

AZOFERT®: A DYNAMIC DECISION SUPPORT TOOL FOR FERTILIZER N ADVICE ADAPTED FOR ORGANIC PRODUCTS AND CATCH CROPS

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The increasing demand for high quality crops (protein content of cereals, technological quality of sugar beet, nitrate rate of vegetables) and protection of the environment (minimising nitrate leaching and gaseous losses) on the one hand, the evolution of agricultural practises with increasing and diversification of organic applications on the other hand, require an adaptation of reasoning and a rigorous management of the N fertilization, as well as an evaluation of environmental impacts.

Materials and Methods

AzoFert® is based on a complete inorganic N balance sheet (Meynard et al, 1997). The following equation is used to predict fertiliser-N rates, expressing that the variation of soil inorganic N between opening and close of balance sheet equals the difference between N inputs and outputs:

$$Rf - Ri = (Mn + X + Ap + Fns + Fs + Ir) - (Pf - Pi + Ix + Gx + Lx + Gs + Ls)$$

With $Mn = Mh + Mr + Ma + Mci + Mp$

Rf: soil inorganic N at close of balance sheet (at harvest), **Ri**: soil inorganic N at opening of balance sheet (end of winter for winter crops, sowing for spring crops), **Mn**: net mineralization from humus (**Mh**), crop residues (**Mr**), organic products (**Ma**), catch crops (**Mci**) and meadow (**Mp**) residues, **X**: amount of fertilizer 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**: fertilizer N immobilised, **Gx**: fertilizer N lost as gas, **Lx**: fertilizer N lost by leaching, **Gs**: soil inorganic N lost as gas, **Ls**: soil inorganic N lost by leaching between opening and close of balance sheet.

AzoFert® integrates a dynamic simulation of soil N supplies (Machet et al., 2012). At the opening of the balance sheet (end of winter for winter crops, at sowing for spring crops), the soil inorganic N pool is measured at the rooting depth. In order to take into account the various contributions of crop residues, catch crops and organic products previously applied to the residual mineral N (varying with climate and characteristics of added organic matter), the decomposition of the different organic sources are simulated (using observed climatic data) from harvest of the previous crop, until the opening of the balance sheet. Decomposition is expressed over time using a “normalized time”, based on temperature (T) and soil moisture (W) functions:

$$\text{Normalized time}_{(\text{day } i, \text{day } j)} = S_{ij} f(T) * g(W)$$

Normalized time takes into account climatic variations and determines a potential rate of decomposition. From the opening of the balance sheet to the harvest of the crop, the subsequent net contribution of the organic residues or wastes and the net mineralisation of the humified organic matter are simulated using normalised days calculated from the past years mean climatic data of the area.

Results and Discussion

The decay of crop residues and organic amendments in the soil results in net mineralization or net immobilization of soil nitrogen. Each crop residue and organic product is characterised by a specific kinetic curve of decomposition according to N and C. The decay rate of these products depends on the nature of organic residues (chemical characteristics and C:N ratio) and temperature and moisture soil conditions (Nicolardot et al., 2001). AzoFert® estimates the direct effect of organic product or catch crop, using the curve of decomposition

Transposition in AzoFert® software is shown for vinasses and mustard catch crops residues, as indicated on figure 1. Thanks to this transposition in real time, it is possible to determine the mineralized part of products before the measure of soil mineral N pool at opening balance sheet, and the part which will be mineralized between soil mineral N measure and harvest (direct effect).

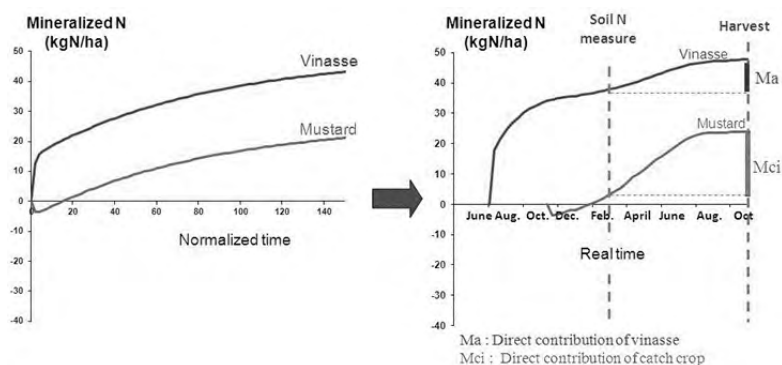


Figure 1: Curve of N decomposition in normalized and real time

A validation work was carried out by French Technical Institute for Sugar Beet (ITB) in order to test N recommendations. In the same farm, in deep loamy soils with frequent applications of organic products, there were annual (from 1992 to 1997) experiments on sugar beet, in order to know the optimal dose (table 1). Optimal dose varies a lot, from 0 to 180 kg N ha⁻¹, and AzoFert recommendation is close to optimal dose.

Table 1: Results of N annual experiments on sugar beet in the same farm

Experiment site	Soil inorganic N end of winter Kg N/ha	Humus mineralisation Kg N/ha	AzoFert dose Kg N/ha	Optimal dose Kg N/ha
Fieffes 1992	58	112	87	80
Fieffes 1993	79	131	0	0
Fieffes 1994	37	104	110	120
Fieffes 1995	33	84	165	180
Fieffes 1996	62	70	170	140
Fieffes 1997	99	139	40	0

Deep loamy soils with frequent applications of organic products

Conclusions

AzoFert® constitutes a decision support tool for fertilizer N advice based on a dynamic version of the predictive balance sheet method. The introduction of a dynamic simulation of soil N supplies allows its application to a larger range of cultural situations and pedoclimates. The integration of real data characterising the climate, soil type and cultivation practices leads to a significant improvement of N recommendations accuracy at field scale, especially with organic products and catch crops.

Machet JM, Dubrulle P, Damay N, Philippon E 2012. Plaquette de présentation de l'outil AzoFert®, English version. LDAR and INRA (Eds). 25 p

Meynard JM, Justes E, Machet JM, Recous S 1997. Les colloques de l'INRA 83, 183-200.

Nicolardot B, Recous S, Mary B 2001. Plant Soil 228, 83-103.