Modelling banana nitrogen losses

Using computer simulation modelling to examine nitrogen losses to water from banana production

Tony Webster | Jeff Daniels, John Hargreaves, John Armour

20 August 2014
IHC2014 Brisbane
The issue – why look at nitrogen losses

Twofold:
Economics and Environment.

Cost of fertiliser
• Low in high value crop, but not insignificant

World Heritage Great Barrier Reef
• Under threat from a number of fronts
• Anthropogenic N contributions (attributable to agriculture) is one
The issue – why look at the Banana industry

Nitrogen balance shows that inputs far out weigh exports

E.g. trial with 400 kg N/ha fertiliser exported 57 kg in harvested bunch and fruit

Uptake was 218 kg N/ha
11,000 hectares, predominantly located in the Wet Tropics

- High rainfall
- Short catchments
- Flood water has very short residence times
- Any N leaving farms likely to reach GBR lagoon
- Historically high N rates
- Large area, but not the dominant cropping landuse
- Groundwater losses linked to surface water
Measurements of nitrogen losses from banana

1995 – 1997 (Armour et al.)

<table>
<thead>
<tr>
<th>N Rate</th>
<th>0</th>
<th>400</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Loss</td>
<td>393</td>
<td>453</td>
<td>391</td>
</tr>
</tbody>
</table>

1994 (Prove et al.)

<table>
<thead>
<tr>
<th>N Rate</th>
<th>400-500</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Loss</td>
<td>10-221 (109)</td>
</tr>
</tbody>
</table>

2001 (Prasertsak et al.)

<table>
<thead>
<tr>
<th>N Rate</th>
<th>&gt;500</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Loss</td>
<td>165</td>
</tr>
</tbody>
</table>
Measurements of nitrogen losses from banana

• There are always issues surrounding measuring nitrogen losses
• Measurement is expensive, time consuming and often difficult
• Spatial variability in soils and climate
• Temporal variability in climate (and soil)

Therefore it can be difficult to extrapolate measurements from a few places (in space and time) across an industry.

It is also difficult to assess the impact of changing management.
Soils are spatially variable -

Catchment scale
Soils are spatially variable -

Paddock scale
Climate is temporally variable

Monthly rainfall - South Johnstone

Year
1999
2003

Rainfall (mm)
0
200
400
600
800
1000
1200
1400

1
2
3
Using modelling to overcome limitations of measurement

Modelling as a tool can be used to create ‘virtual experiments’

• A number of crop modelling environments exist
• Cropping systems models can add value
• Models are used to extrapolate measurements (either empirically or deterministic way)

• APSIM was used to develop a banana model
What is APSIM?

A highly advanced **agricultural systems model** created:

- to model system performance over time
- with an equal emphasis on crop and soil dimensions
- with a capability to deal comprehensively with management matters

Development and maintenance is underpinned by rigorous science and software engineering standards

*The soil provides a central focus, crops, seasons and managers come and go, finding the soil in one state and leaving it in another*
APSIM – Plug-in, Pull-out modularity

Simulating nitrogen losses from banana | Tony Webster | IHC2014 Brisbane
## APSIM Modules

### Plant / animal
- wheat
- sugarcane
- mungbean
- navybean
- maize
- lucerne
- fababean
- lupin
- cowpea
- pigeonpea
- Trees (Eucalyptus)
- Pastures
- Weeds (C<sub>3</sub>, C<sub>4</sub> grass, herb)

### Environment
- Met
- MicroMet
- SoilWat (tipping bucket)
- SWIM (Richard’s eqn)
- SoilN
- SoilP
- Solute
- SurfaceOrganicMatter
- Erosion
- SoilTemp
- WaterStorage

### Management
- Manager (sow, harvest, fallow, tillage)
- Irrigation
- Fertiliser
- Intercrop/mixture competition
APSIM: Nitrogen balance

- Fertiliser
- Denitrification
- Manure
- Crop Residue

Mineral Nitrogen (NH$_4$, NO$_3$, Urea)

Organic Matter

Leaching

Soil

Water balance

- Rainfall
- Transpiration
- Evaporation
- Irrigation
- Runoff

Root zone

Drainage
Modelling nitrogen losses from banana

Two climates – South Johnstone and Tully
Two soils – Ferrisol, Brown Dermisol
Multiple years
Different N management – 520, 350, 150 kg N/ha
Modelling nitrogen losses from banana

Two climates – South Johnstone and Tully
Two soils – Ferrisol, Brown Dermisol
Multiple years
Different N management – 520, 350, 150 kg N/ha

Planted November
Fertilised monthly
Same starting conditions (80 kg N/ha in soil)
1680 plants/ha
Leaching N losses reported
## Nitrogen leaching losses

<table>
<thead>
<tr>
<th>Climate</th>
<th>South Johnstone</th>
<th>Tully</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Dermisol (SJ)</td>
<td>Ferrisol</td>
</tr>
<tr>
<td>150N</td>
<td>96</td>
<td>245</td>
</tr>
<tr>
<td>350N</td>
<td>116</td>
<td>287</td>
</tr>
<tr>
<td>520N</td>
<td>145</td>
<td>350</td>
</tr>
</tbody>
</table>

### 2004

<table>
<thead>
<tr>
<th>Climate</th>
<th>South Johnstone</th>
<th>Tully</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Dermisol (SJ)</td>
<td>Ferrisol</td>
</tr>
<tr>
<td>150N</td>
<td>66</td>
<td>230</td>
</tr>
<tr>
<td>350N</td>
<td>75</td>
<td>267</td>
</tr>
<tr>
<td>520N</td>
<td>88</td>
<td>323</td>
</tr>
</tbody>
</table>

### 2010

<table>
<thead>
<tr>
<th>Climate</th>
<th>South Johnstone</th>
<th>Tully</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Dermisol (SJ)</td>
<td>Ferrisol</td>
</tr>
<tr>
<td>150N</td>
<td>65</td>
<td>82</td>
</tr>
<tr>
<td>350N</td>
<td>72</td>
<td>85</td>
</tr>
<tr>
<td>520N</td>
<td>78</td>
<td>131</td>
</tr>
</tbody>
</table>
Conclusions

• N losses from banana production have reduced with improved N fertiliser management practices over time
• Considerable temporal and spatial variability exists
• Modelling is a functional way of overcoming limitations of measuring N losses and assessing potential management practices
• Modelling as a tool can be used to extrapolate measurements to the whole industry
Thank you

Tony Webster
Research Agronomist

+61 7 4059 5002
tony.webster@csiro.au