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How to optimize ecosystem services of cover crops while reducing their cost?

A case study in Northern France

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Introduction

Cover-crops have become mandatory in several vulnerable agricultural areas in Europe to reduce nitrogen leaching and limit soil erosion. Nevertheless, they represent a cost for farmers who would like to optimize their use. This study aims to identify, in cover crop management, the practices to be optimized in order to minimize nitrogen leaching, other ecosystem services and costs.

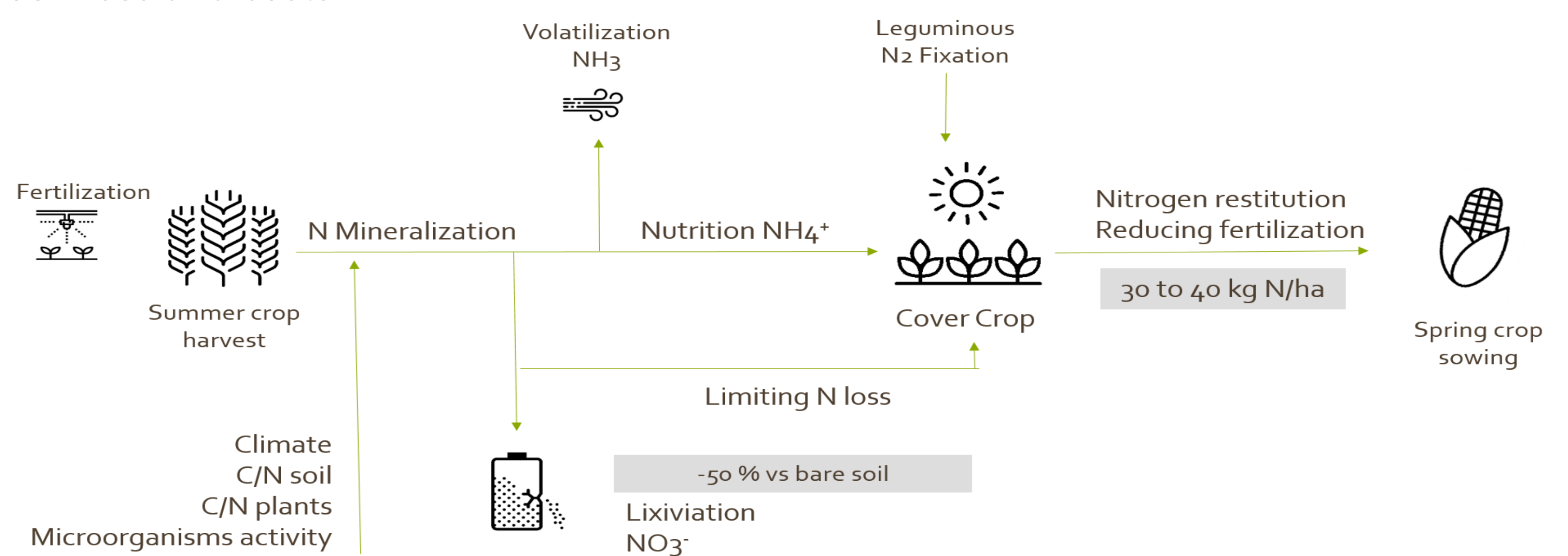


Figure 1 Nitrogen cycle with cover crop and expected effects (INRA, 2012 ; Justes et al., 2012 ; ARVALIS, 2011)

Main hypothesis:

- The soonest is the cover-crop sowing date the highest is the biomass produced
- The highest is the number of species in the cover crop mixture the highest is the biomass
- The highest is the biomass the highest is the N recovered
- The highest is the cost the highest is the biomass produced

Materials and Methods

The study was conducted between 2018 and 2020 in 100 fields from 15 arable farmers in the Oise region (Northern France), situations differ on soil types, cropping systems and species mixtures of cover-crops. Each field was managed according to the farmer's cropping system, leaving an uncropped part as control. Farmers were interviewed to survey its practices on each cover-crop field. Some register their costs (9 parcels) and the time to manage cover crops.

The cover-crop growth was followed from September to December: plants/m², species (weeds and cover crops), biomass and photos at several stages, N content both in biomass (weeds and cover crops) and soil (beginning and end of the winter).

To identify the best sowing and destroying dates and model the impact of the N delivered by the cover crop to the following spring crop in terms of N economy, two cover crops species were simulated by STICS in different soil types * 9 climatic years (2005-2014) from the Beauvais meteorological station.

Results

Results showed that, in 2018 & 2019, potential cover crops **biomass** was generally not reached (maximum 2.5T DM/ha) (Fig. 2). To reach this threshold at least 1200°C.day from sowing and 50 plants/m² density were required. We also observed that this density was reached more often with 3 species in the mixture.

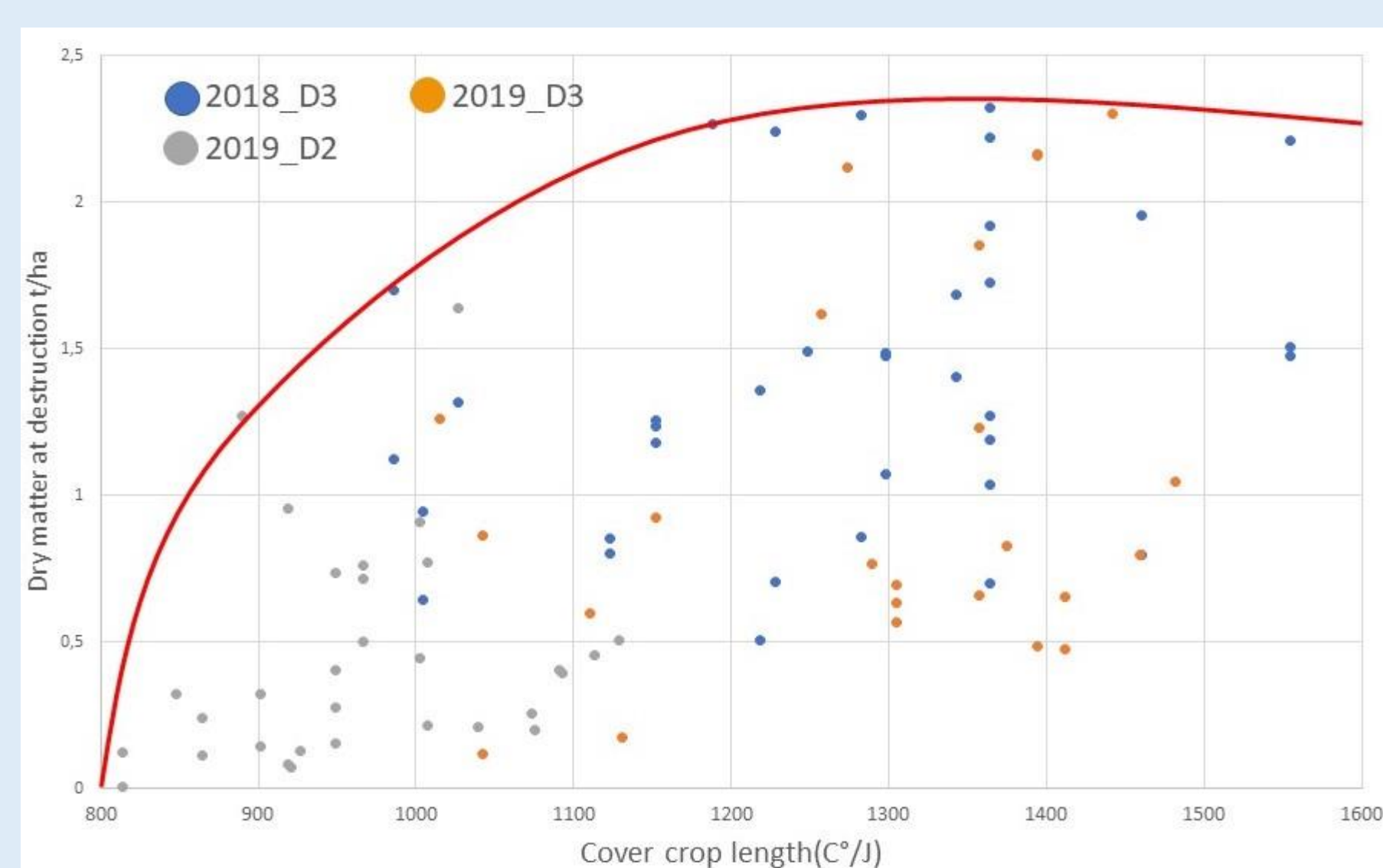


Fig. 2 Relation between cover crop length and biomass produced during two growing seasons 2018 & 2019

different horizons was reduced with the presence of cover crop compared to a bare soil (Fig.4) Moreover, the highest was the cover-crop biomass and the soonest was obtained the lowest was the infestation by weeds.

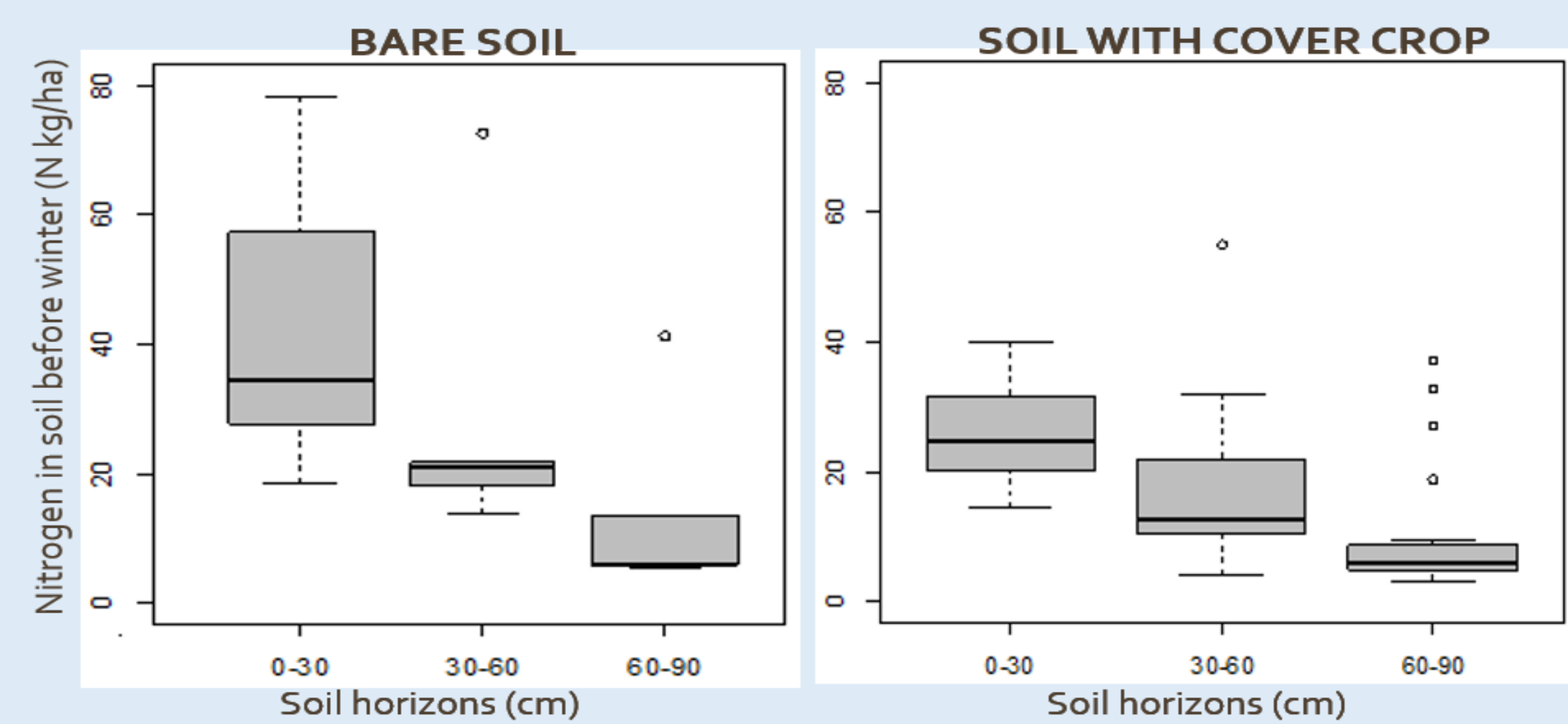


Fig. 4 Boxplots of Nitrogen in soil before winter in three soil horizons in bare soils (5 parcels) and with cover crops (23 parcels)

Simulation showed (Fig. 3) that leaching was reduced with early cover crop sowing in deep soils, destruction date have less impact on leaching.

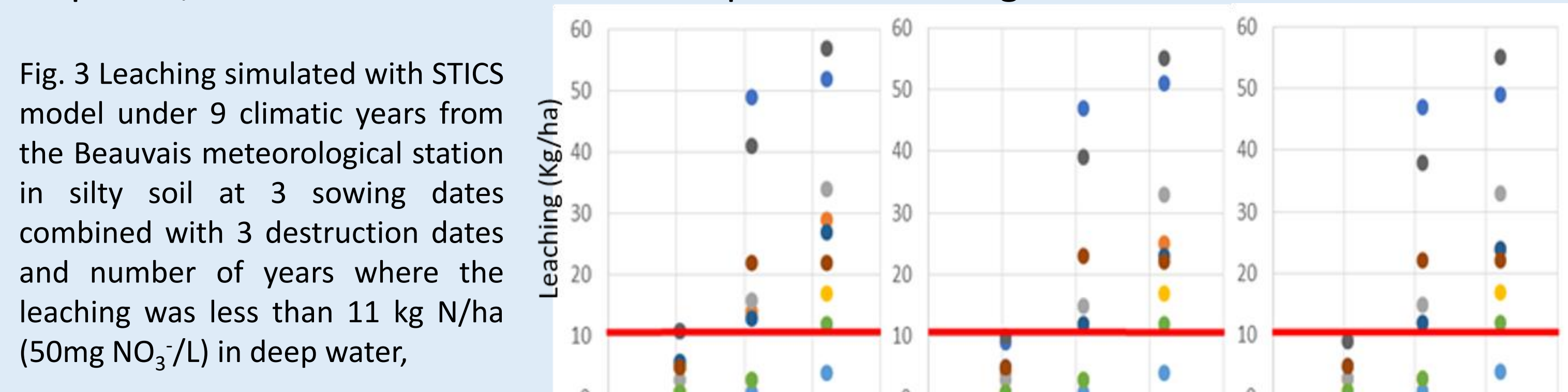


Fig. 3 Leaching simulated with STICS model under 9 climatic years from the Beauvais meteorological station in silty soil at 3 sowing dates combined with 3 destruction dates and number of years where the leaching was less than 11 kg N/ha (50mg NO₃⁻/L) in deep water,

Sowing date	20/07	10/08	01/09	20/07	10/08	01/09	20/07	10/08	01/09
Destruction date	01/11			01/12			15/01		
Acceptable years	7/9	3/9	1/9	9/9	3/9	1/9	9/9	3/9	1/9

Soil **nitrogen** availability was not the limiting factor to cover crop growth. The highest is the cover crop biomass, the highest is the nitrogen recovering and providing to the next spring crop. The risk of leaching was reduced as long as the Nitrogen content in the

The use of variable cover-crop mixture and sowing techniques induced a large variable **costs** range, from 40€/ha to 174€/ha and even higher (Fig. 5). Cover crops biomass was not significantly different between techniques showing that maximization of ecosystem services, such as nitrogen retrieving, soil C enrichment or again weeds limitation from cover-crop, does not imply increasing seeds and sowing costs.

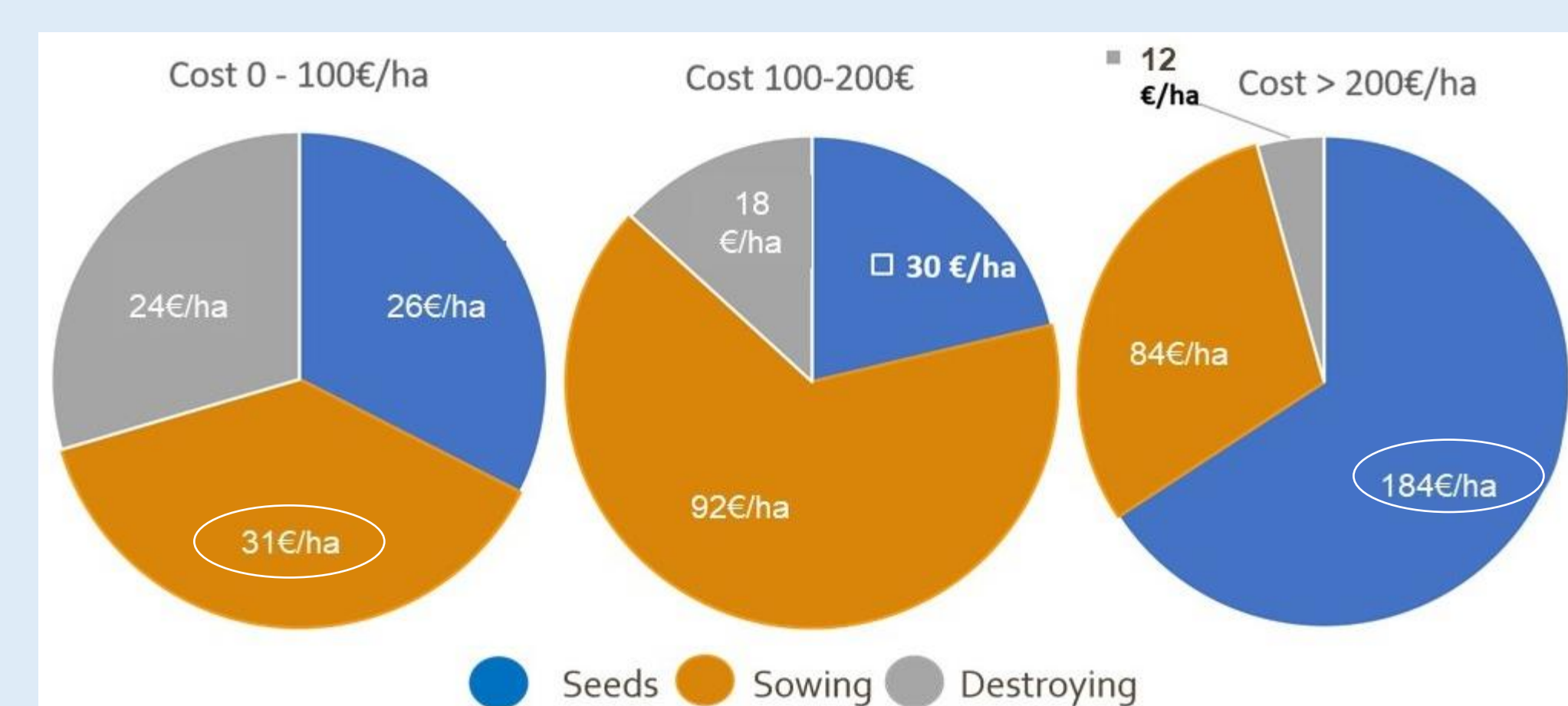


Fig. 5 Distribution of costs in function of the total cover crop cost, data from a sample of 9 parcels (*exceptional species mixture of 10 species)

Conclusions

According to those results, in Northern France arable systems, sowing as soon as possible (for minimum 1200°Cj) should be recommended to maximize environmental benefits of cover crops such as reducing leaching and weeds development and sowing 3 different species to ensure a minimal number of plants/m² while increasing seeds and sowing costs has showed no impact on biomass quantity.