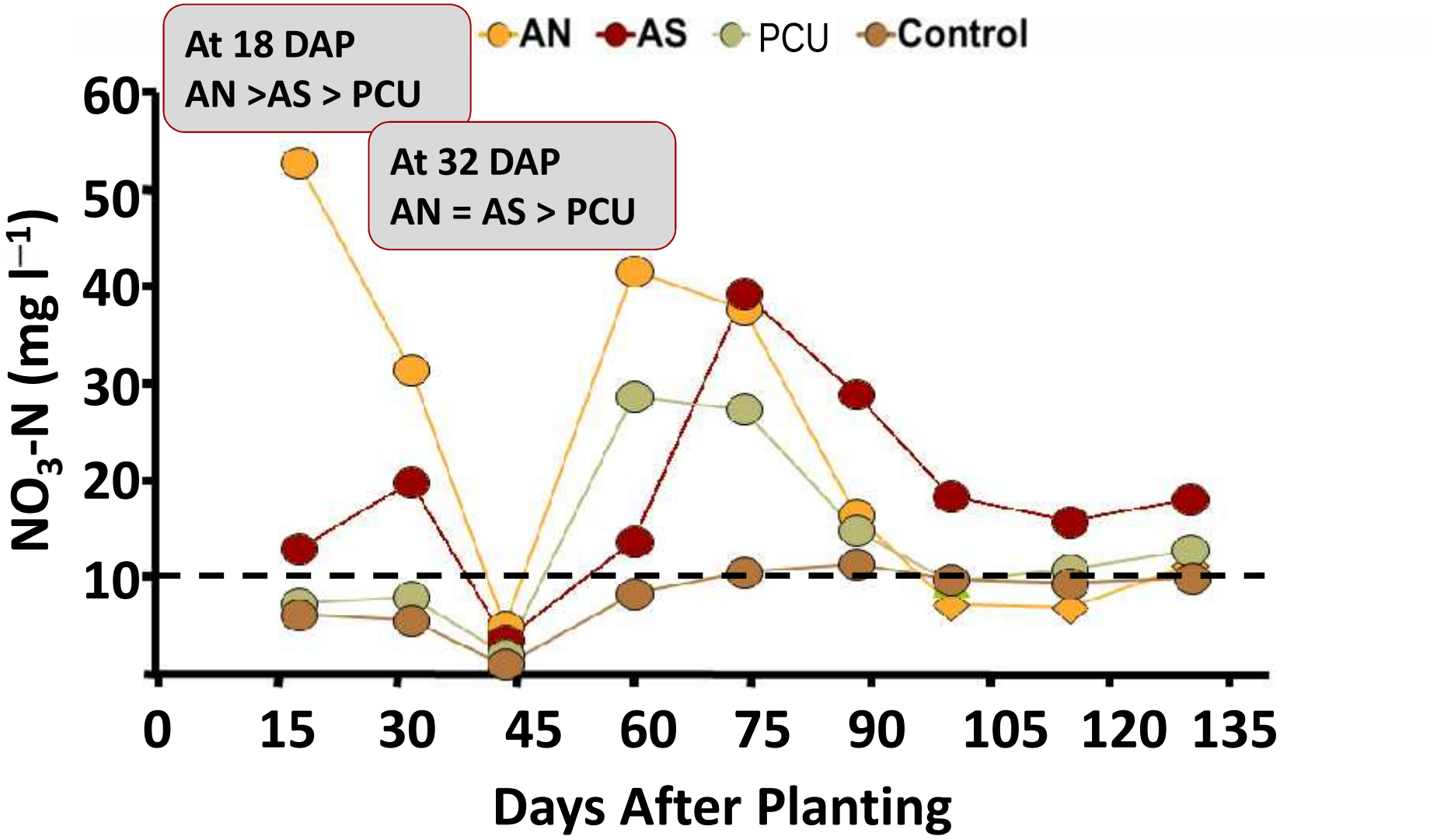


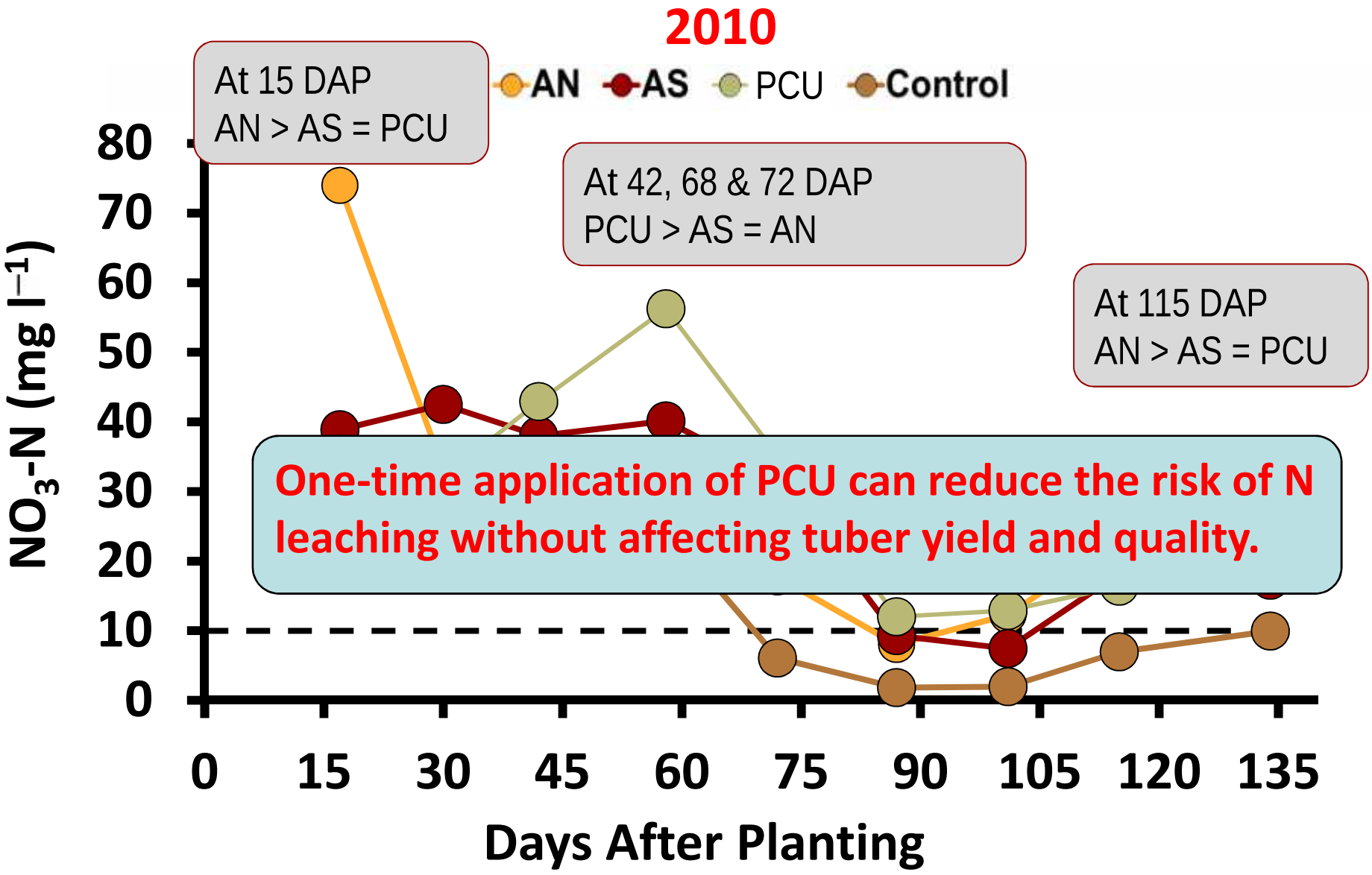
31% above normal rainfall (150 & 38% above in June and July, respectively).

Cambouris et al. (2016)

In season NO_3-N leaching



In season NO_3-N leaching



Study 3: 2008 – 2010 (3 yrs)

- Site: Fredericton Research Centre, New Brunswick
- Loam soil
- Potato cultivar: Russet Burbank
- Treatments (N rate of 193 kg N ha^{-1}):
  - Control
  - Diammonium phosphate + ammonium nitrate (conventional) at planting
  - Split N application (60% at planting and 40% at hilling)
  - PCU* at planting
- Randomized complete block design with 4 replicates.

*PCU: Environmentally Smart Nitrogen, Agrium Inc.

Zebarth et al. (2012)

Study 3: 2008 – 2010 (3 yrs)

Treatment	Total yield (Mg ha^{-1})	Mean tuber weight (g)	Specific gravity	Total N uptake (kg N ha^{-1})
Control	21.2b	146b	1.092a	77b
Conventional	36.3a	180a	1.089ab	175a
Split	34.7a	177a	1.092a	171a
PCU	36.2a	185a	1.087b	190a
ANOVA				

- N uptake numerically greater for conventional and split than PCU when rainfall was below normal (2008 and 2010). The reverse was true when rainfall was above normal (2009).
- Average apparent N recover was 51% (conventional), 49% (split N) and 58% (PCU).

Zebarth et al. (2012)

Conclusions

- **PCU can minimize the risk of N leaching without affecting yield and quality;**
- **PCU is a promising N source for potato production in the humid regions of eastern Canada;**
- **Lower N application rates for PCU may need to be evaluated (undergoing)**



Acknowledgements

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Thanks for your attention

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