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## **Crop residue management and N<sub>2</sub>O emissions: is it worth worrying? A 12-years experiment on arable cropping system in northern France**

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# Crop residue management and N<sub>2</sub>O emissions: is it worth worrying?

## A 12-years experiment on arable cropping system in northern France

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### Introduction

Carbon storage in agricultural soils might help to reduce our current excess atmospheric carbon while improving soil quality.

Attempts at increasing soil carbon often involve promoting residue restitution, i.e. the return of organic matter to the soil after harvest

of a cash-crop or destruction of a cover-crop. This practice might lead to greater nitrous oxide (N<sub>2</sub>O) emissions. N<sub>2</sub>O is a greenhouse gas with a 273 times stronger global warming potential than carbon dioxide and the single greatest ozone-depleting substance. Recent meta-analysis on N<sub>2</sub>O emissions during crop residue decomposition shows high-unexplained variability and a lack of long-term data on interactions between residue management and other agricultural practices.

### Objectives

What is the relative contribution of crop residue management to N<sub>2</sub>O emissions?

Using a 12-years field experiment and statistical models,

1. identify key variables driving N<sub>2</sub>O emissions and,
2. assess the relative importance of different crop residue management practices, i.e. tillage, biomass (quantity, carbon and nitrogen content), on N<sub>2</sub>O emissions, compared to other known drivers such as nitrogen fertilization or soil water content.

### Materials & Methods

We used the ACBB long-term experiment located in northern France, cf. Table 1. The soil is a deep silt loam, with 9.8 g.kg<sup>-1</sup> of organic carbon and a pH of 7.8.

Table 1: the eight experimental treatments of SOERE ACBB

Treatment	1	2	3	4	5	6	7	8
Plowing	✓	✗	✗	✓	✓	✗	✓	✓
Exportation of cash crop residues	✗	✗	✓	✗	✗	✓	✗	✗
Mineral N (% of ref. dose)	100%	100%	100%	35%	35%	100%	0%	0%
Legumes' frequency	low	low	low	low	high	low	low	high
Perennial crops within succession	✗	✗	✗	✗	✗	✓	✗	✗
Chemical protection	✓	✓	✓	✓	low	✓	✗	✗



N<sub>2</sub>O emissions have been measured daily since 2011 with automatic chambers, cf Fig 2. and are summarized at the scale of restitution cycles, cf Fig. 3.

Fig. 2: the automatic chambers system measures N<sub>2</sub>O emissions

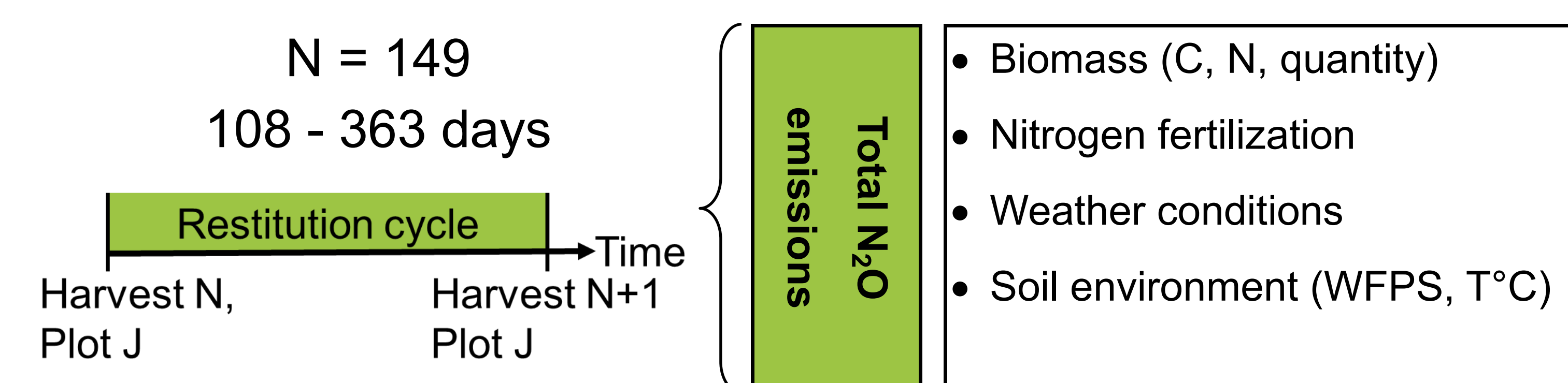


Fig. 3: spatiotemporal scales and variables of each individual in the analysis

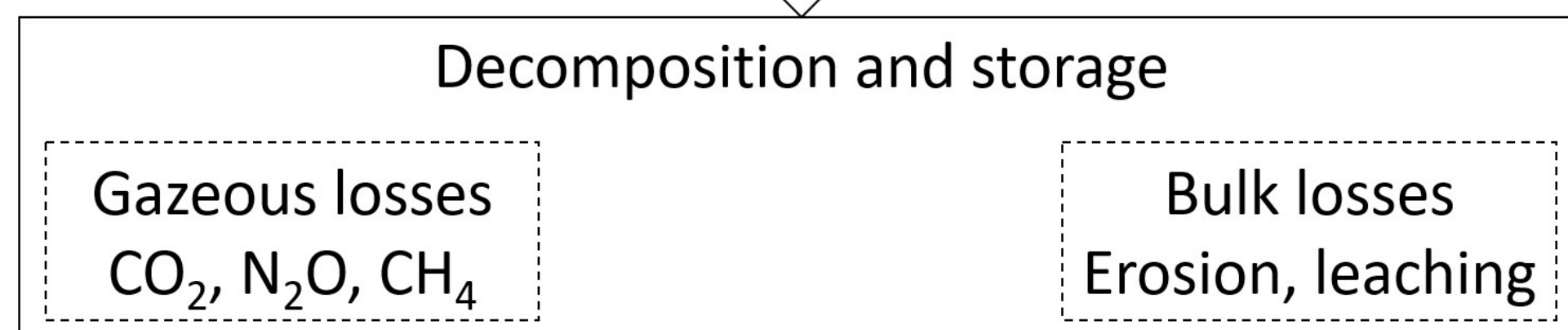


Fig. 1: crop residue managements decomposition, storage and N<sub>2</sub>O emissions

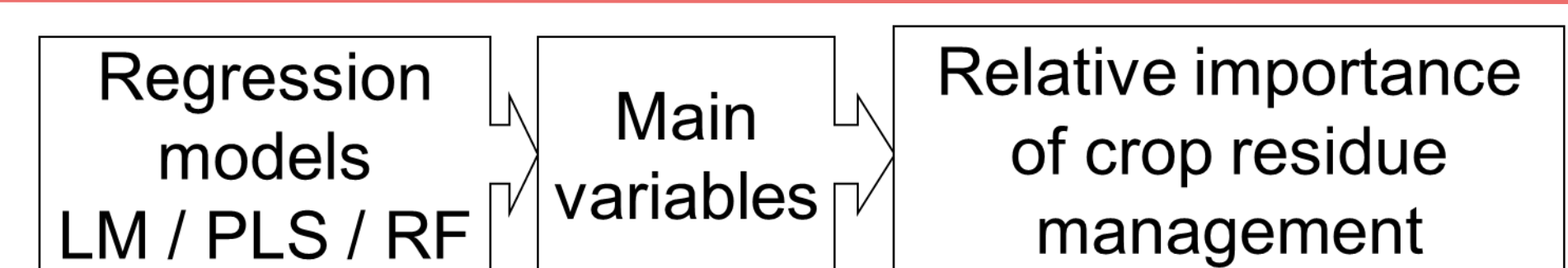


Fig. 4: general workflow to reach the objectives

### Results & discussion

Visual assessment, such as the one in Fig 5, of the relationship between N<sub>2</sub>O and all variables, gives an a priori indication of key drivers for the LM.

PLS and RF models are trained using the entire dataset.

#### Abbreviations:

LM: linear model

PLS: partial least square

RF: random forest

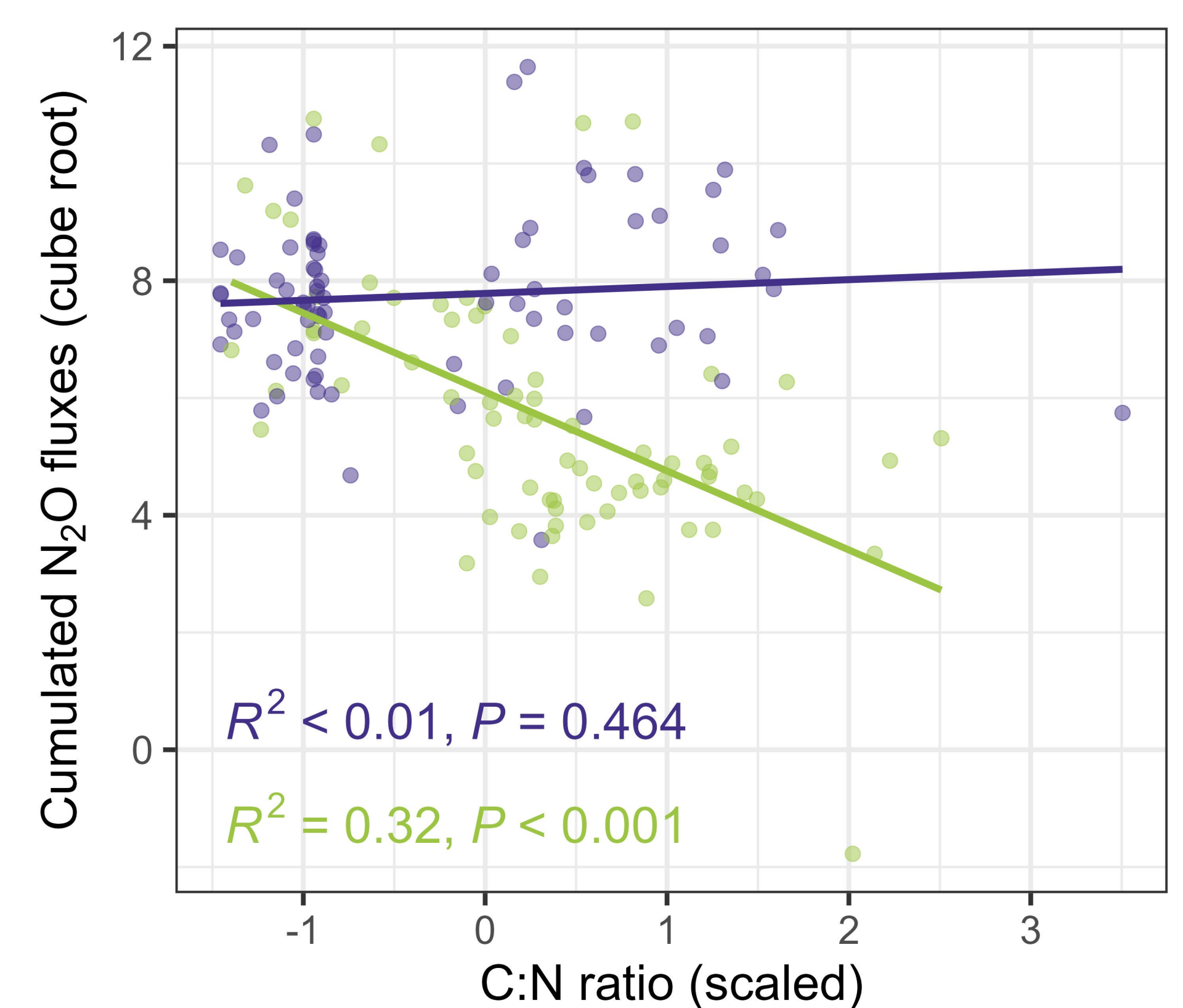


Fig. 5: visual exploration, here illustrating the interaction between C:N ratio and cumulated rainfall

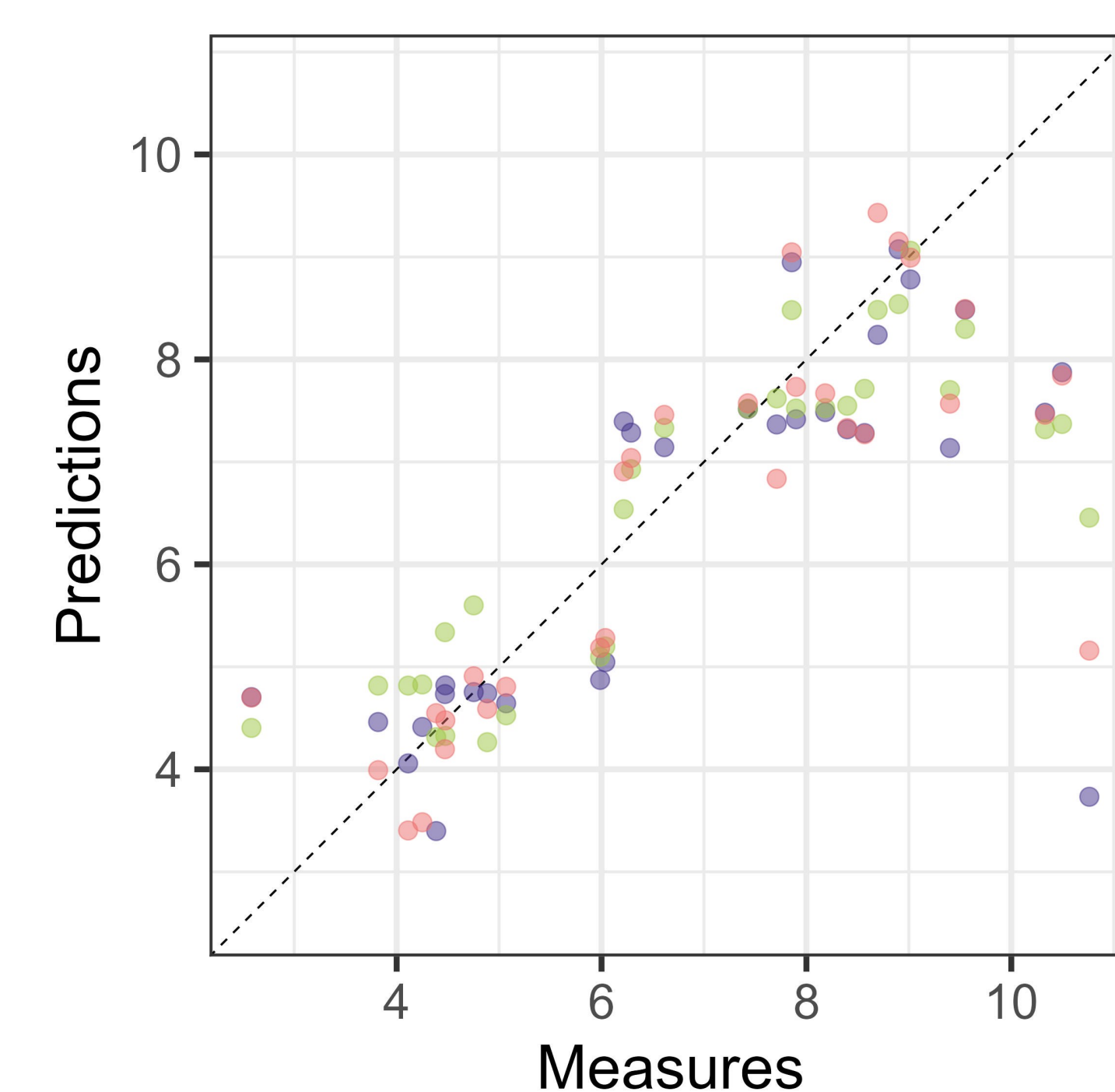


Fig. 6: models' predictions of cumulated N<sub>2</sub>O fluxes (cube root) using test dataset.

The three tested models perform similarly on a test dataset (20% of the full dataset sampled), cf Fig. 6.

The analysis of these models give indications about the hierarchy of the drivers and the contribution of crop residue to N<sub>2</sub>O emissions, cf Table 2.

Table 2: variable importance assessed on training dataset

Method	Importance of variables
LM	Cum. Rain. > C:N ratio ~ N Ferti.
RF	Cycle length ~ Cum. Rain ~ C:N ratio ~ N ferti.
PLS	Cycle length ~ Cum. Rain ~ N ferti. >> C:N ratio

- Cum. Rain., Cycle length and N Ferti. are the main influential variables.
- C:N ratio is the only variable directly related to residue in this list.
- None of the Soil-related or tillage-related variables are identified as "important" - which is surprising for the WFPS-related variables.
- Results are consistent with existing literature.

### Conclusion & perspective

Crop residues and related management, within this pedoclimatic context, impact N<sub>2</sub>O emissions through C:N ratio, when cumulated rainfall is low. Cumulated rainfall, cycle length and mineral nitrogen fertilization are the main drivers of N<sub>2</sub>O

emissions. Soil water content, surprisingly, is not a driver of N<sub>2</sub>O emissions here. This work suggests that it is possible to aim for carbon storage, using crop residue, without causing extra N<sub>2</sub>O emissions, especially if the C:N of the latter is high.