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► To cite this version:

Katja Klumpp, Tiphaine Tallec, Franck Poly, Olivier Darsonville. How defoliation frequency acts on N₂O emission in grasslands?. EmiLi 2012 International Symposium on Emissions of Gas and Dust from Livestock, Jun 2012, Saint-Malo, France. pp.17. hal-02811419

HAL Id: hal-02811419

<https://hal.inrae.fr/hal-02811419v1>

Submitted on 6 Jun 2020

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How defoliation frequency acts on N₂O emission in grasslands?



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INRA, Grassland Ecosystem Research, Clermont Ferrand



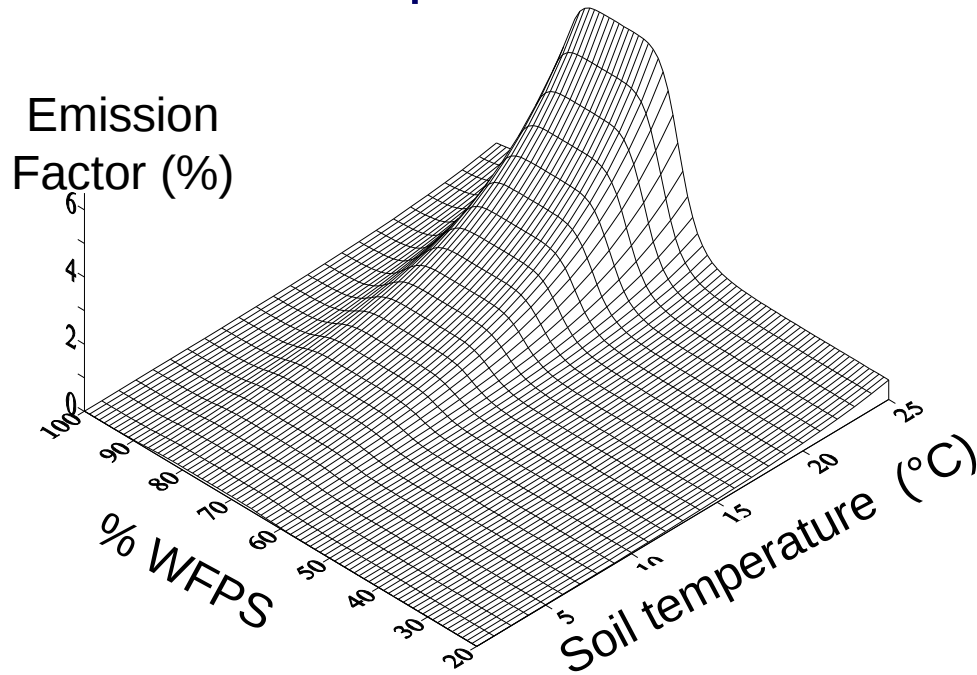
Context

- In agricultural sector, 46% of N_2O is emitted by soil through microbial activity: denitrification and nitrification (IPCC 2007).
- Global N_2O emissions are estimated to increase at a rate of 0.25% per year (IPCC, 2001)
- Soil management strategies may reduce emissions by 10 to 30%.

Grassland : at local scale N₂O emissions depend on

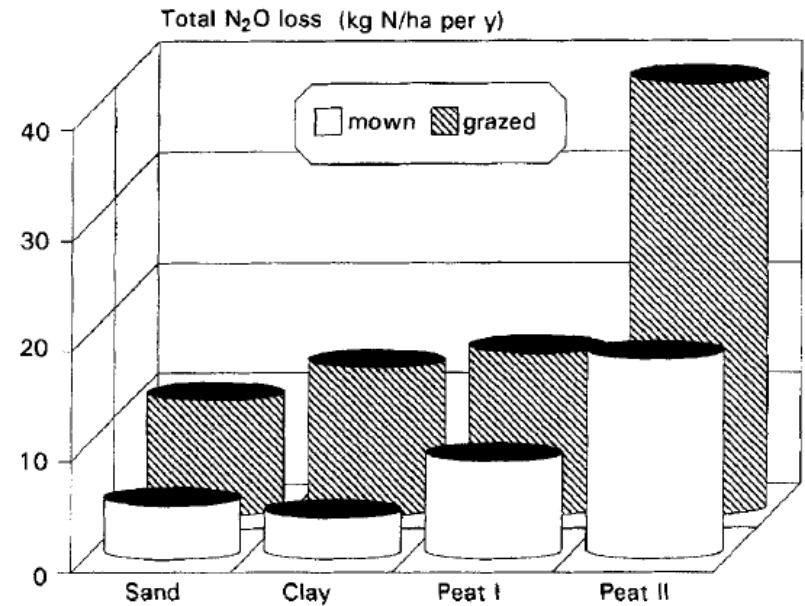
Environmental parameters and management

N supply, water filled pore space and soil temperature



Flechard et al. 2007 AGEE

Soil texture and management

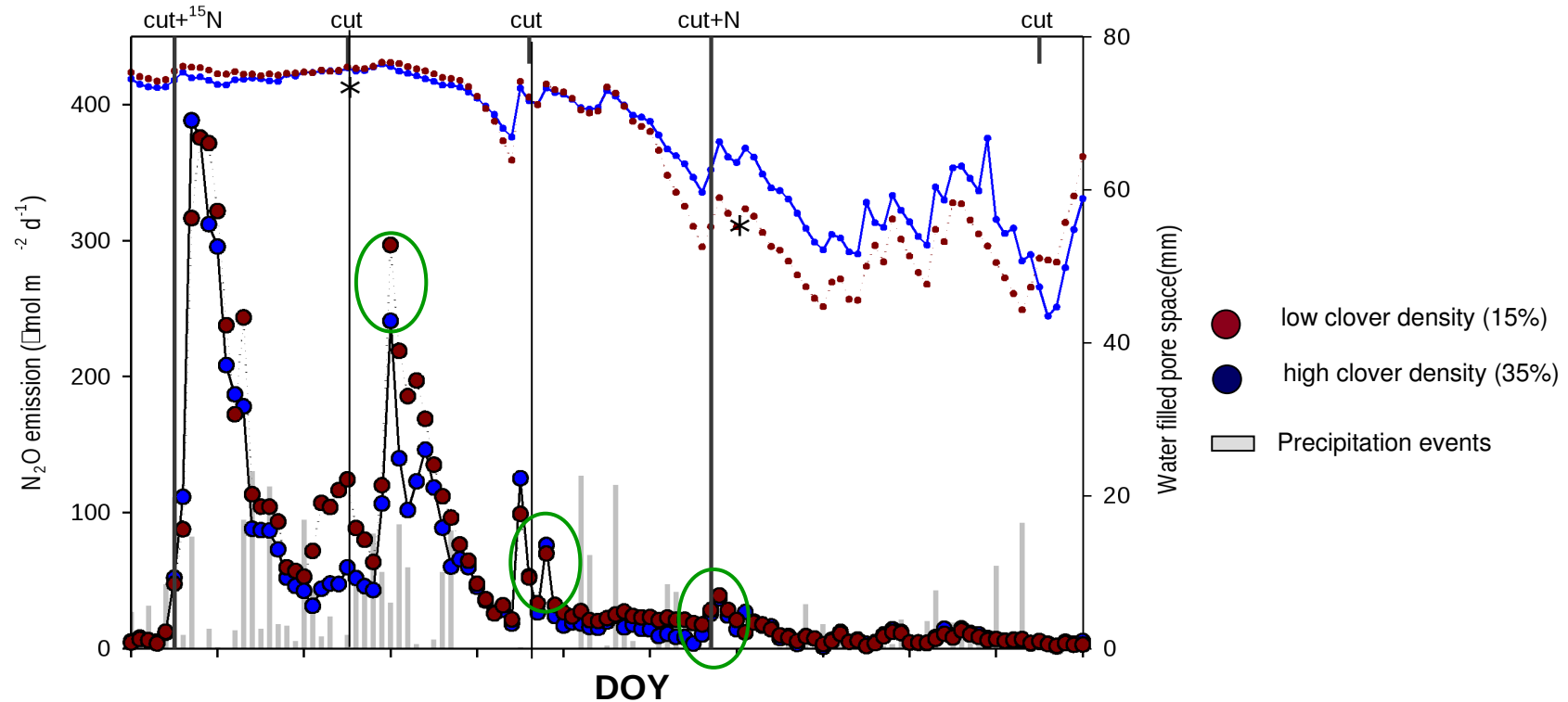


Velthof et al. 1996

Grassland : N₂O emissions depend on

Management and community structure

- Clover density and defoliation

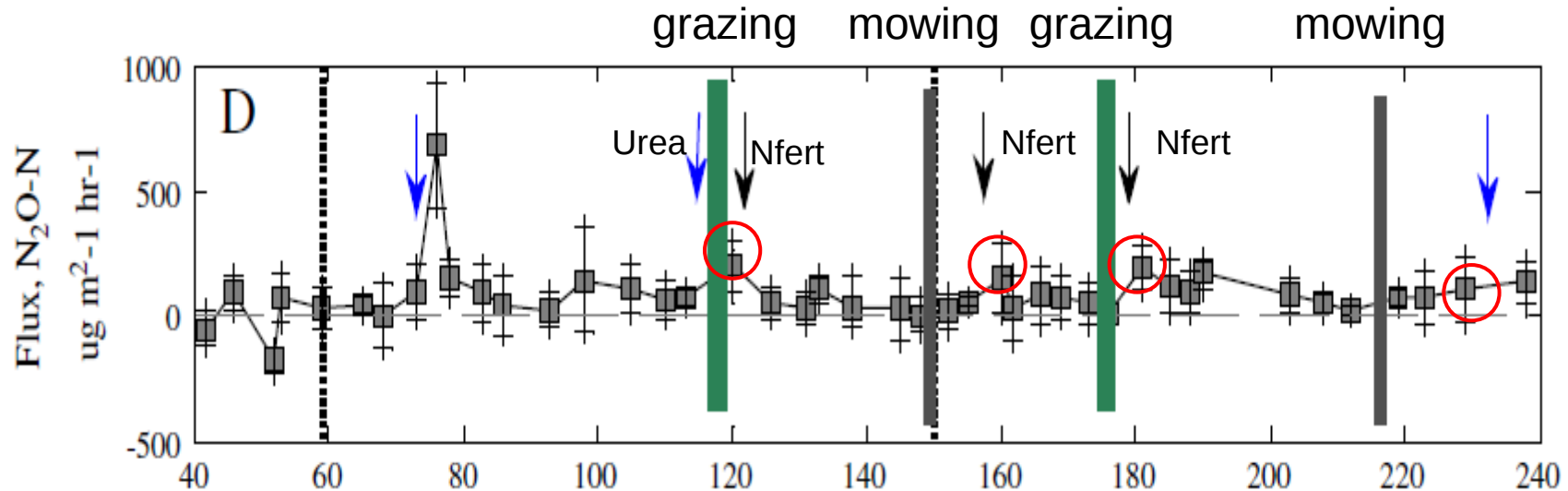


- N₂O emissions ↗ with **low clover** content
- competition plant/microbs for N depending on clover density
- N₂O emissions peak at after cuts

Grassland : N₂O emissions depend on

Management and N supply

- Grazing and mowing events and N supply



However, N₂O emissions are difficult to ascribe to defoliation events as other variables favouring emissions coincident (e.g. T_{soil}, WFPS, Nfert).

Grassland : N₂O emissions depend on

Management and nutrient availability

•C supply/availability

Denitrification-derived N₂O is triggered by organic matter with high labile C content (Senbayram et al. 2012)

Cutting-induced flushes in plant rhizodeposition and soil C availability may modify microbial activity (Ostle et al. 2007).

OBJECTIVES

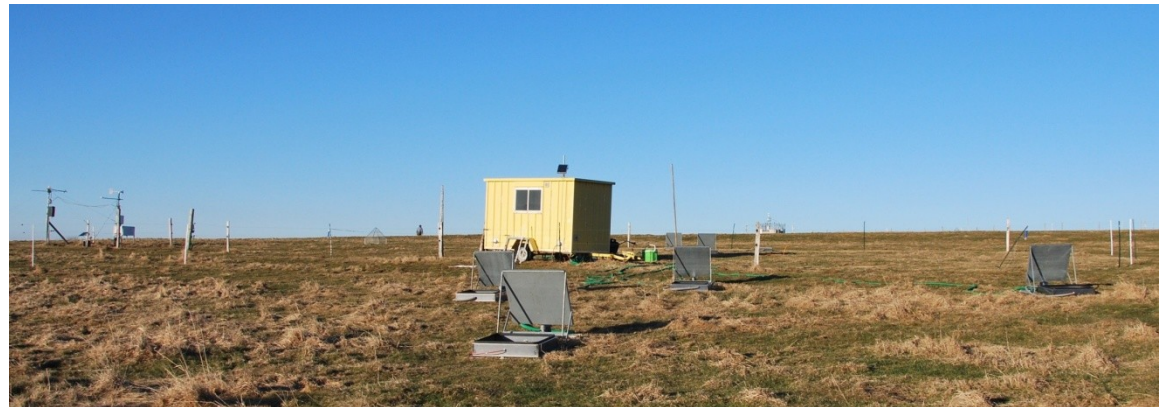
In a field experiment we tested following hypothesis

- (i) High defoliation frequency will increase N₂O emissions (ext vs int) and
- (ii) High defoliation enhances denitrifier activity by an potential increase in labile C (i.e. rhizodeposition (exudation, roots death) for microbes.

Permanent upland grassland site F-Laqueuille

Alt. 1050m, mean T 8°C, 1000mm

8 automated chambers +IRGA to measure continuously (6times d⁻¹) N₂O, H_{soil} and T_{soil}



Management

1.2 LSU ha.yr⁻¹

210 g N ha.yr⁻¹ (3 splits)

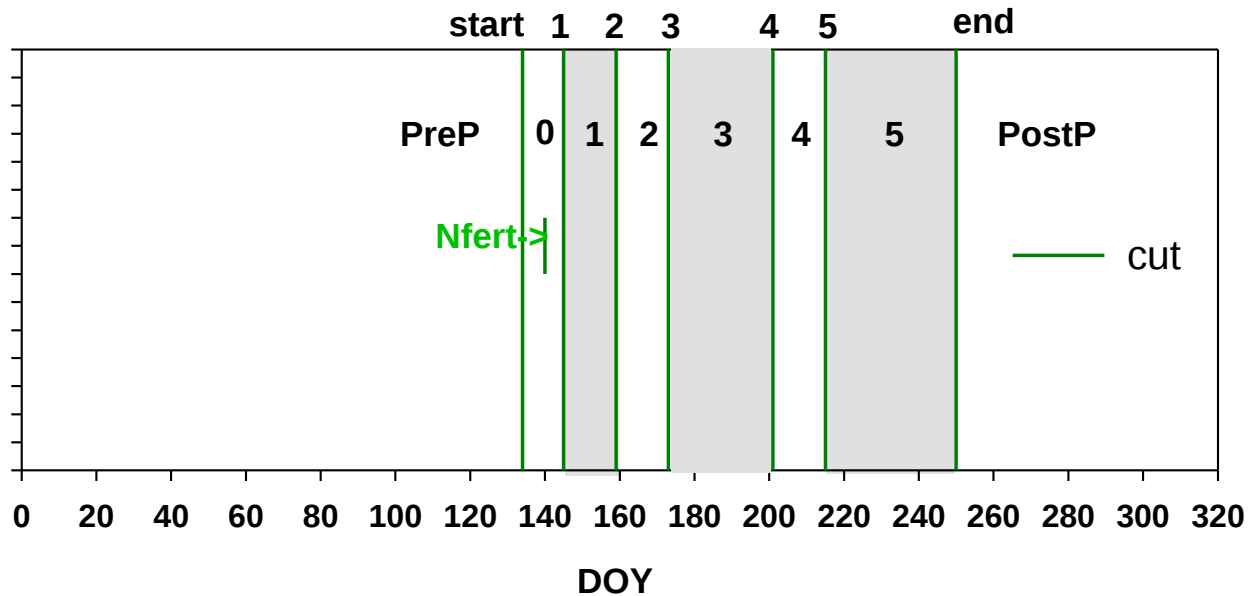
13.7 % clover

7 dominante species (36)

Prod: 7.1t DM green.ha.yr⁻¹

Standing: 2.6t DM.ha.yr⁻¹

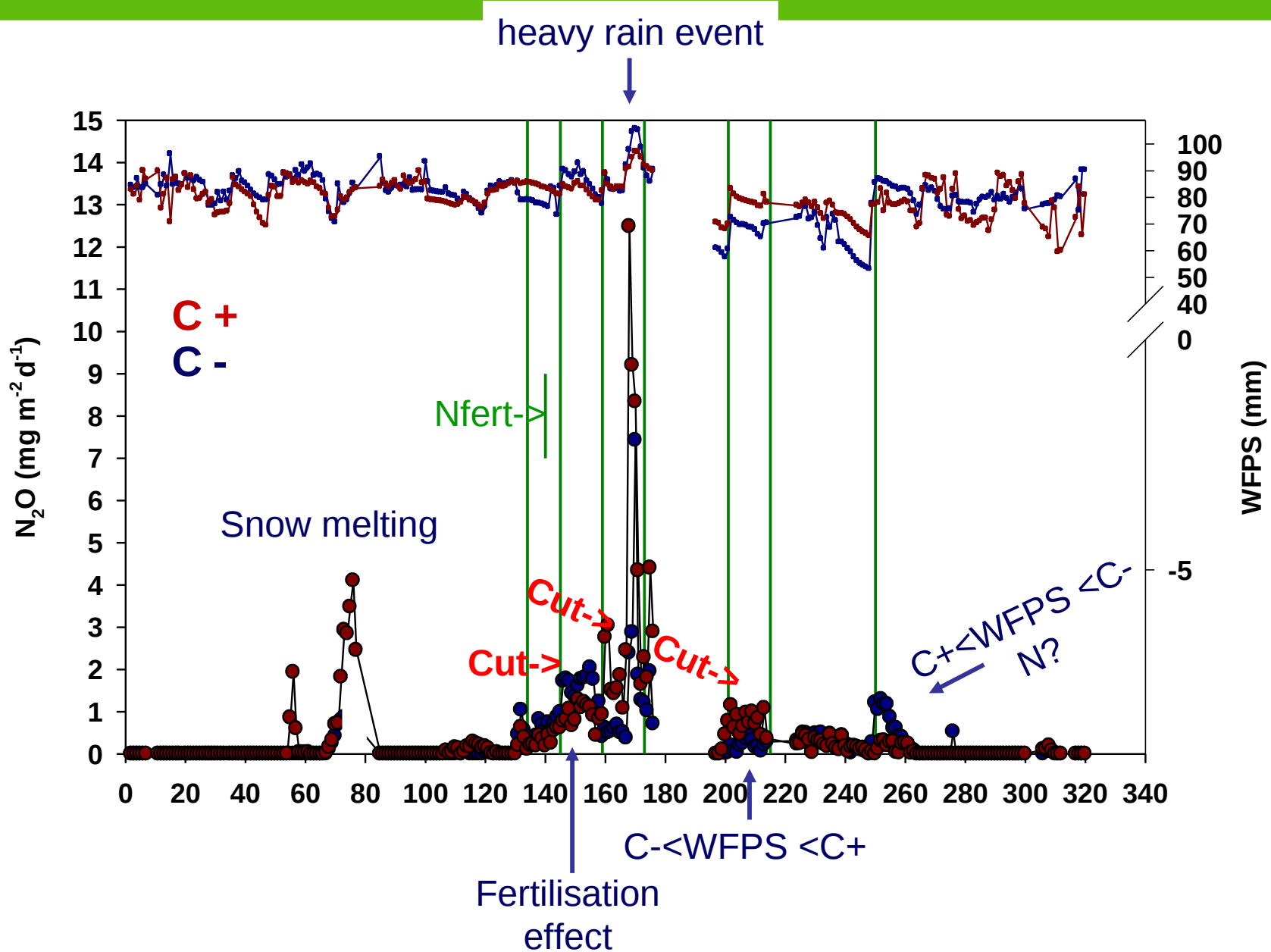
Experimental Setup



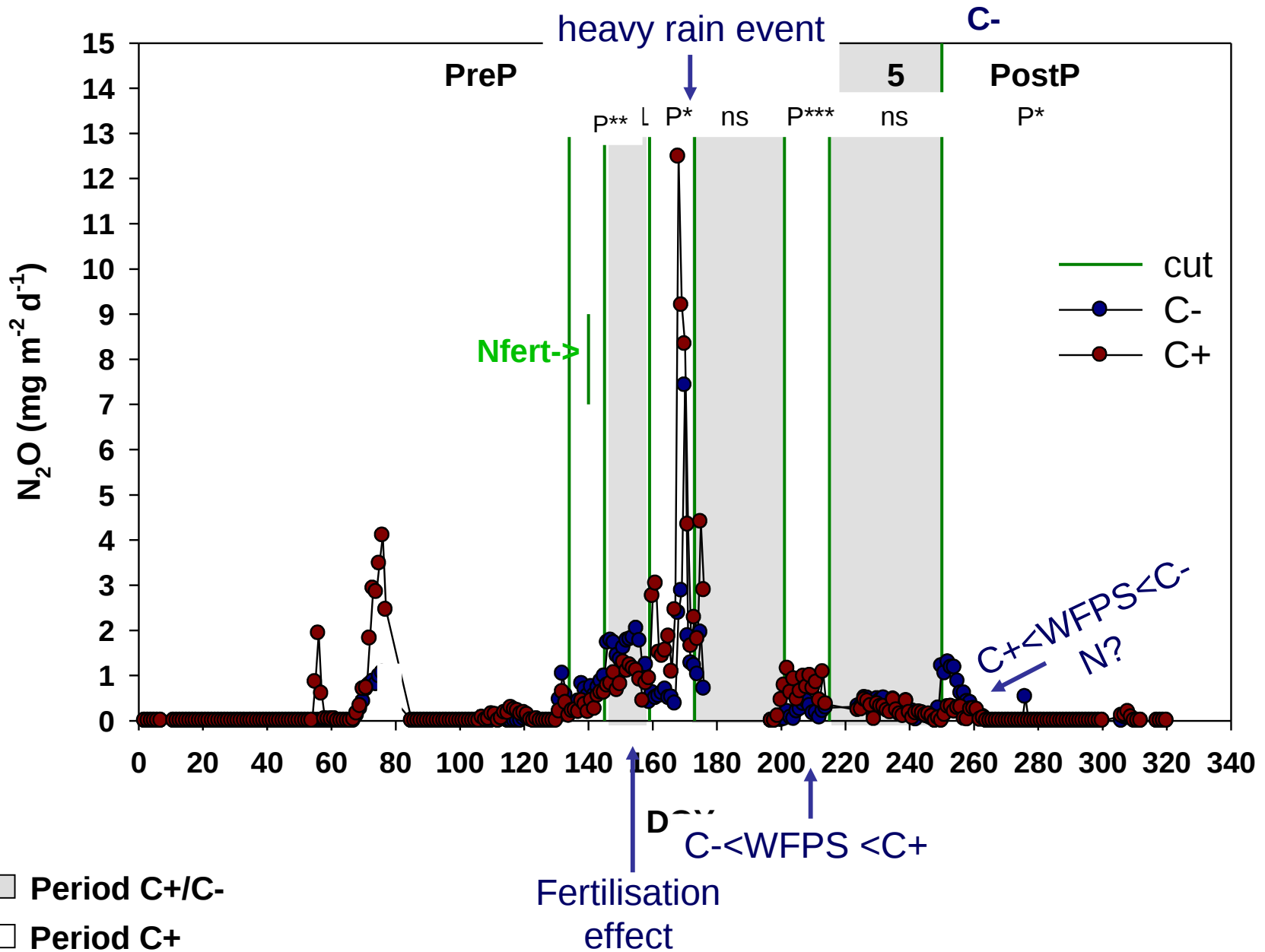
At cutting dates :

- aboveground biomass, litter and stubble mass
- % clover
- Potential nitrification and denitrification activity (after 3 days)
- pH, NH_4 and NO_3 contents

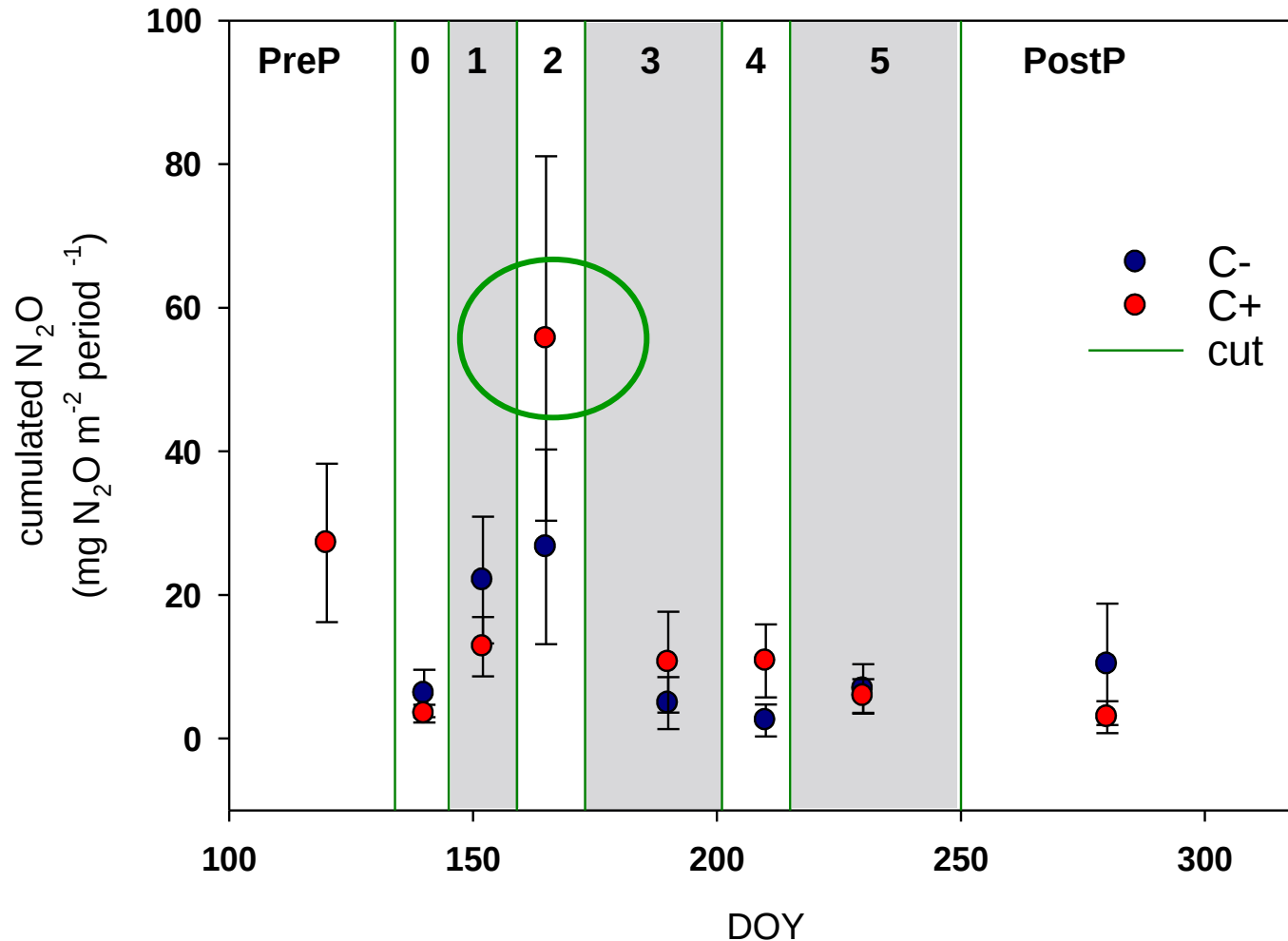
Results: daily N_2O



Results: daily N₂O



Results: cumulated N₂O over the cutting period

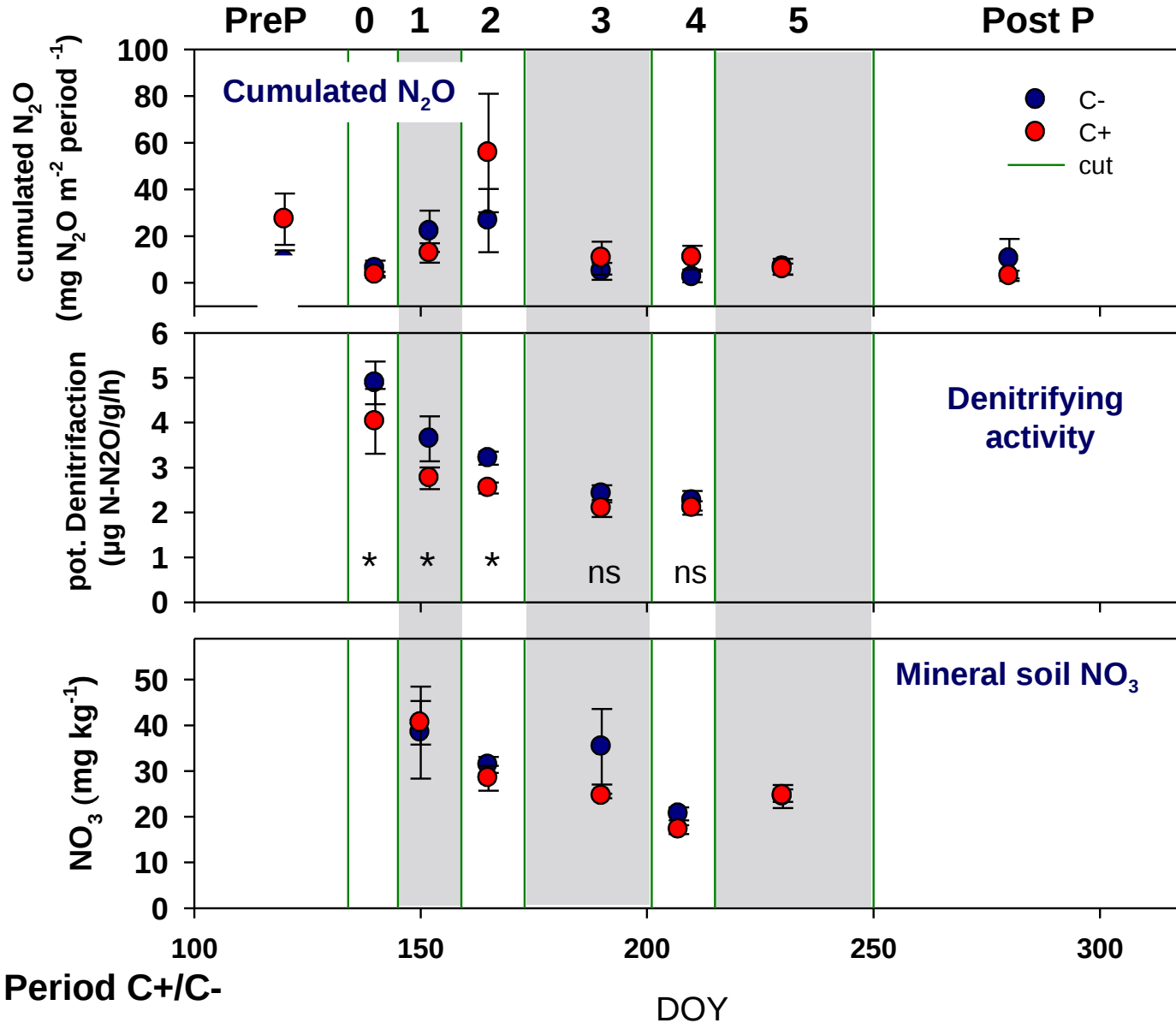


■ Period C+/-
□ Period C+

Cumulated C- = 107±11mg N₂O m⁻² (EF 0.015)

Cumulated C+ = 130±10mg N₂O m⁻² (EF 0.018)

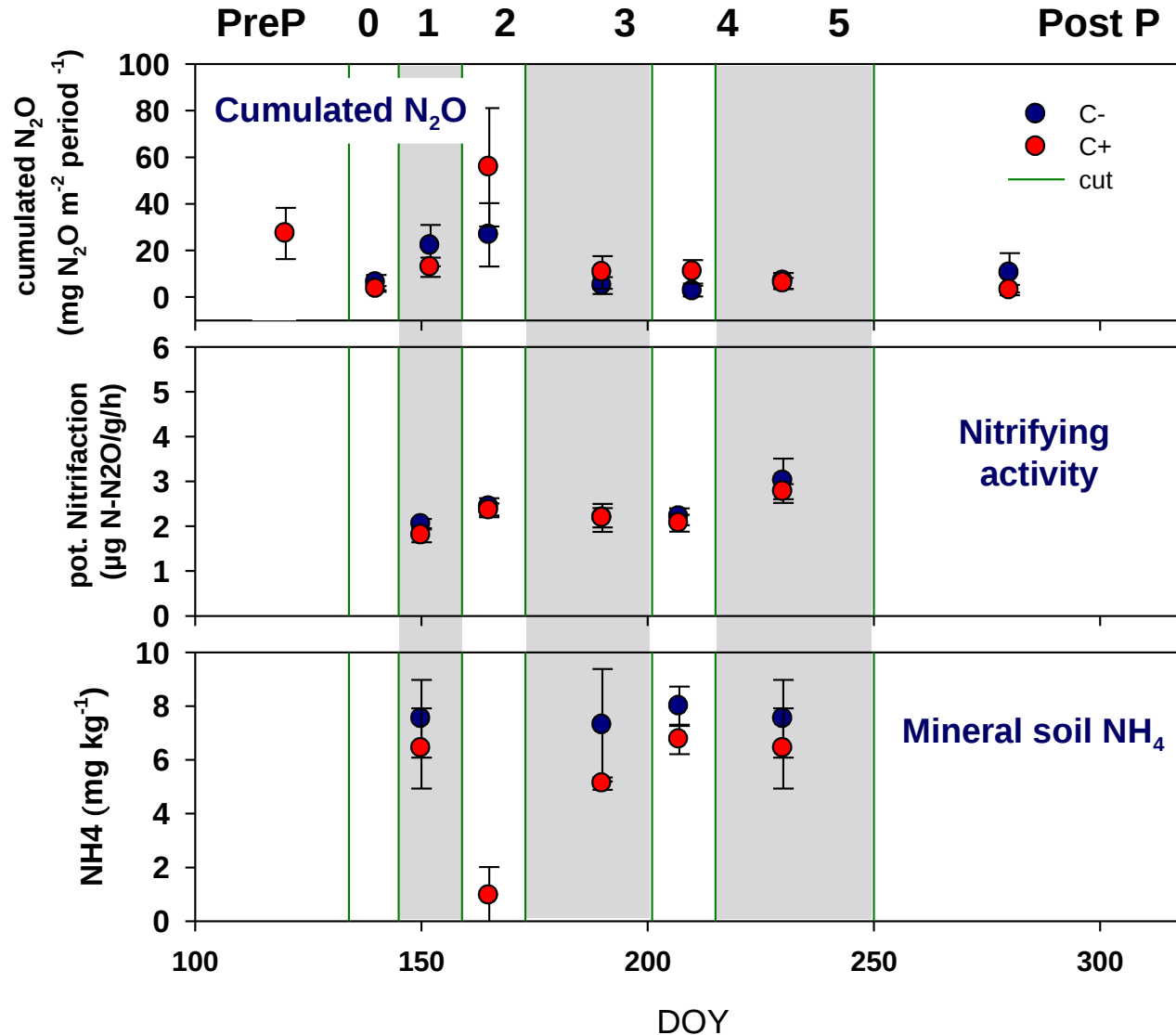
Results: cumulated N₂O flux and microbial activities



potential N₂O emission by denitrifying activity
 ↗ C- due to better NO₃ availability

Period C+/C-
 Period C+

Results: cumulated N₂O flux and microbial activities



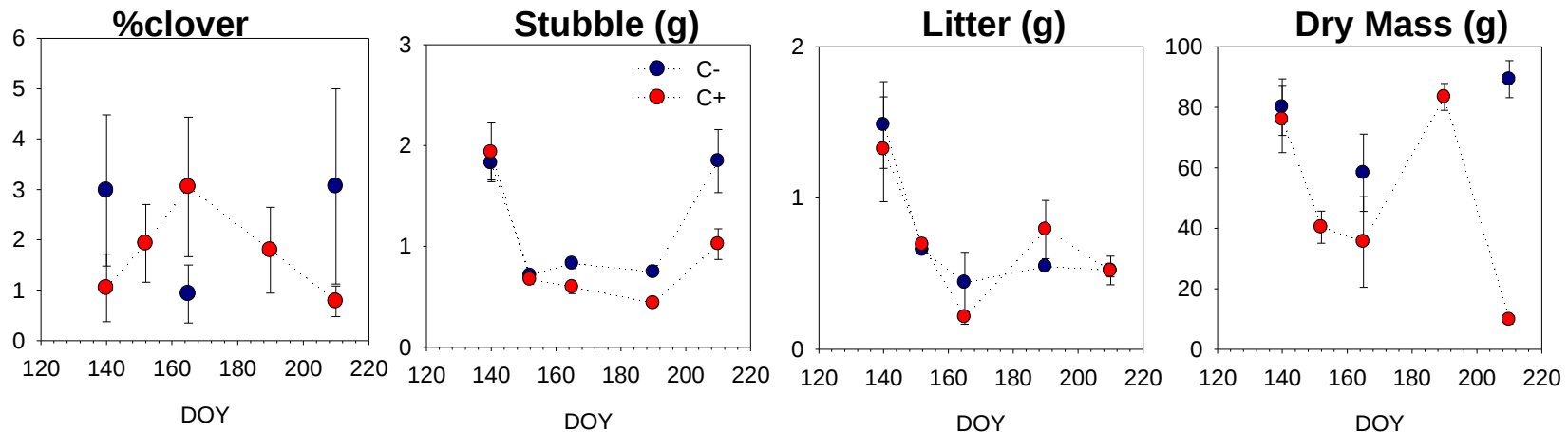
potential N₂O emission by Nitrifying activity showed no effect
↗ NH₄ availability in C-

Period C+/C-

Period C+

Results: Microbial activity and other data

- Potential denitrifying activity increased with litter and green stubble mass and NO_3^- ($p < 0.05$, $R^2 = 0.80$)



Except for %clover in period 2,3 and 4

$$C+ < C-$$

- **C+** Denitrifier activity was negatively related to mean N_2O emissions over the periode

($p < 0.05$, $R^2 = -0.68$)

- **C+** Denitrifier activity was positively related to %clover

($p < 0.05$, $R^2 = 0.58$)

Results: N₂O emissions and other data

Forward stepwise multiple regression analyses

$$\text{Lg N}_2\text{O} = -0.34 \text{ DMass} - 1.8 \text{ NH}_4 - 1.1 \text{ stubble} + 0.8 \text{ NO}_3 - 0.94 \text{ Denit} - 0.45 \text{ pH}$$

(p-model < 0.001, R²=0.62)

•C+ $\text{Lg N}_2\text{O} = -1.2 \text{ Litter} - 0.8 \% \text{ clover} - 0.9 \text{ NH}_4$

(p-model < 0.01, R²=0.72)

Conclusions

- **C+** tended to have higher N₂O emissions probably due to higher clover fraction (i.e. N rich substrate) and labil C through cuts (3 out of 5 cut events).
- However, on annual basis this was out leveled due to other flux favouring variables (i.e. WFPS).
(**C-** 107±11; **C+** 130±10 mg N₂O m⁻²)
- Our results indicate that not only amount and timing of N supply plays a role but also timing and frequency of defoliation.

Thank you

