Crop covers and the nitrogen fertilisation of the following crop

Advantage to legumes

The introduction of the 4th action programme of the Nitrate Directive will result in an increase in the areas planted with cover crops in the period between main crops. Will such a practice affect the management of the nitrogen fertilisation of the following crop? An update from several noteworthy trials from those available.

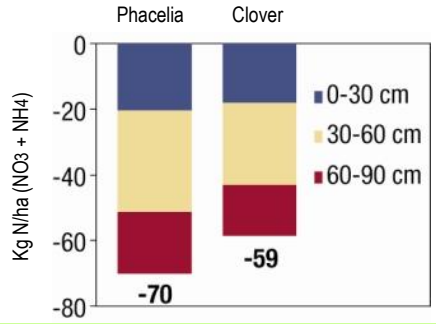
Cover crops based on legumes (pure or in a mixture) can be a useful way of increasing the nitrogen supply to the following crop.

The introduction of the 4th action programme of the Nitrate Directive will lead, among other things, to an increase in the areas planted with cover crops between the main crops. Currently most of these cover crops are non-leguminous species grown over a period of not more than 2-3 months. What effects will such a practice have on the management of the nitrogen fertilisation of the following crop? To turn a management issue into an agronomic asset, what technical changes should one introduce to maximise the nitrogen supply to the following crop? We give an update from notable examples taken from the available trials (*table 1*).

Table 1 : The three trials analysed

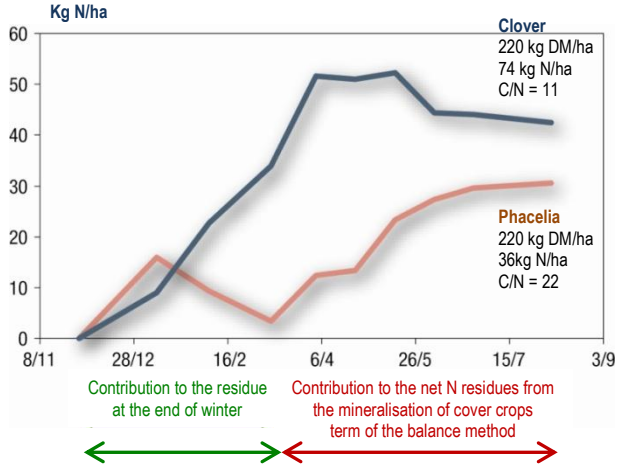
	Villexanton (41) 1991-1992 (ITCF – HYDRO AGRI)	Bignan (56) 1992-2003 (ARVALIS – Institut du vegetal)	Lyon St Exupéry (69) 1990-1991 (ARVALIS – Institut du vegetal)
Soil type	Clayey silt	Sandy silt	Deep gravel
Cover crops tested	Phacelia and clover	Italian rye-grass	mustard and crimson clover
Sowing date/destruction date	21-08-91 / 27-11-91		11-07-90 / 21-01-91
Yield of cover crops	Phacelia : 200 kg DM/ha ; 36 kg N/ha ; C/N = 22 Clover : 210 kg DM/ha . 74 kg N/ha ; C/N = 11	60 à 150 kg DS/ha ; 20 à 38 kg N/ha ; C/N : de 12 à 17	Mustard : 310 kg DM/ha. 86 kg N/ha . C/N =14 Clover : 520 kg DM/ha ; 171 kg N/ha ; C/N = 12
Layout	Monitoring the mineralisation of the cover crops under bare soil after destruction	Monitoring of soil nitrogen reserves, measurement of quantities of N absorbed by the crops (cover crop and winter wheat / forage maize)	Monitoring soil nitrogen reserves, measurement of quantities of nitrogen absorbed by the crops (cover crop and following maize)

The nitrogen trapping (NT) effect = difference in the soil mineral nitrogen compared with bare soil on the date of destruction of the crop covers *(Figure 1)*



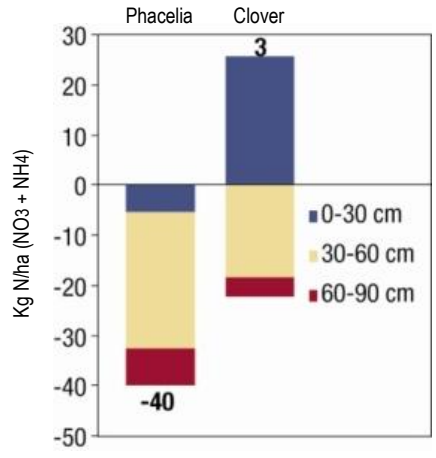
Although the legume (clover) has a « NT » effect, the effect is more marked for the non-legume (Phacelia).

Kinetics of mineralisation of cover crops after destruction *(Figure 2)*



More nitrogen is mineralised from clover than from Phacelia.

The end of winter residues (EWR) effect = difference in soil mineral nitrogen compared with bare soil at the date of measuring the EWR *(Figure 3)*



Phacelia has a negative effect on the end of winter residues compared with bare soil.

The dynamics of nitrogen in the soil in the period between crops

From their emergence until their destruction, cover crops take up nitrogen from the soil. This is the « nitrate trapping » effect (NT effect). By fixing nitrogen from the air, legumes, as well as taking up soil mineral nitrogen, accumulate atmospheric nitrogen. At Villexanton in 1991 (*figure 1*), the NT effect at the date of destruction of the cover crops was the most marked for the non-legume (Phacelia). Nevertheless the legume (clover) also had an effect by reducing the mineral nitrogen reserve (subject to leaching) compared with bare soil.

The crop covers based on legumes (pure or in a mixture) can have a NT effect, although it is smaller than that of non-leguminous species.

After destruction, the organic nitrogen contained in the residues of the cover crop is mineralised. The dynamics of mineralisation are determined by the quantities of nitrogen accumulated in the residues and by their nitrogen content (their C/N ratio). The quantities of nitrogen mineralised were greater from the clover than from the Phacelia (*figure 2*). In this trial, for the equivalent biomass produced, the legume provided a larger quantity of nitrogen potentially available for the following crop. A part of the N mineralised is « accounted for » in the measurement of the residue at the end of winter (« the EWR » effect of the cover); the other part is accounted for in the balance method (the net N residues from mineralisation of cover crops: MrCI term). At Villezanton (41) (*figure 3*), the effects of the two types of cover on the EWR were compared. The Phacelia reduced it strongly compared with the bare soil, whereas the clover was neutral, mainly because of an enrichment of the surface layer. The strong negative effect of the Phacelia is explained by the very small amount of leaching during the winter.

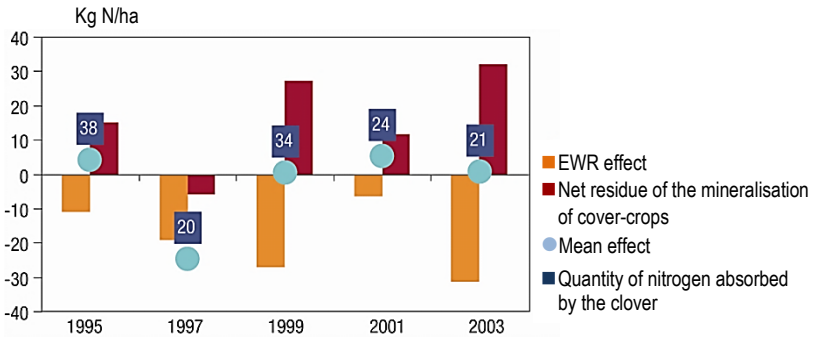
The nitrogen corresponding to the quantities trapped and only fractionally returned later by the Phacelia was not « lost » by the bare soil. The quantities of nitrogen to take into account in the MrCI term (net N residues from the mineralisation of cover crops**)** (*figure 2*) are about 20 kg N/ha for both cover crops. By combining the two terms, one obtains for this specific case a positive « fertilisation » effect of clover of 20-25 kg N/ha, and a negative one of about -20 kg N/ha for the Phacelia.

In the balance method, the quantities of nitrogen to take into account are about 20 kg N/ha for both cover crops.

These results explain the consequences of the mineralisation of the organic nitrogen of the residues of the crop covers:

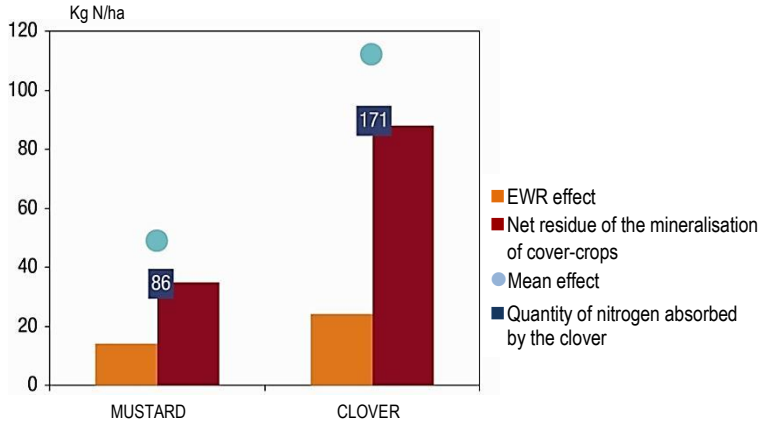
- The restitution is quite rapid and depends on the quantities and concentration of nitrogen in the cover crop.
- A major part of the quantities mineralised contributes to the EWR. The positive or negative effect of the crop cover on this index depends, in part, on the ratio of the quantity of nitrogen absorbed by the crop cover coming from the soil and the quantity of nitrogen lost by leaching from bare soil. With early destruction in November, much of the nitrogen mineralised is usually already accounted for in the EWR measured in February-March; hence the importance of measuring the EWR in the cropping systems, including the cover crops.
- Another part of the quantities mineralised contributes to the nitrogen supplies after the measurement of the EWR (the MrCI term). It depends on the time between the date of destruction of the cover crop and the date of measurement of the residue. With destruction in November and EWR measurements made in February-March, the remainder of the nitrogen supply still to be mineralised during the active phase of absorption by the following crop is quite often less than the quantities found in the soil mineral nitrogen reserve at the end of winter. Mean values were given in n° 357 of *Perspectives Agricoles* (June 2009). For the usual cultural practices they range from 0-30 kg N/ha.

Effect of a Italian rye-grass cover crop between a wheat and a maize crop on the nitrogen supply of the maize (*Figure 4)*



Although the cover crop supplies significant amounts of nitrogen to the maize after the measurement of the EWR, this surplus is compensated for by a reduction in the EWR.

Effect on the nitrogen supplies of maize of a cover crop of mustard and of crimson clover *(Figure 5)*



The trial at Lyon St Exupéry illustrates the yield performance which can be expected in terms of nitrogen supply to the yield performance following crop if the leguminous cover develops well and if it is not destroyed too soon.

These results teach us two things:

- In spite of exceptions in some years (with high winter leaching for example), a non-leguminous cover crop cannot be regarded as a means of increasing the nitrogen supply to the following crop over the short / medium term. Recent results show a long-term effect, but any relationship with the yields of the crops is still being studied.
- By accumulating large quantities of nitrogen while not obtaining it only from the soil and by returning them rapidly, leguminous cover crops (pure or in a mixtures) can constitute a valuable means of increasing the nitrogen supplies to the following crop.

Quantifying the effects of cover crops on the nitrogen supply to the following crop: the example of maize.

For non-leguminous cover crops, the long-term trial of Bignan (56) *(figure 4)* illustrates the conclusions from most experiments of this type : the insertion of a non-leguminous cover crop has a neutral effect in the short or medium term on the nitrogen fertilisation of the following crop. Although the cover crop supplies significant amounts of nitrogen to maize after the measurement of EWR (MrCI term of 15-30 kg N/ha), this surplus supply is on average compensated for by a reduction in the EWR (of 10-30 kg N/h a).

Of course this long-term trend masks the year-to-year variability which necessitates taking account every year of the presence of the cover crop in the calculation of the amount of nitrogen to apply to the following crop.

In most of the experiments, the insertion of a non-leguminous cover crop has a neutral effect in the short or medium term on the nitrogen fertilisation of the following crop.

For leguminous cover crops, the trial at Lyon St Exupéry in 1991-1992 *(figure 5)* illustrates the yield performance to be expected if the cover crop develops well and if it is not destroyed too soon. In this trial there was a great deal of winter N leaching, which also explains the good performance of the mustard cover crop.

To convert an administrative hindrance into an agronomic asset, what technical changes must one introduce to maximise the nitrogen supply to the following crop ?

The introduction of the 4th action programme of the Nitrate Directive will lead, among other things, to an increase in the area planted with cover crops in the interval between main crops.

From their emergence to their destruction, the NT effect at the date of destruction of the cover crops is most marked for the non-legume (Phacelia) than for the legume (clover).

tillage (the need to plough at the start of winter on certain soils; the difficulty in planting the crop in the spring without ploughing on top of a cover crop destroyed late etc.) and due to the technical difficulties of destroying a well-developed cover crop late, with legal restrictions on the use of complete herbicides for this purpose.

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Towards a change in cultural practices?

Present –day « typical » cultural practices including cover crops cannot assure a surplus of nitrogen supplies to the following crop over the short / medium term, mainly because the species used are not leguminous (they are usually crucifers or grasses). If the objective is to make use of the cover crops to economise on nitrogen mineral fertilisers, it is necessary to sow leguminous cover crops (pure or in mixtures according to local legislation). From this point of view, one has to consider three important aspects of the cultural practices:

Present cultural practices of inserting a non-leguminous cover crop cannot be regarded as a means of increasing the nitrogen supply to the following crop in the short/medium term

- **the choice of species** : the species currently available were not selected for their capacity to grow in a period between crops (i.e. late summer-autumn). Work in progress on this aspect should result in finding species (and indeed varieties) most suited for this climatic niche.

- **sowing date** : as a general rule, by comparison with a crucifer or a grass, a legume needs more accumulated heat units to reach a given biomass. Sowing therefore needs to be very early (early August in many regions), which poses problems of quality of emergence and of the early growth phase, due to the frequent lack of rain at this time of year. Added to this, the early occupation of the soil can lead to difficulties in weed management in the cover crop (perennials, regrowth etc).

- **the date of destruction** : even by using a legume of suitable growth (at least 200 kg DM/ha), if the destruction has taken place early (November), only part (often a minority) of the nitrogen supply will coincide with the active phase of absorption of the following crop. Most of the nitrogen mineralised will usually be found in the EWR.

The optimisation of the returns to the following crop should no doubt be a matter of later destruction of the leguminous cover crop. This point is particularly tricky, both because of problems of soil

The choice of species, the sowing date and the date of destruction should be taken into account if one wants the cover crop to have a positive effect on the fertilisation of the following crop.