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

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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 2014)
Potato Production: Economically Important

Year: 2012

Seeded area (x 1000 ha)

Newfoundland & Labrador
Nova Scotia
Saskatchewan
British Columbia
Ontario
Quebec
New Brunswick
Alberta
Manitoba
Prince Edward Island

(Statistics Canada)
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 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.

Synchronization of plant needs with N availability.

Simple but elusive principle.

Sources
Genetic
Spatio-temporal
Variability
Rates
Nitrification 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
### Study 1: 2006 – 2008 (3 yrs)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable yield (Mg ha(^{-1}))</th>
<th>Specific gravity</th>
<th>NUE (kg tuber kg(^{-1}) N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>17.2c</td>
<td>1.070</td>
<td></td>
</tr>
<tr>
<td>150CAN</td>
<td>26.0b</td>
<td>1.070</td>
<td>55.3b</td>
</tr>
<tr>
<td>150PCU</td>
<td>29.3a</td>
<td>1.066</td>
<td>84.8a</td>
</tr>
<tr>
<td>200CAN</td>
<td>26.3b</td>
<td>1.070</td>
<td>44.6c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Goldrush</td>
<td>22.5</td>
<td>1.068</td>
<td>49.7b</td>
</tr>
<tr>
<td>Chieftain</td>
<td>26.8</td>
<td>1.070</td>
<td>73.5a</td>
</tr>
</tbody>
</table>

**ANOVA**

<table>
<thead>
<tr>
<th></th>
<th>Treatment (T)</th>
<th>Cultivar (C)</th>
<th>T x C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 0.001</td>
<td>0.14</td>
<td>0.46</td>
</tr>
</tbody>
</table>

Ziadi et al. (2011)
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.
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.
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
Study 2: 2008 – 2012 (5 yrs)

Total tuber yield

<table>
<thead>
<tr>
<th>Nitrogen fertilizer source</th>
<th>Control</th>
<th>AN</th>
<th>AS</th>
<th>PCU</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg ha⁻¹</td>
<td>10</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

 Marketable tuber yield

<table>
<thead>
<tr>
<th>Nitrogen fertilizer source</th>
<th>Control</th>
<th>AN</th>
<th>AS</th>
<th>PCU</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg ha⁻¹</td>
<td>5</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>
Study 2: 2008 – 2012 (5 yrs)

31% above normal rainfall (150 & 38% above in June and July, respectively).
In season NO$_3$-N leaching

2008

At 18 DAP
AN > AS > PCU

At 32 DAP
AN = AS > PCU

Days After Planting

NO$_3$-N (mg l$^{-1}$)
One-time application of PCU can reduce the risk of N leaching without affecting tuber yield and quality.
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.
Study 3: 2008 – 2010 (3 yrs)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total yield (Mg ha(^{-1}))</th>
<th>Mean tuber weight (g)</th>
<th>Specific gravity</th>
<th>Total N uptake (kg N ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21.2b</td>
<td>146b</td>
<td>1.092a</td>
<td>77b</td>
</tr>
<tr>
<td>Conventional</td>
<td>36.3a</td>
<td>180a</td>
<td>1.089ab</td>
<td>175a</td>
</tr>
<tr>
<td>Split</td>
<td>34.7a</td>
<td>177a</td>
<td>1.092a</td>
<td>171a</td>
</tr>
<tr>
<td>PCU</td>
<td>36.2a</td>
<td>185a</td>
<td><strong>1.087b</strong></td>
<td>190a</td>
</tr>
</tbody>
</table>

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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