Effect of Land-use Change on Greenhouse Gases in Jambi, Sumatra

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Introduction

1. Indonesia, the 3rd largest countries in term of deforestation ➔ 2 million ha forest yr^{-1} (FAO, 2010)
2. Oil palm and rubber are important comodities in Indonesia
3. But forest convertion leads to :

- Vegetation type simplification & composition
- Litterfall production (quality and quantity)
- Soil organisms
- N turnover rate
- Micro climate : soil moisture&temperature, etc
- Land management

Soil emissions

Initial studies about emissions in Sumatra : Ishizuka (2002), Ishizuka et al. (2005a), Ishizuka et al. (2005b), and Verchot et al. (2006)

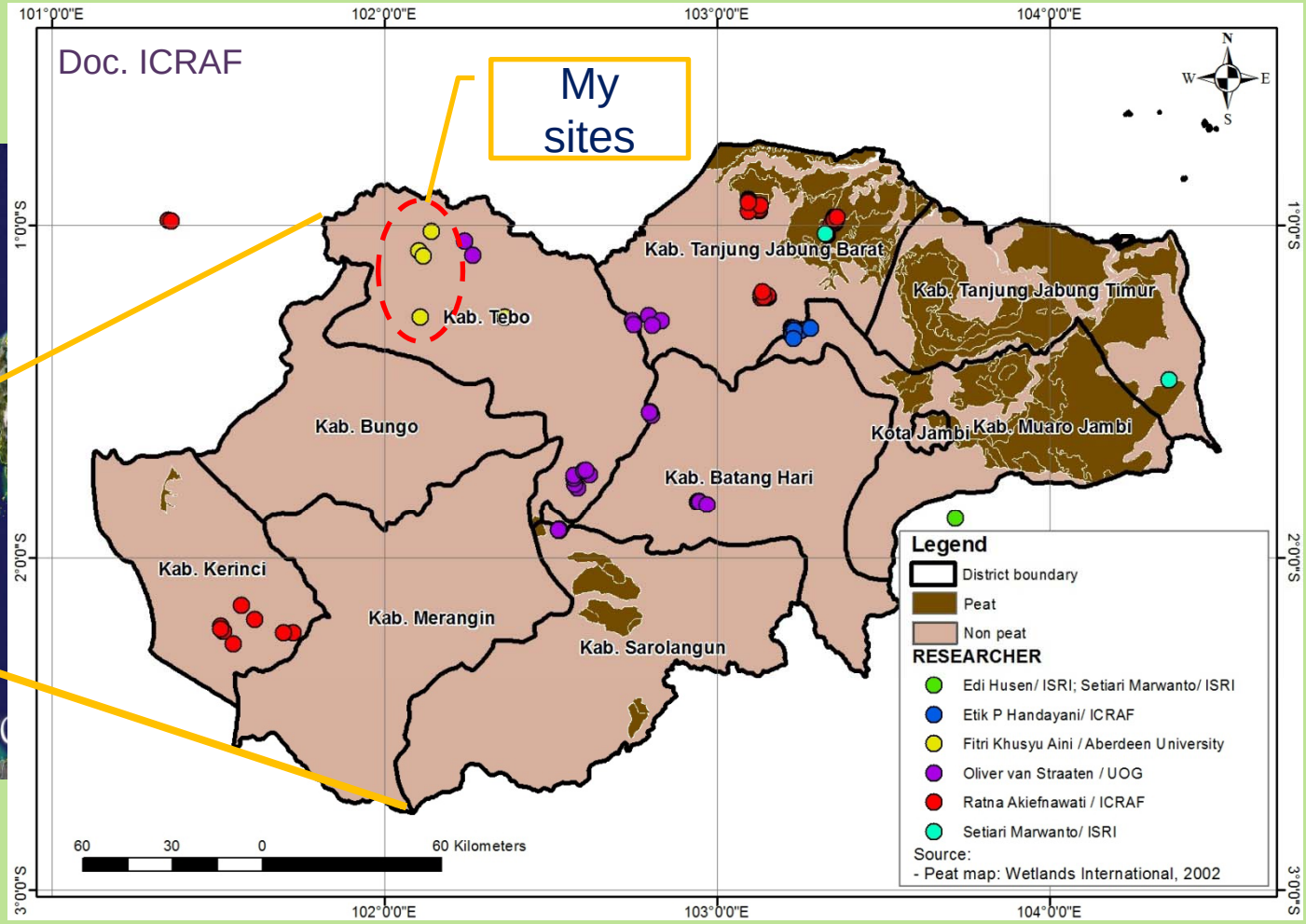
- the long-term effects are still unknown

➔ **Big oportunity for filling the data gap**

Objectives

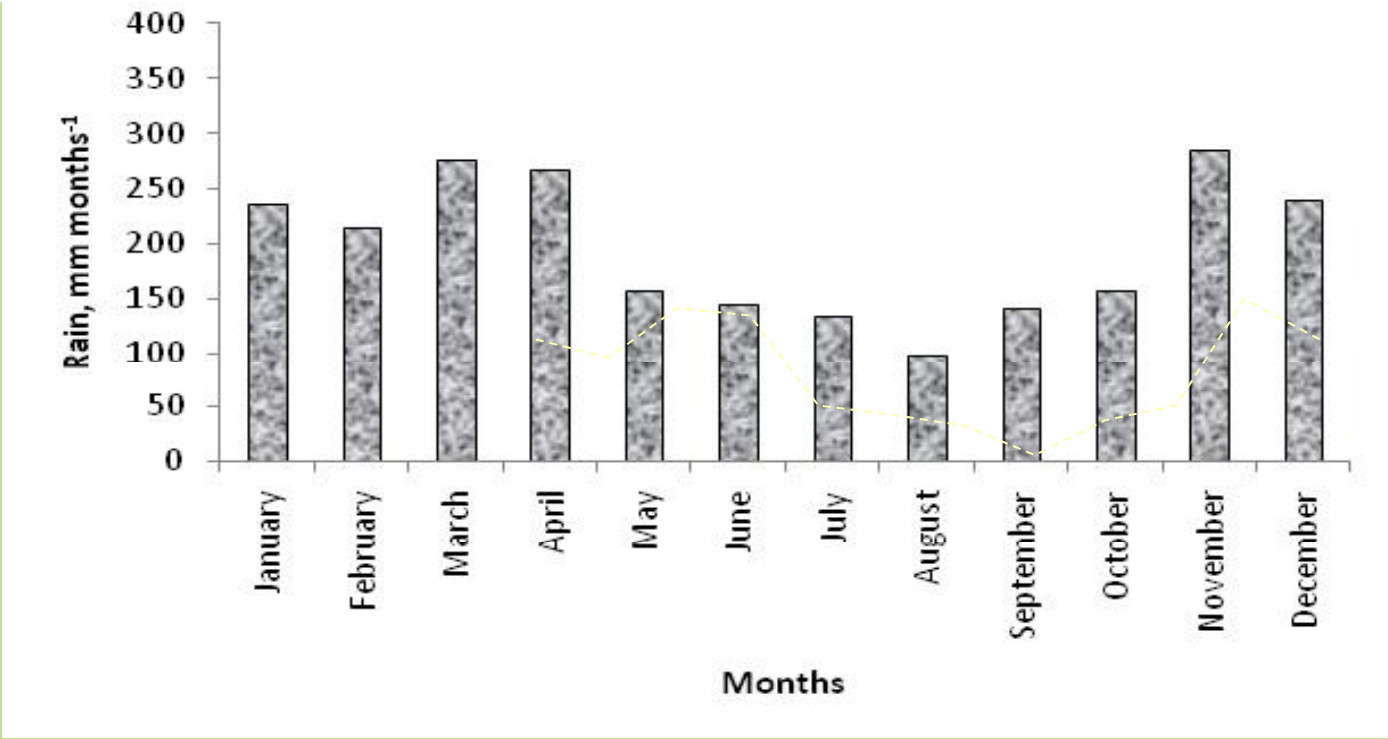
1. To quantify the effect of tropical forest conversion on greenhouse gas fluxes (N_2O, CH_4, CO_2)
2. To quantify the temporal variation of greenhouse gas fluxes in rubber and oil palm plantation

Site Description

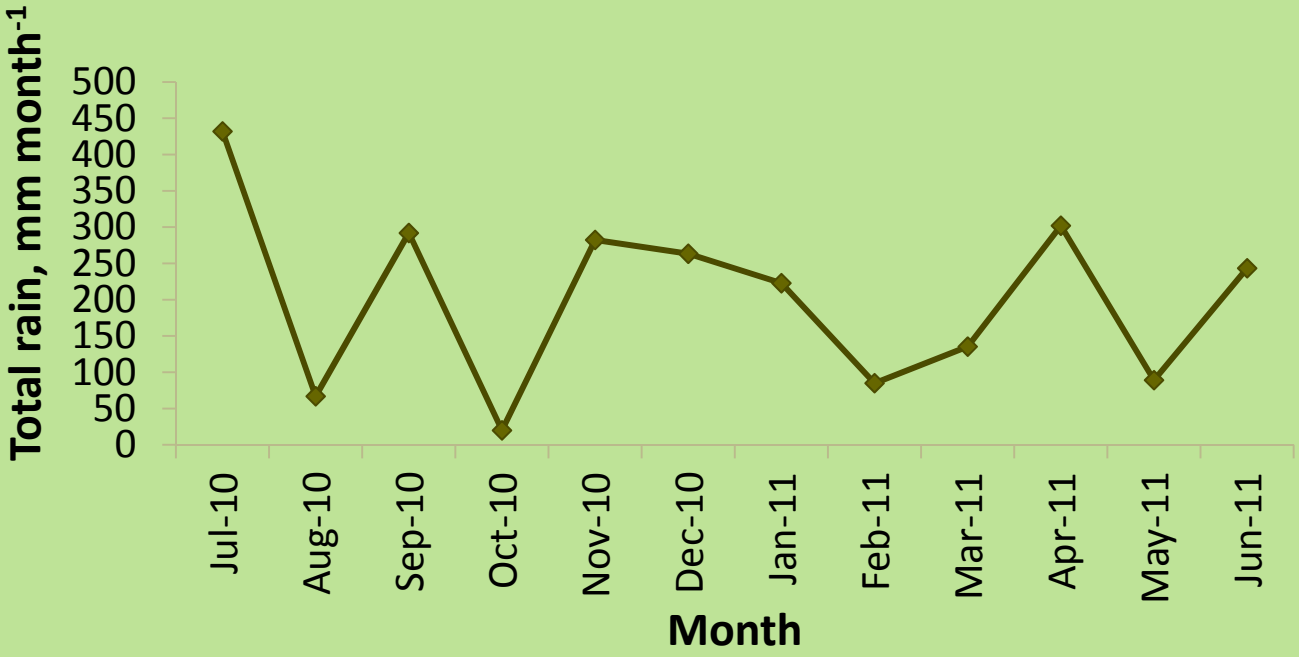


Location: Pasir Mayang, Jambi Province, Indonesia
The soil type: Ultisols
Altitude: > 100 above sea level

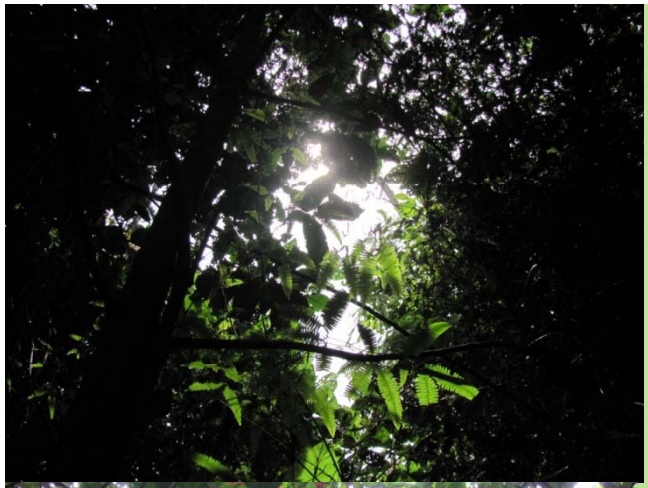
Rainfall pattern from 2006-2011 from Pasir Mayang weather station and VII Koto Ilir Weather Station



Rainfall pattern during fluxes monitoring (July 2010-June 2011)



Land-use Systems

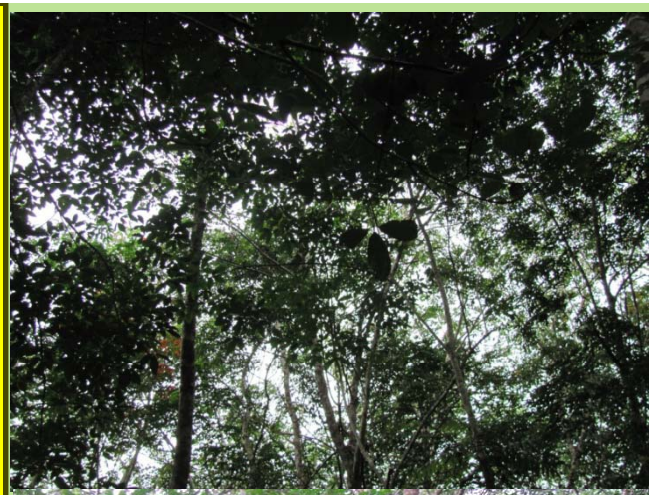


Left: Forest site
• closed canopy cover
•Bigger trees
•Thick litter on forest floor

Right:
Disturbed forest site
•Canopy trees more open
• was burnt in 1997
• a lot of woods on forest floor

Left:
1 year rubber plantation
• previous classification is logged over forest
•Open canopy cover
•Was opened by community 2 years ago
•Recent LUS: 1 year rubber

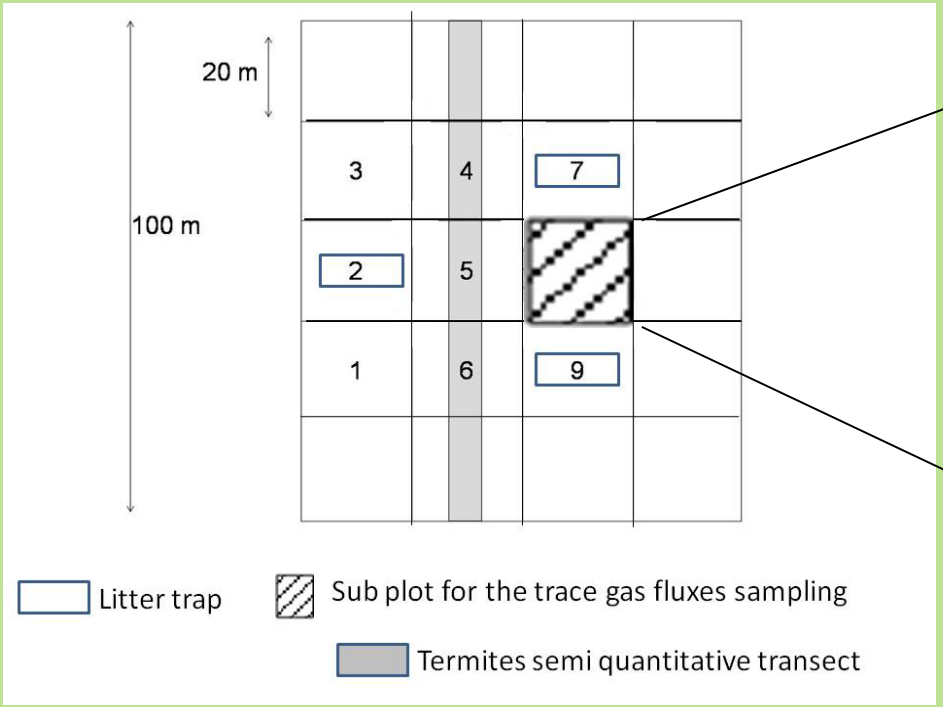
Right: 20 years old rubber plantation site
• conopy cover condition closer with forest&disturbed forest sites
•No fertilizer
•Dense understorey



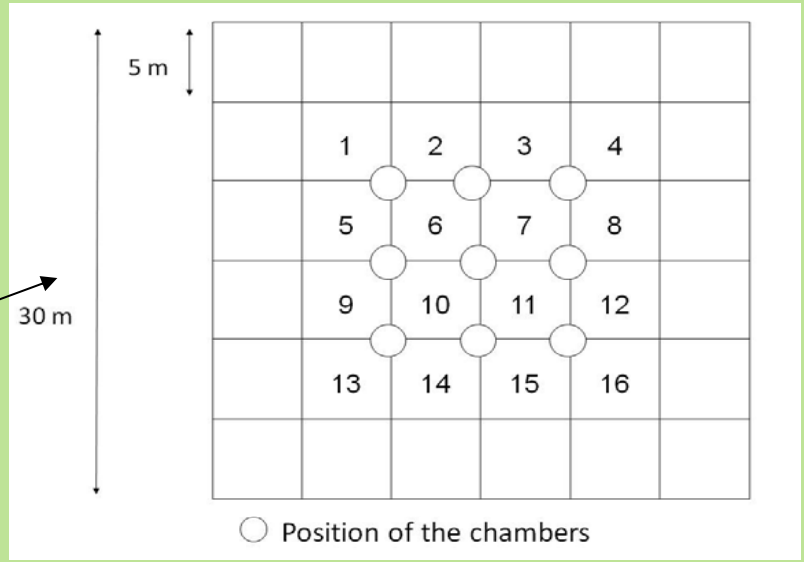
Left: OP_8yr
• Harvest every 2 weeks
•The distance between trees is 9 x 8 m
•No fertilizer application
•Farmer applies herbicide

Right: There are some big termites mounds in the oil palm area (± 50-140 cm height)

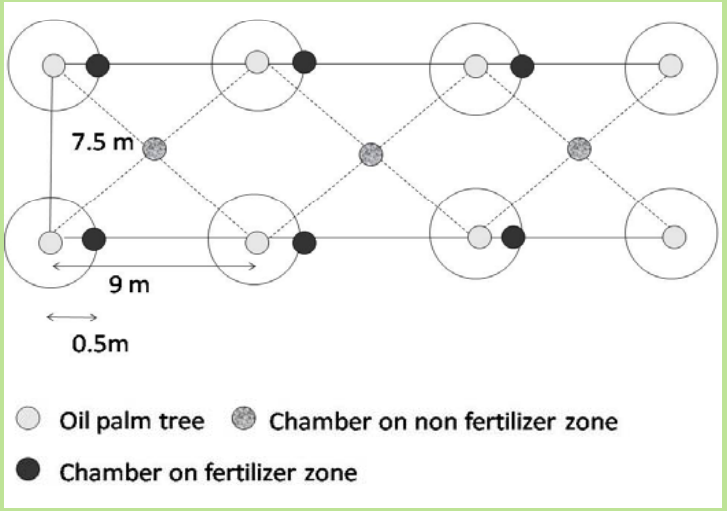
Sampling Design



A



B



Activity 1. Routine measurements

A. CO_2 measurement with IRGA
B. Downloads rainfall data from rain gauge
C. Litterfall harvesting
D. Gas sampling for N_2O and CH_4 measurement
E. Soil sampling for soil moisture analysis
F. Micro climate measurement for soil temperature

Activity 2. Fertilizer application

Aim: to determine to what extent fertiliser increases the fluxes and for how long the impact continues

Type of fertilizers: Urea, KCl, ZA

Dosage: 1:1:1 at a rate of 500 g tree^{-1}

Application: spread around the oil palm trees

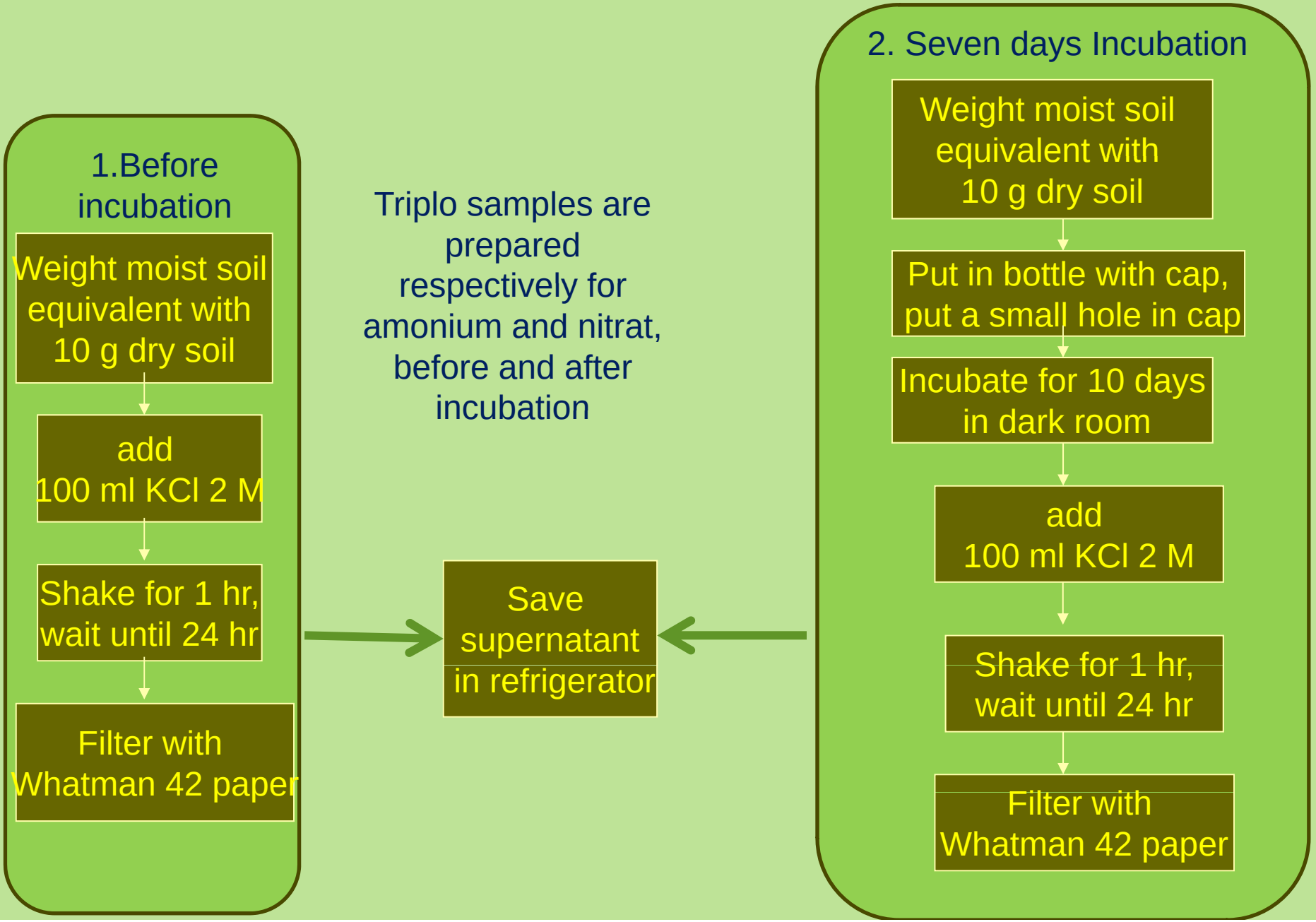
When: in rainy season (April 2011)

Monitoring schedule: on -1, 0, 1, 2, 3, 4, 5, 6, 7, 10, 14, 17, 21 and 28 days following fertilizers application

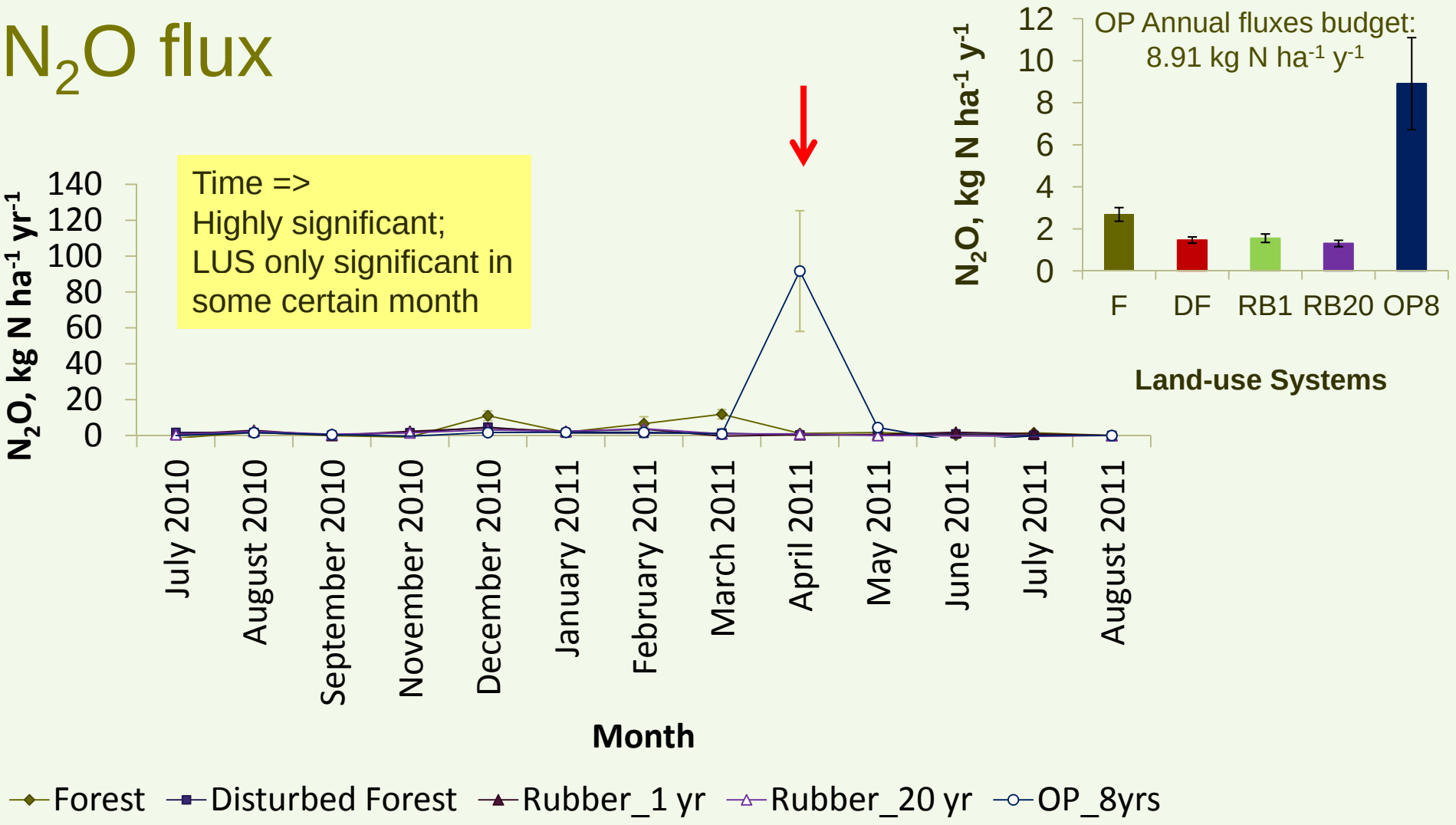
Activity 3. Effect of termites on CH_4 emission

A. 100 m termite semi quantitave sampling, B. Chamber instalation for gas sampling, C& D collecting termite from the mound, E. CO_2 gas sampling from termite mound using IRGA, F. Field assistants measured height of termite mound while the other measured the gas

Activity 4. Net mineralization and nitrification



N_2O flux



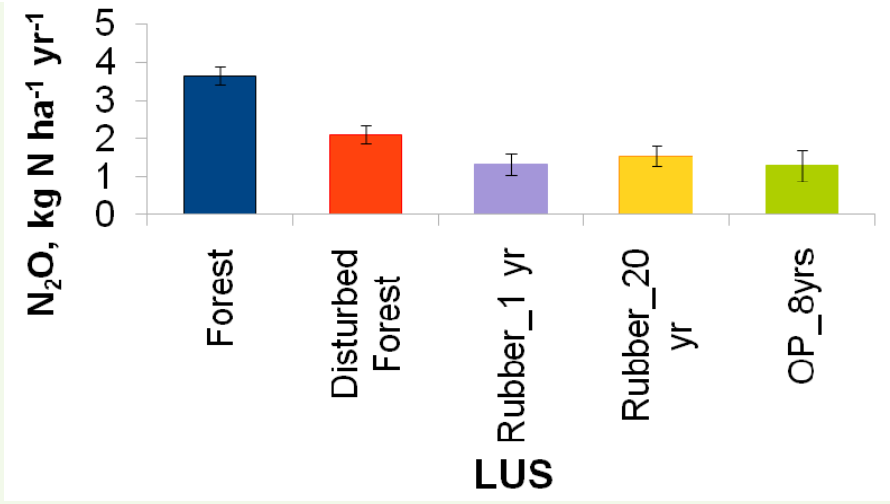
Average fluxes in during fertilization application 91.69 kg N ha-1 y-1

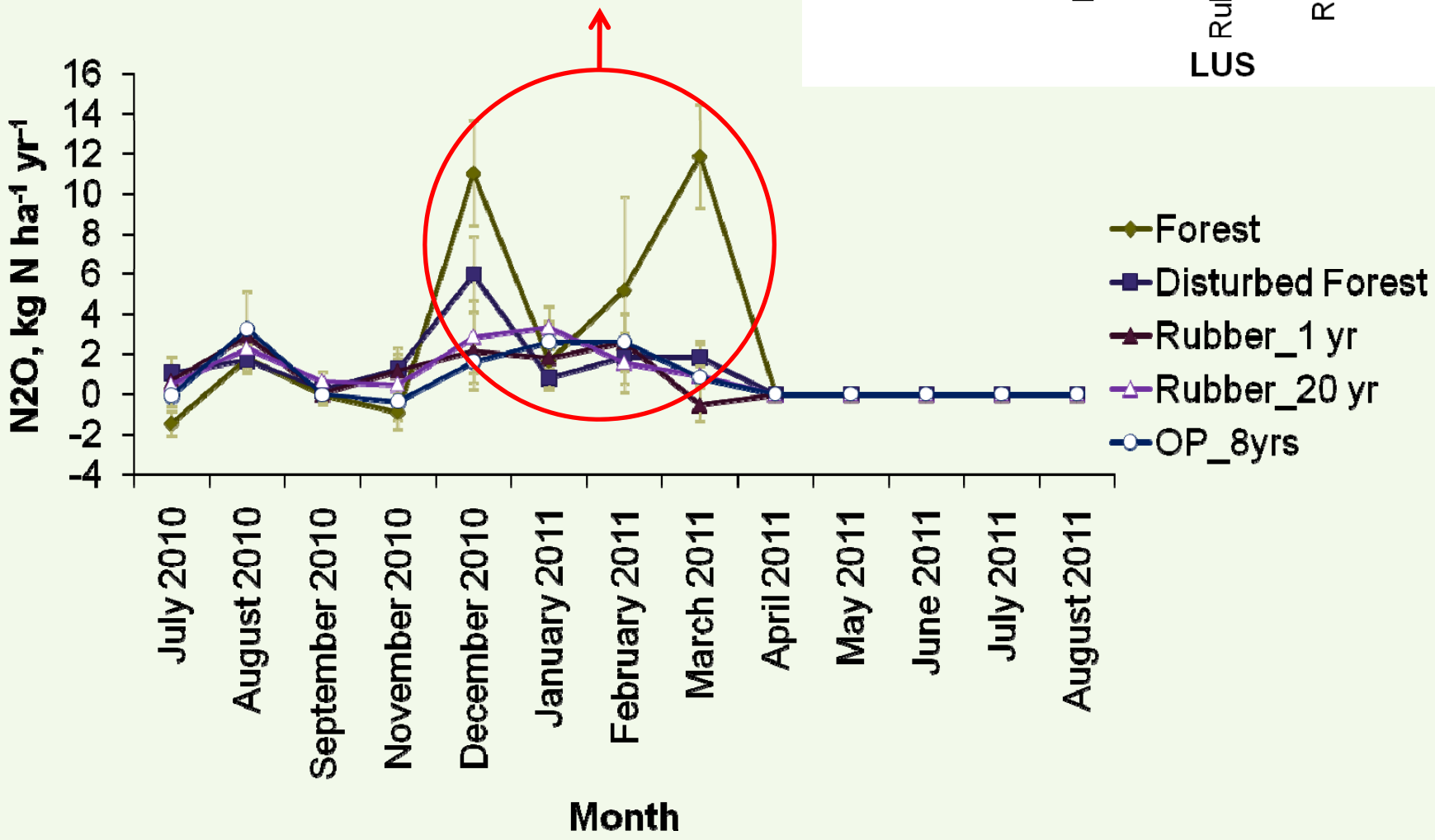
Average fluxes budget before urea application 0.954 kg N ha-1 y-1

Average fluxes after urea aplication: 0.36 kg N ha-1 y-1

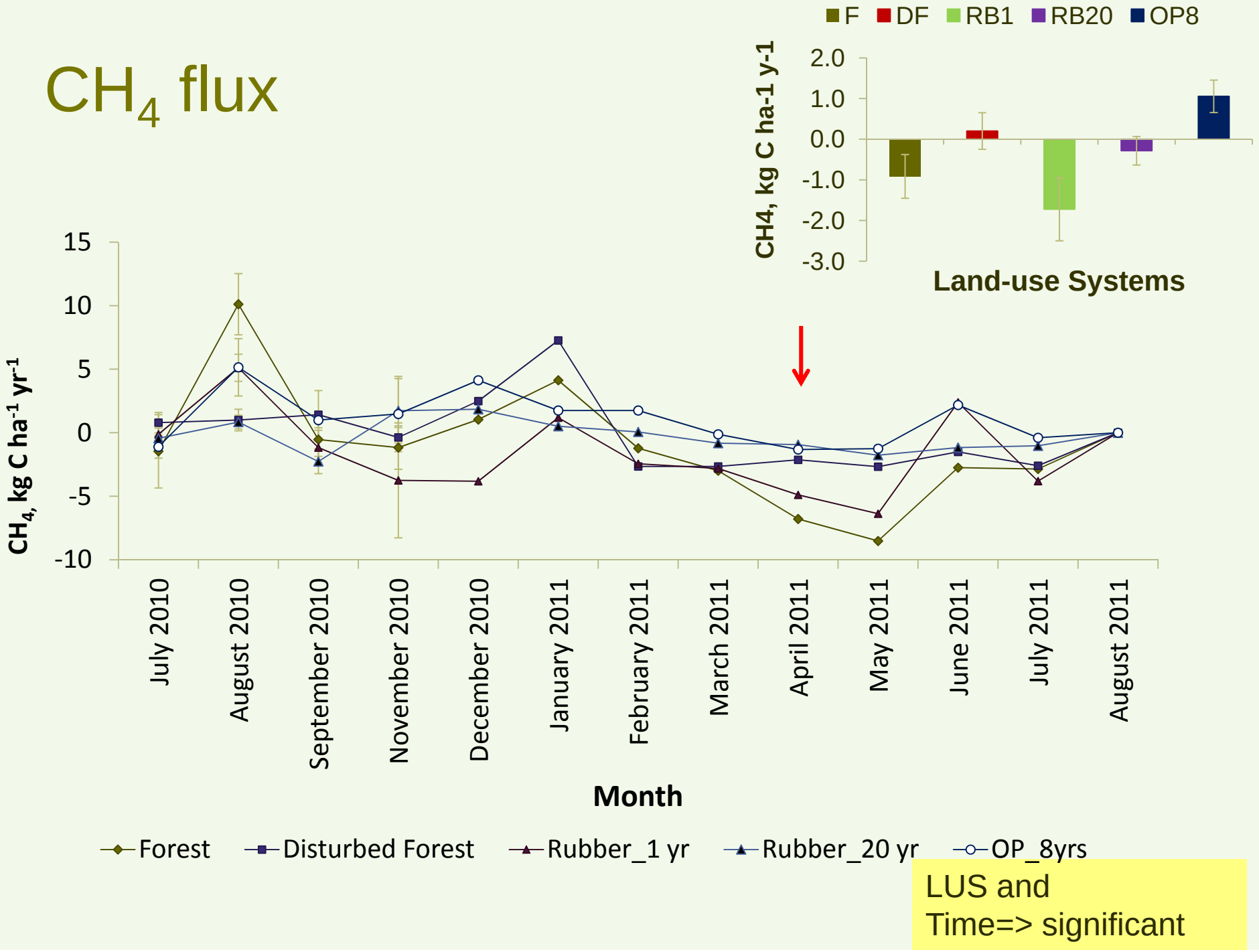
Before urea application flux

The highest was in Dec and Forest



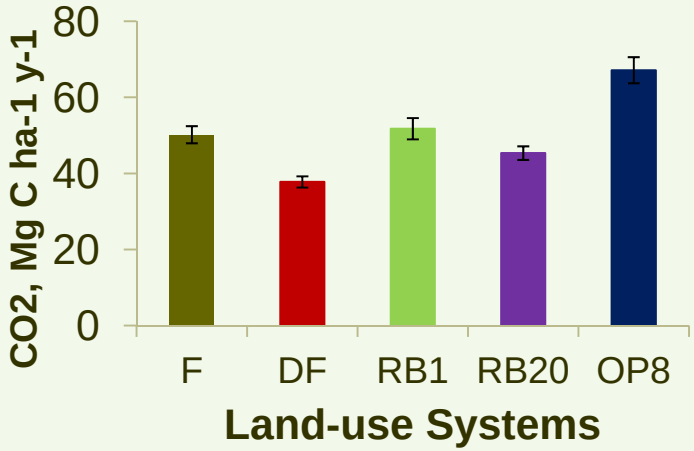


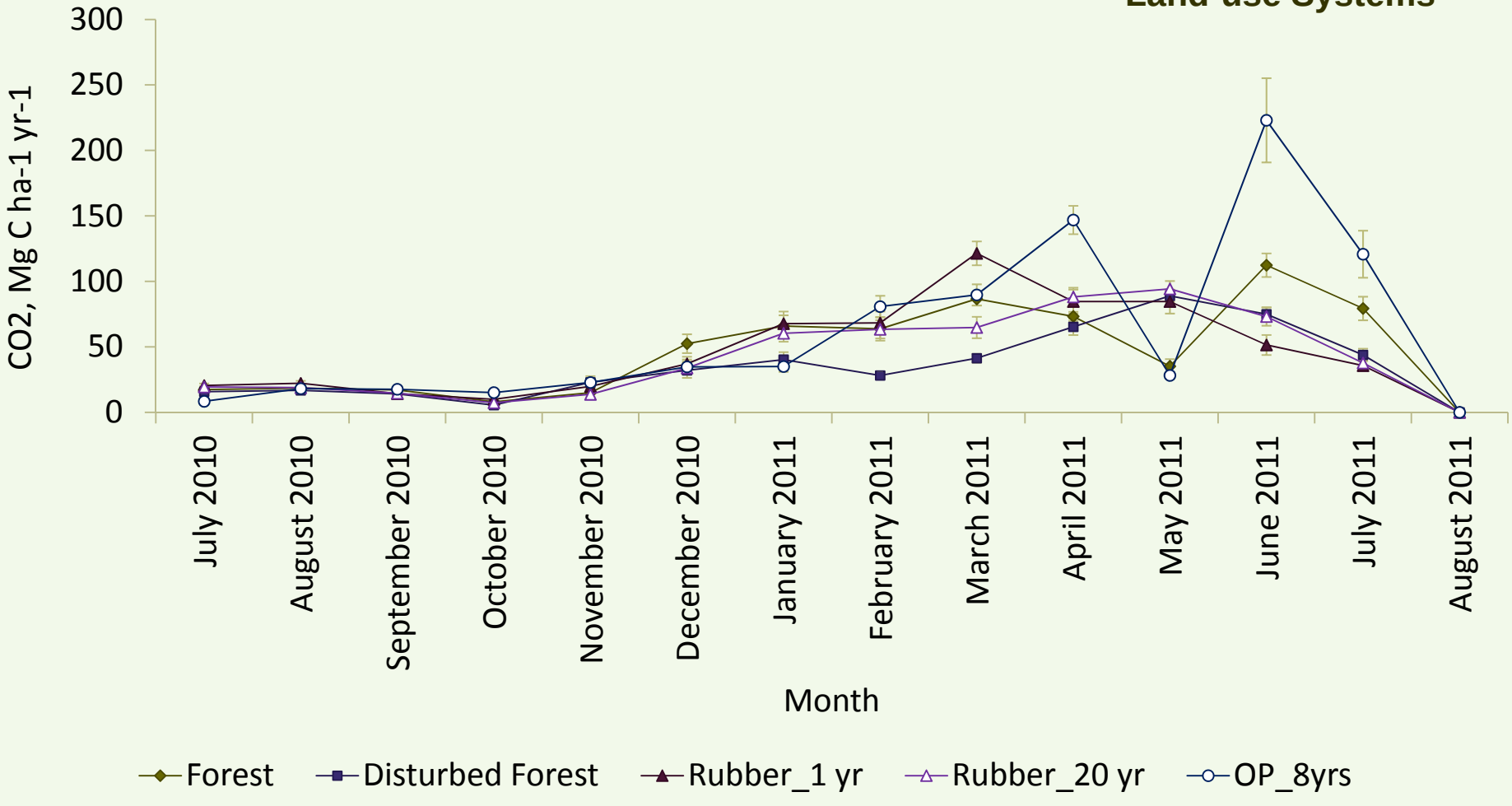
CH_4 flux



LUS and
Time=> significant

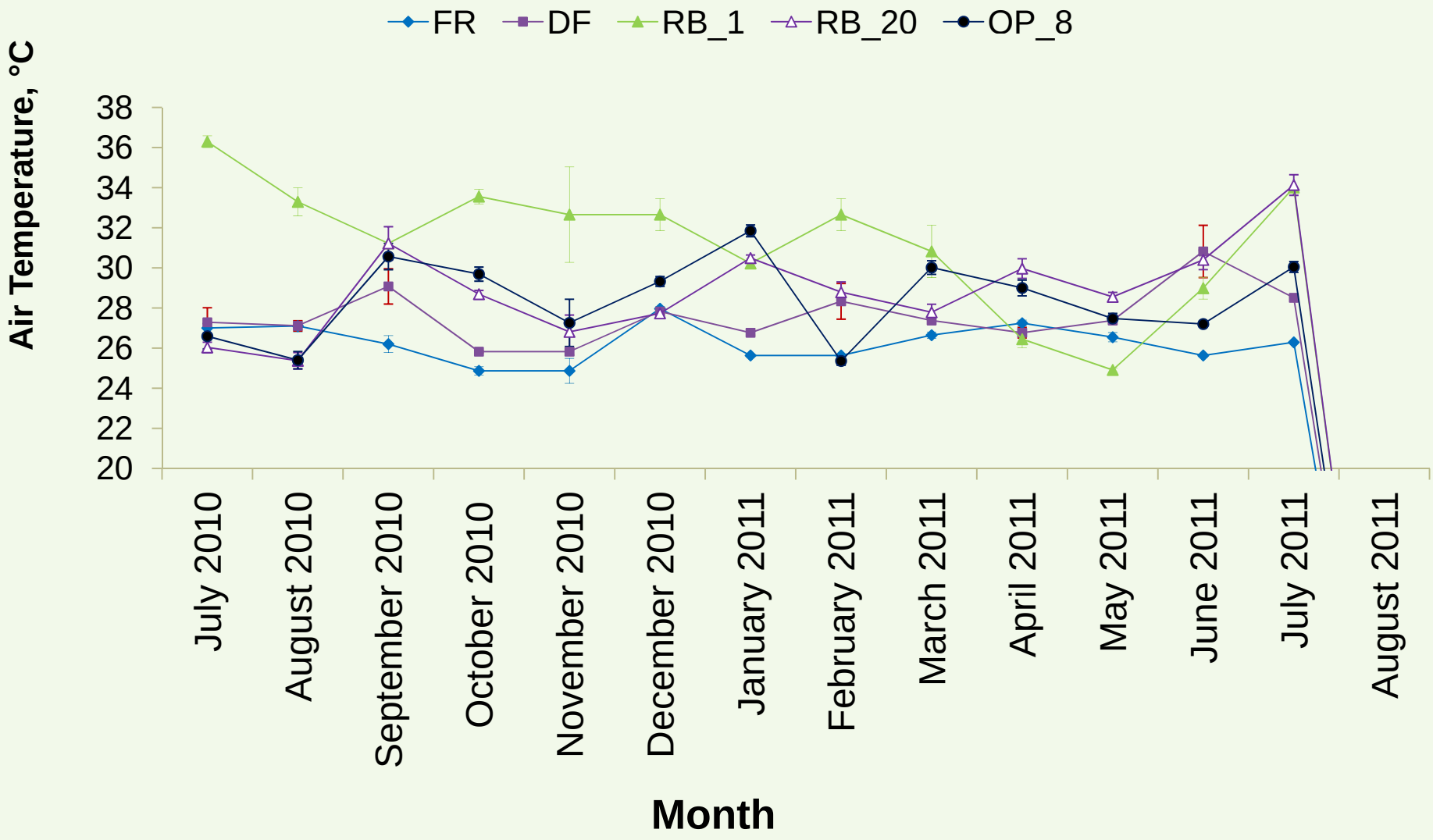
CO_2 flux


CO2, Mg C ha-1 y-1
80
60
40
20
0
F
DF
RB1
RB20
OP8
Land-use Systems


CO2, Mg C ha-1 yr-1
300
250
200
150
100
50
0
July 2010
August 2010
September 2010
October 2010
November 2010
December 2010
January 2011
February 2011
March 2011
April 2011
May 2011
June 2011
July 2011
August 2011
Month
Forest
Disturbed Forest
Rubber_1 yr
Rubber_20 yr
OP_8yrs

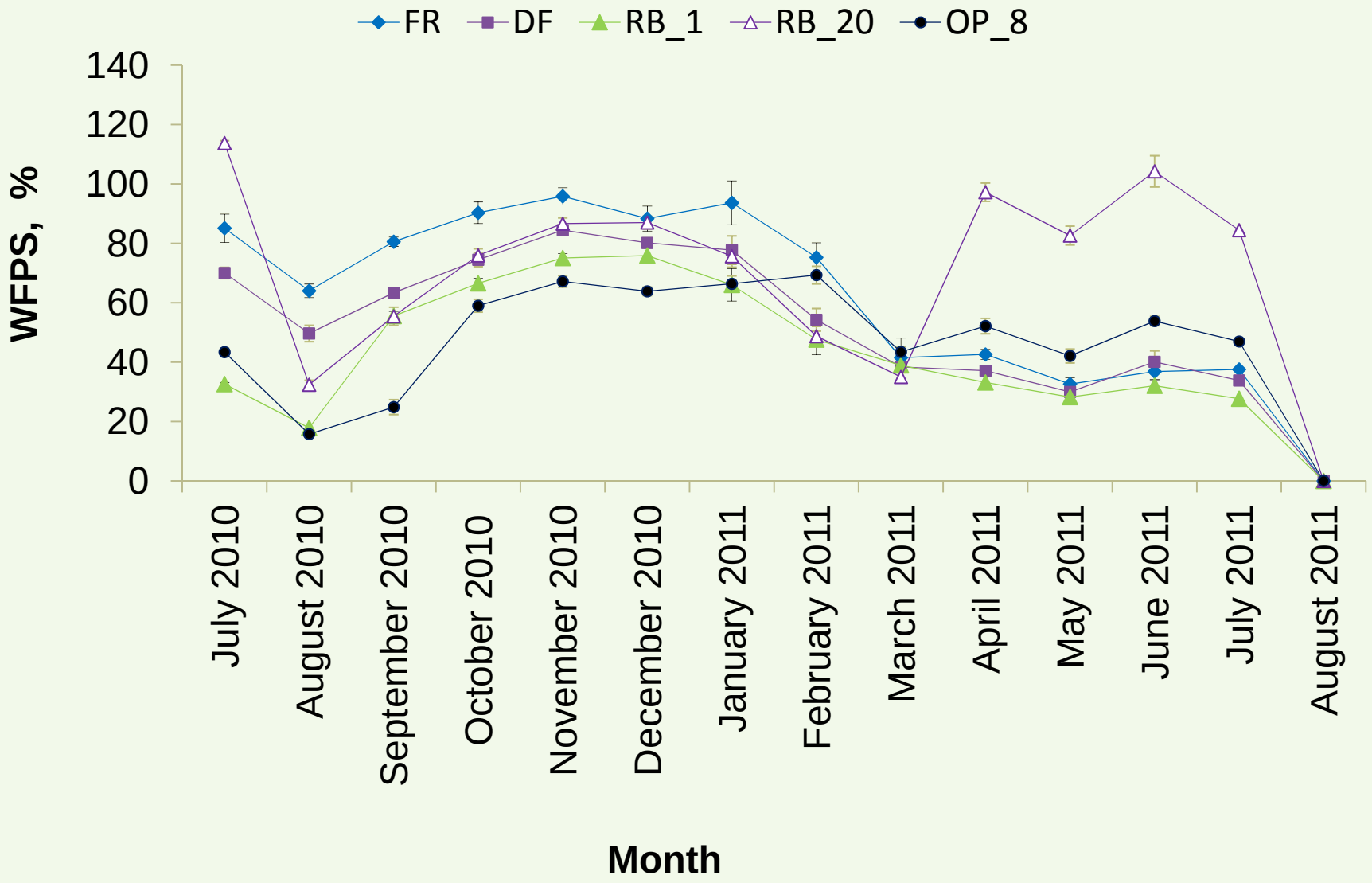
Air Temperature

LUS change leads increasing air temperature 2.6-5.1 °C

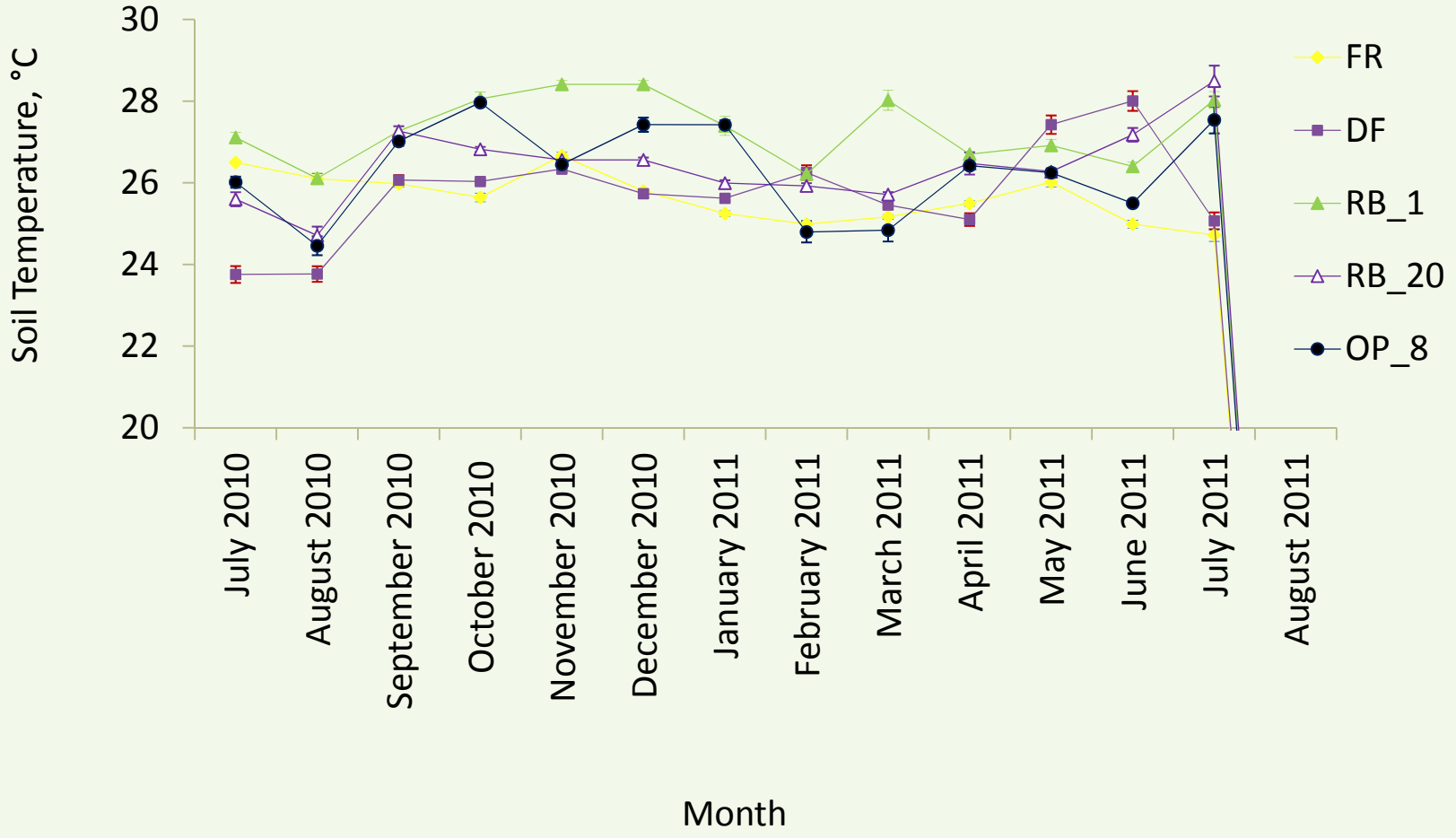


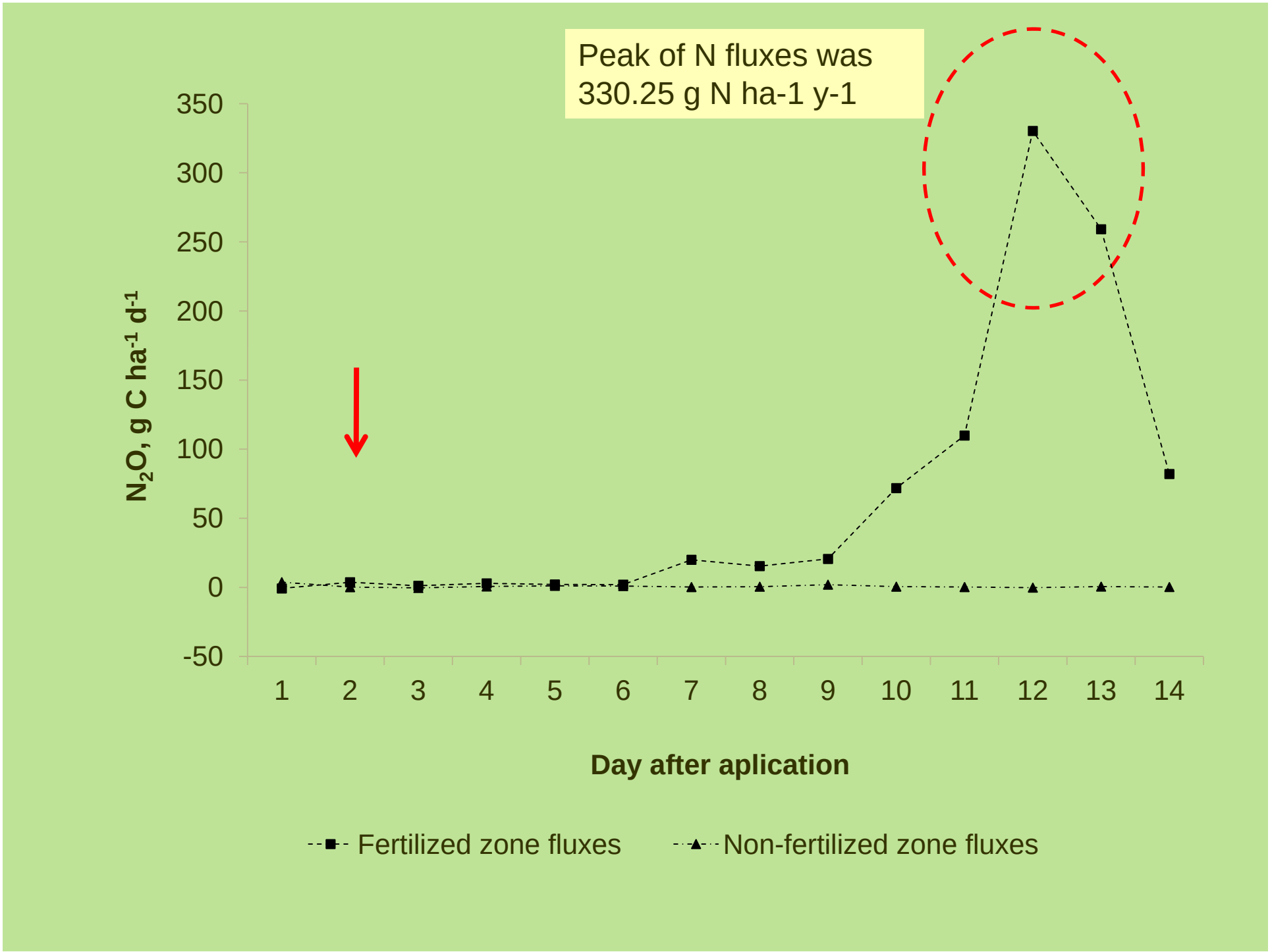
Soil Moisture

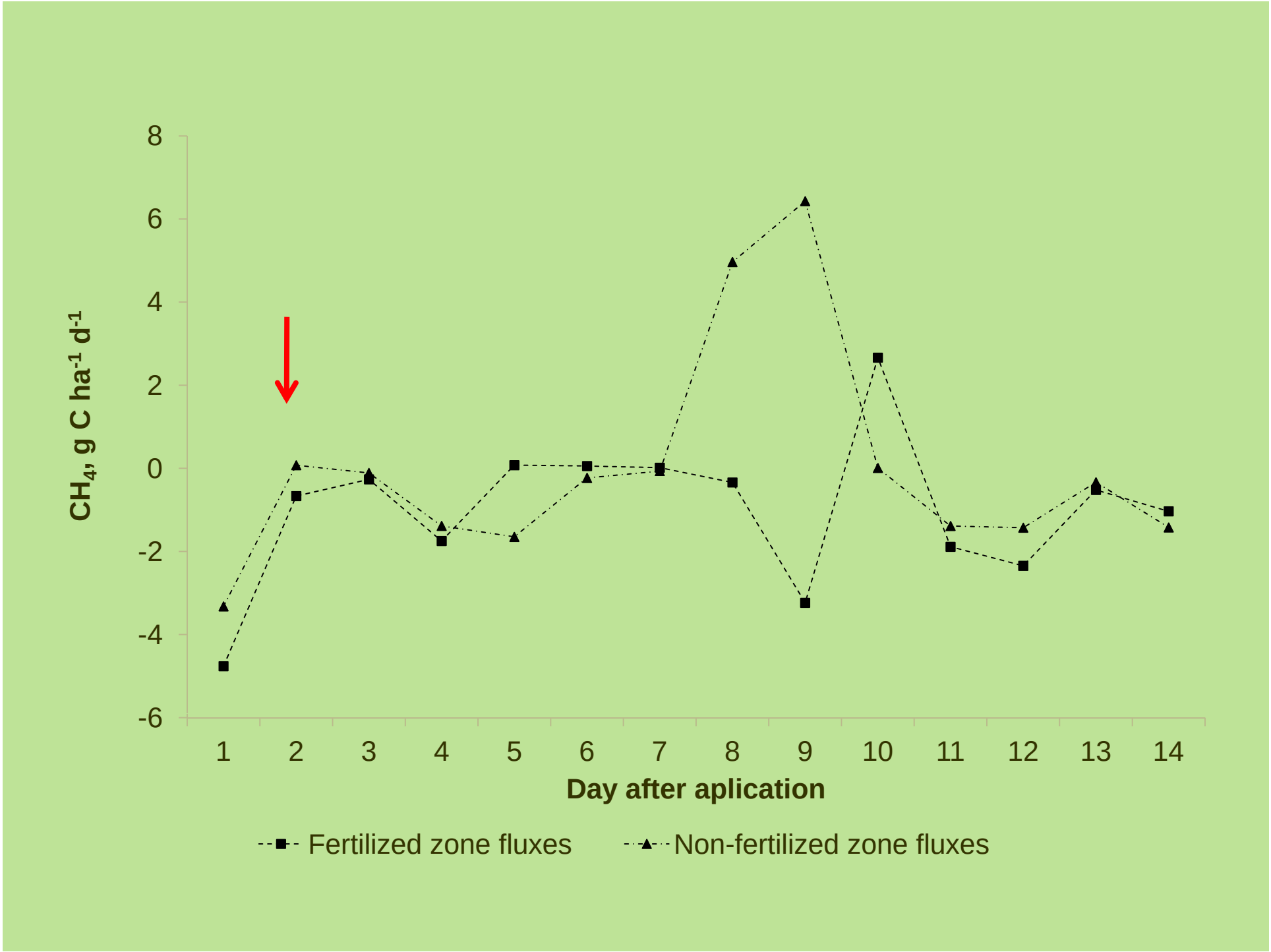
Expressed by WFPS



Soil Temperature




Peak of N fluxes was
330.25 g N ha-1 y-1
350
300
250
200
150
100
50
0
-50
N_2O, g C ha^{-1} d^{-1}
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Day after aplication
Fertilized zone fluxes
Non-fertilized zone fluxes


8
6
4
2
0
-2
-4
-6
CH_4, g C ha^{-1} d^{-1}
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Day after aplication
Fertilized zone fluxes
Non-fertilized zone fluxes


0.05
0.05
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
CO2, Mg C ha-1 d-1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Day after aplication
Fertilized zone fluxes
Non-fertilized zone fluxes

Discussion

1. N_2O fluxes vs distance from termite nest ($p<0.00$), mineralisation ($p<0.019$), nitrification ($p<0.021$), N-NH_4 ($p<0.001$), N-NO_3 ($p<0.018$) and soil porosity ($p<0.045$) ➔ correlated

2. CH_4 fluxes vs gravimetric soil moisture ($p<0.023$), WFPS ($p<0.014$) , distance from termite nest ($p<0.010$) ➔ correlated

3. CO_2 fluxes Vs air temperature ($p<0.00$), soil temperature ($p<0.017$), total litterfall biomass ($p<0.02$), twigs/branches biomass ($p<0.00$), distance from termite nest ($p<0.000$) mineralisation ($p< 0.006$), nitrification ($p<0.005$), N-NH_4 ($p<0.00$), N-NO3($p<0.006$), pH ($p<0.007$) ➔ highly correlated

4. N_2O fluxes in oil palm before urea application (0.954 kg N ha^{-1} yr^{-1}) and rubber plantation (1.21-1.46 kg N ha^{-1} yr^{-1}) were lower than N_2O fluxes in *Acacia mangium* plantation in South Sumatra (1.97 kg N ha^{-1} yr^{-1}) (Konda et al., 2008). But after fertilizer application in oil palm plantation the annual budget of N_2O fluxes in OP higher than the other plantation systems (8.91 kg N ha^{-1} yr^{-1}) .
5. Maximum N2O effect after fertilization was at 17 days after fertilization. It was longer compare other literature.

Thank You!