AzoFert® : a decision support tool for fertiliser N advice based on a dynamic version of the predictive balance sheet method

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N-Pérennes : AzoFert® adaptation for perennial crops

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French History of Nitrogen Fertilisation

1969-2018: 50 years of N balance sheet method

1969: Publication of INRA method (INRA)
1978: Diffusion of N balance sheet method (ITCF)
1990: Local adaptation of the method (Agricultural Chambers)
2004: AzoFert® is born. Decision-support tool including dynamics simulation of soil N supplies (INRA, LDAR)
Since 2010: Developpment of dose calculation services (Agricultural Chambers etc...)

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ITCF: Institut Technique des Céréales et des Fourrages = Technical institut of cereals and fodders
INRA: Institut National de Recherche en Agronomie = National Institut of Agronomic Research
LDAR: Laboratoire Départemental d'Analyses et de Recherche = Departmental Laboratory of Analysis and Research

Source: Adapted from Meynard J-M. 2018. Colloque sur l'azote (AFA, Paris).
AzoFert®: agronomical innovations

• Based on a complete mineral nitrogen balance sheet: all balance sheet inputs and outputs are taken into account

• Approach by a dynamic simulation of soil nitrogen supplies as well as nitrogen mineralisation of various organic sources: integration of climatic data

• Availability of fertiliser nitrogen is estimated with: simulation of gas losses and microbial immobilisation

• Adapted to a large number of annual crops: when nitrogen requirements and cycle of development are known
AzoFert®: balance sheet equation

\[ \text{Rf} - \text{Ri} = (\text{M}'n + X + \text{Ap} + \text{Fns} + \text{Fs} + \text{IR}) - \]
\[ \text{N inputs} \]
\[ (\text{Pf} - \text{Pi} + \text{Ix} + \text{Gx} + \text{Lx} + \text{Gs} + \text{Ls}) \]
\[ \text{N outputs} \]

**Rf**: soil mineral N at close of balance sheet,

**Ri**: soil mineral N at opening of balance sheet,

**M’n**: net mineralisation from humus (Mh), crop residues (Mr), organic products (Ma), catch crops (Mci) and meadow (Mp) residues,

**X**: amount of fertiliser N,

**Ap**: N wet deposition,

**Fns**: non symbiotic fixation,

**Fs**: symbiotic fixation,

**Ir**: N irrigation contribution

**Pf**: total N uptake by crop at close of balance sheet,

**Pi**: N uptake by crop at opening of balance sheet,

**Ix**: fertiliser N immobilised,

**Gx**: fertiliser N lost at gas,

**Lx**: fertiliser N lost by leaching,

**Gs**: soil inorganic N lost at gas,

**Ls**: soil mineral N lost by leaching between opening and close of balance sheet
A dynamic simulation of soil N supplies

- Simulation of N supply during time from soil and various organic contributions:
  * crop residues
  * catch crops
  * organic products

Decomposition and mineralisation are expressed over time using « normalised time » integrating by decade the variations of temperature (T) and soil moisture (W)
Temperature (T) and soil moisture (W) functions

\[ \text{normalised day} = f(T) \times g(W) \]
Climatic data – Normalised time

• Climatic data for each decade: temperature, rainfall and evapotranspiration

• Temperature reference: 15 °C, moisture reference: water field capacity

Example in Laon (France, Aisne):
2nd decade of January: 2 normalised days
1st decade of July: 16 normalised days
Dynamic approach of nitrogen supply

- Previous crop harvest
- Sowing
- Crop residues management, catch crops, organic manure
- Soil inorganic N measurement
- Nitrogen fertiliser applications
- Opening of balance sheet
- Average climatic data
- Harvesting
N mineralisation of various organic sources

Mineralised N in kgN/ha

«Normalised » days

Vinasse

Catch crop

Wheat residues

Mineralised N in kgN/ha

Inorganic N pool sampling

Harvest

Vinassee

Catch crop

Wheat residues

Ma: Organic products N supply
Mci: Catch crops N supply
Mr: Crop residues N supply

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N-Pérennes : AzoFert® adaptation for perennial crops

• Currently no tool available for perennial crops

• Project originating from RMT Fertilisation & Environment (RMT F&E), funded by CASDAR (French Ministry of Agriculture)

• Prototype for vines and apple-trees
# Specificity of perennial crops

<table>
<thead>
<tr>
<th></th>
<th>Vine-growing systems</th>
<th>Fruit-growing systems</th>
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</thead>
<tbody>
<tr>
<td><strong>Opening balance sheet</strong></td>
<td>Budburst</td>
<td>Flowering</td>
</tr>
<tr>
<td><strong>End of balance sheet</strong></td>
<td>Veraison</td>
<td>Start of yellowing leaves</td>
</tr>
<tr>
<td><strong>Cover crop management</strong></td>
<td>Hypothesis: cover crop place is an isolated compartment and there is no interaction with the vine or fruit-growing systems</td>
<td></td>
</tr>
</tbody>
</table>
| **Estimations of N requirements** | Definition of N repartition on different compartments of vine established from literature | Apple trees: $80 + 0.6 \times \text{yield}$  
Peach trees: $90 + 1.3 \times \text{yield}$ |
| **Reserves**                   | Hypothesis of equality reserves between the start and the end of the annual cycle | Taken into account in the previous relation |
| **Leaves on soil**             | Taken into account of the % of leaves returned in the plot |                                              |
| **Vigor**                      | Not considered. We have to take it in the finish recommendation |                                              |
| **Planting density**           | Integrated indirectly in the calculation on the specific surface area |                                              |
| **Canopy management**          |                                                          | Not considered                               |
Future enhancements for N’Pérennes

• Take into account organic fertilizers for recommendation (organic agriculture)

• Make a driver tool, especially for fruit-growing systems

• Integrate peach-tree besides vine and apple-tree

• Finalize the tool