Potential to optimise fertiliser N inputs based on soil N supply

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Horse & Jockey
**Introduction**

- Nitrogen (N) fertiliser is a key factor in achieving high levels of agricultural output.
- Large variability in optimum N application rates across soil types
- Current N recommendations do not account for soil N supply
  - “One soil fits all” approach
  - Fertiliser advice is demand driven (i.e. grassland stocking rate)
  - Risk of under- or over-supply of N fertiliser in many fields?
- A reliable, repeatable and economical soil N test could provide a basis for making soil specific N fertiliser recommendations.
- Potential to offset a proportion of the N fertiliser used on farms
Nitrogen use on Irish Dairy farms

• Simple farm N model

N Input  

\[ \text{N Fertiliser} \]

\[ \text{denitrification} \]
\[ \text{volatilisation} \]

N Output

leaching

• Teagasc National Farm Survey (NFS) 2009 & 2010
  – EU Farm Accountancy Data Network (FADN)
  – Specialist dairying systems (n=195)
    ➢ Excluded those importing/exporting organic manure

Buckley, Murphy & Wall,. 2013
**Nitrogen use on Irish Dairy farms**

Measurement Metrics

- **Farm-gate nutrient balance**
  - N Inputs – N outputs = N balance (kg/ha)
  - Indicator of potential N loss from the system

- **Nitrogen Use Efficiency**
  - N Outputs / N Inputs x 100
  - Indicator of agronomic efficiency in N use

*Buckley, Murphy & Wall, 2013*
## Nitrogen use on Irish Dairy Farms

<table>
<thead>
<tr>
<th>Nitrogen imports (kg ha(^{-1}))</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>% of total imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical fertiliser</td>
<td>154.9</td>
<td>60.7</td>
<td>10.2 - 436.7</td>
<td>85</td>
</tr>
<tr>
<td>Concentrate feedstuffs</td>
<td>23.1</td>
<td>12.9</td>
<td>2.6 - 98.82</td>
<td>13</td>
</tr>
<tr>
<td>Forage feeds</td>
<td>4.8</td>
<td>8.6</td>
<td>0 - 52.5</td>
<td>2</td>
</tr>
<tr>
<td>Milk replacer</td>
<td>0.003</td>
<td>0.01</td>
<td>0 - 0.2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total imports</strong></td>
<td><strong>182.8</strong></td>
<td><strong>68.1</strong></td>
<td><strong>13.7 - 473.7</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Nitrogen exports (kg ha(^{-1}))</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>% of total outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>29.2</td>
<td>11.1</td>
<td>4.0 - 62.7</td>
<td>74</td>
</tr>
<tr>
<td>Livestock</td>
<td>9.5</td>
<td>4.8</td>
<td>-3.6 - 26.1</td>
<td>24</td>
</tr>
<tr>
<td>Crop</td>
<td>0.7</td>
<td>3.7</td>
<td>0 - 32.0</td>
<td>2</td>
</tr>
<tr>
<td>Wool</td>
<td>0.01</td>
<td>0.06</td>
<td>0 - 0.7</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total N exports</strong></td>
<td><strong>39.4</strong></td>
<td><strong>13.1</strong></td>
<td><strong>8.1 - 75.52</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### N Surplus (kg ha\(^{-1}\))

- **143.4**
- Mean: 60.0
- Range: 5.6 - 419.3

### N use efficiency (%)

- **23.2**
- Mean: 8.2
- Range: 5.3 - 59.3

(N=195, populated weighted to 12,798)
Soil Nitrogen pools

- Total N concentration typically ranges from 2000 – 8000 kg/ha
Effect of N fertiliser on SOM turnover

SOM turnover (µg C/g soil/hr)

Time (weeks)

- High SOM soil planted
- High SOM soil planted + N fertiliser
- Low SOM soil planted
- Low SOM soil planted + N fertiliser

Murphy et al. 2014

The Irish Agriculture and Food Development Authority
Do soil N tests relate to grass N supply?

- Microcosm Studies conducted at Johnstown Castle

**Methods**

- Soil types: 28
- Placed into a controlled environment facility
  - Temperature: 15°C,
  - Relative Humidity: 80%
  - Daylight: 16 h
  - Moisture: 65% field capacity

- Grass harvests at 5 week intervals
  Grass DM yield, N content, N uptake measured

- Soil sampling at each harvest
  Soil mineral N, AI-7, ISNT and Total N & C measured

McDonald et al. 2014 J.Ag.Sc.
Production potential of grassland soils in Ireland

5 week grass growth interval in controlled environment

Dry Matter Yield (kg ha\(^{-1}\))

N uptake (kg ha\(^{-1}\))

Location Code (n = 28)
Mineralisable N vs. grass N uptake

Mineralisable N _ Illinois Soil N test (mg/kg)

Grass N uptake (kg/ha)

GR1 \( y = 0.09983x + 31.48 \)
\( R^2 = 0.27 \) \( P=0.0032 \)

GR2 \( y = 0.09983x + 16.53 \)
\( R^2 = 0.33 \) \( P=0.0009 \)

GR3 \( y = 0.09983x - 0.28 \)
\( R^2 = 0.35 \) \( P=0.0006 \)

The Irish Agriculture and Food Development Authority
Soil mineral N test vs. grass N uptake

Soil Mineral N _ Nitrate-N test (mg/kg) vs. Grass N uptake (kg/ha)

GR1: \( y = 27.46x - 25.84 \)  
\( R^2 = 0.82, P<0.0001 \)

GR2: \( y = 27.46x - 2.91 \)  
\( R^2 = 0.88, P<0.0001 \)

GR3: \( y = 27.46x - 0.27 \)  
\( R^2 = 0.57, P<0.0001 \)
What is the seasonal nature of soil N supply?

- **Two contrasting field sites**
  2. Johnstown Castle, Co. Wexford (JC): Moderately drained clay loam soil
Soil nitrate-N trends

Grass Harvest Dates

Nitrate-N (mg/kg)

Well – Drained_ zero N
Well – Drained_ 300 N
Mod – Drained_ zero N
Mod – Drained_ 300 N

N application
Potentially mineralisable N trends

Grass Harvest Dates

N application

Well – Drained_ zero N
Well – Drained_ 300 N
Mod – Drained_ zero N
Mod – Drained_ 300 N

ISNT-N (mg/kg)
Cumulative grass N uptake

Grass N uptake (kg/ha)

Rainfall (mm)

Well Drained Soil - Zero N
Well Drained Soil - 300 kg/ha N
Mod. Drained Soil - Zero N
Mod. Drained Soil - 300 kg/ha N
Rainfall

The Irish Agriculture and Food Development Authority
Nitrogen Fertiliser Use Efficiency (NFUE)

Apparent NFUE = Grass N uptake \((300\text{kg N ha}^{-1})\) – Grass N uptake (Control) \(\times 100\)
N fertiliser Rate (300 kg N fertiliser)

**Well Drained (Moorepark) Site**

\[
\text{NFUE} = \frac{636 - 263}{300} \times 100 = 124\%
\]

**Moderately Drained (Johnstown Castle) Site**

\[
\text{NFUE} = \frac{485 - 288}{300} \times 100 = 65\%
\]
Early Season N fertiliser use

Rainfall (mm) vs. Soil Temperature (°C) for Spring 2013

Soil Temp

Rainfall

January | February | March | April | May

Spring 2013

The Irish Agriculture and Food Development Authority
Nitrogen fertiliser in the soil

- Urea Hydrolysis
- Ammonium \((\text{NH}_4^+)\)
- Nitrification
- Nitrate \((\text{NO}_3^-)\)
- Plant Uptake
- Volatilisation
- Denitrification
- Leaching
Early Season N fertiliser use

- Zero N
- CAN 32 Kg N/ha
- Urea 32 Kg N/ha
- Foliar-N 15.4 Kg N/ha

Grass N uptake (kg/ha)

- 18th January
- 8th February
- 1st March
- 22nd March
- 5th April

The Irish Agriculture and Food Development Authority
Early Season N fertiliser use

Cumulative grass DM yield (kg/ha)

Fertiliser N Application

18th January  8th February  1st March  22nd March  5th April

Zero N  CAN 32 Kg N/ha  Urea 32 kg N/ha  Foliar-N 15.4 kg N/ha
Effect of fertiliser N type x application rate

Mean 4 harvests

Mean grass DM yield (kg/ha)

Control, CAN 0.5, CAN 1.0, Urea 0.5, Urea 1.0, Foliar 0.5, Foliar 1.0

Mean 4 harvests

The Irish Agriculture and Food Development Authority
N management tips for grassland this spring

- Plan N fertiliser strategy to have optimum grass covers at each stage of the season
- Grass growth will commence once soil temperature reaches ~5°C
- Apply 20-25 units in advance of expected stock turnout
- Delay application to fields with cold wet soils
- Replace N fertiliser with slurry on grazing fields early in the season
- Apply slurry for first cut silage in March/April
- Urea is a good source of N under moist soil conditions in spring
- Stay within total farm fertiliser allowance and spreading dates required under nitrates
Conclusions

- Irish soils have the capacity to supply high levels of N.

- Large variability exists between different soils types in terms of their soil N supply for grass growth.

- Scope to reduce N fertiliser rates without compromising grass DM yields on some soil types.

- Requirement for tools (such as soil N tests) to estimate soil N supply

- Potential to increase N use efficiency on farms by accounting for soil N supply in Irish grassland systems.
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