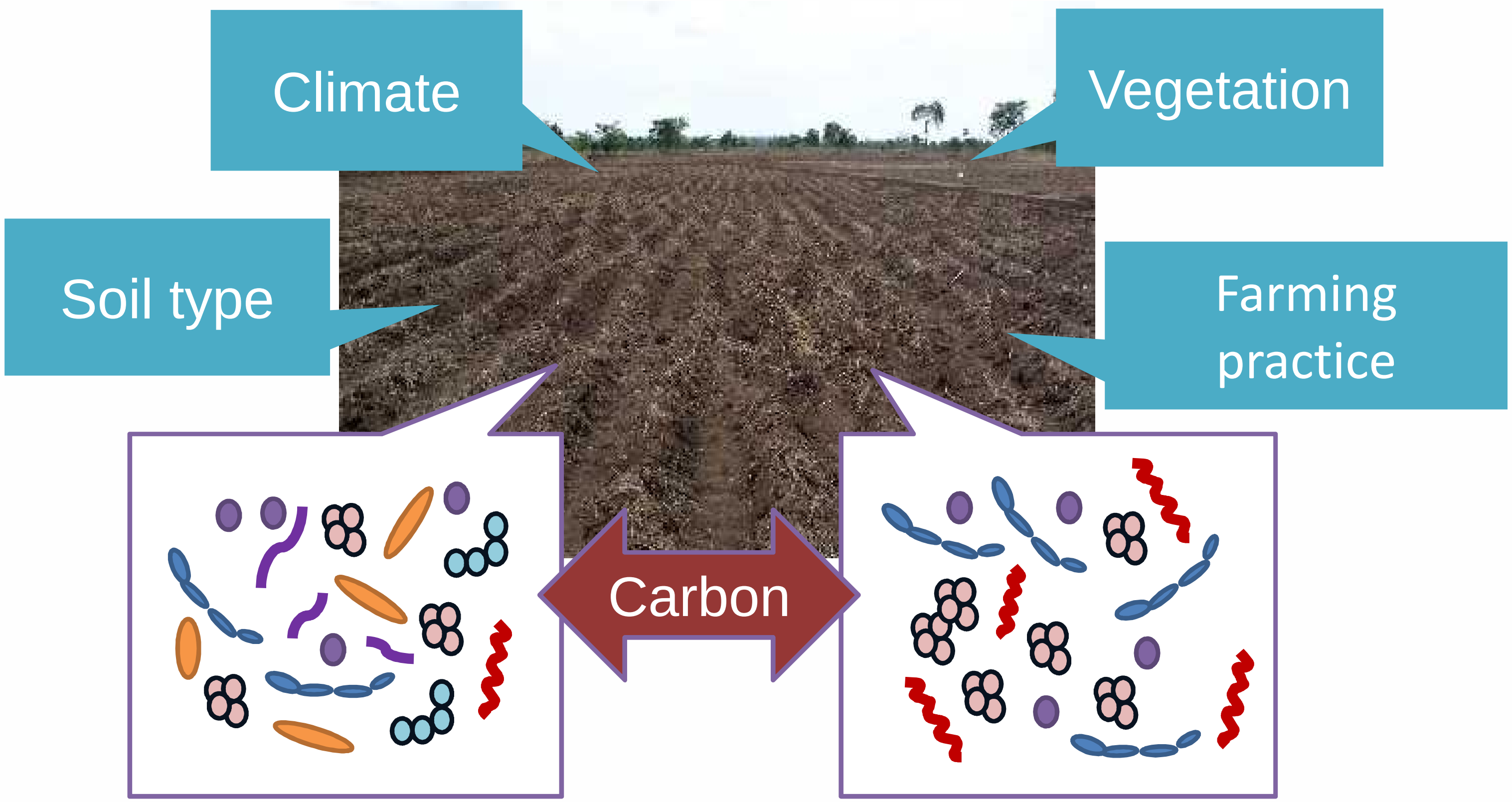
# Soil microbial community structures and activities in relation to nitrogen cycling in two contrasting soils in Malawi - community responses to added carbon -

**Akane Chiba[1], Yoshitaka Uchida[1]**
**Nalivata Patson[2], Njira Keston[2], Satoshi Ishii[3]**
[1]Hokkaido University, Japan
[2]Lilongwe University of Agriculture and Natural Resources, Malawi
[3]University of Minnesota, USA

# Soil microbial community structures influence soil nutrition cycling.




Farming practices could change soil microbial community structures, potentially causing soil functional changes (Berthrong et al., 2013).

# Experimental site in Malawi
# - Two soils managed differently -

**Republic of Malawi, Africa**

Capital: Lilongwe

Climate: Cool dry season (Apr to Aug)
Hot dry season (Aug to Dec)
Rainy season (Dec to Apr)

*Data from Ministry of Foreign Affairs of Japan



**Continuous cropping results in <u>decline of microbial diversity and biomass</u> (Lupwai et al., 1998; Aslam et al.,1999).**

# Soil characteristics of our sites

| | Continuous soil | Fallow soil |
|---|---|---|
| **C(%)** | **1.19** | **2.40** |
| **H(%)** | 0.65 | 1.00 |
| **N(%)** | <0.30 | <0.30 |
| **$NO_3^-$-N(mg N /kg soil)** | **63.74** | **7.17** |
| **$NH_4^+$-N(mg N /kg soil)** | 7.35 | 9.62 |
| **Soil pH** | **4.82** | **5.88** |

*My questions:*

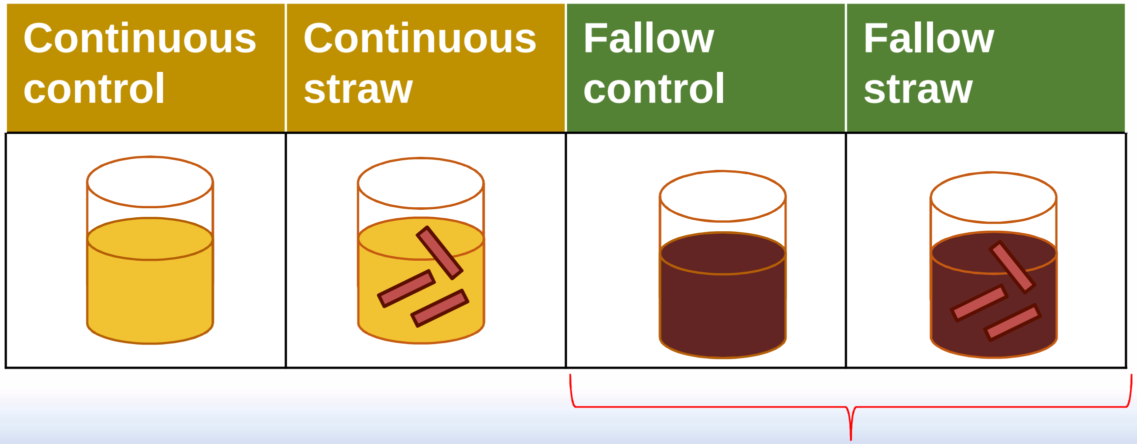
- What are **microbial differences** between the two soils?
- How do microbes **respond to a carbon source**?

## Focus: Soil microbial differences between the fallow and continuous soils.

Finely cut rice straw

- Recalcitrant carbon
- C/N ratio 60-80

| | |
|---|---|
| **Soil** | 80 g |
| **Rice straw** | 12.5 g/kg soil |
| **WHC** | 55% |
| **Replicate** | 4 |




**0.1M $KNO_3$ (53 mg N/kg soil)**

# Measurements

1. **<u>Microbial activities</u> at Day 3, 12, 25, 33**

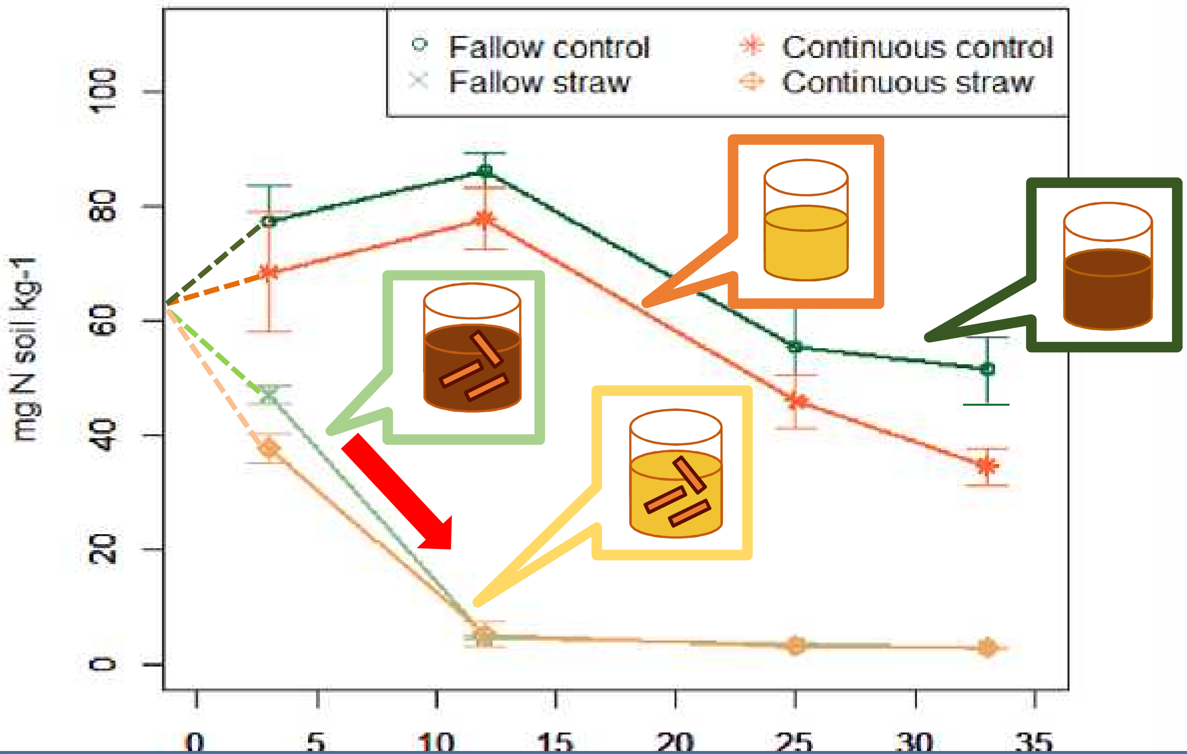
- Changes in $NO_3^-$-N
- $N_2O$ emission

2. **<u>Microbial community</u> at Day 3 and 33**

- 16S amplicon sequencing (Illumina, Miseq)
  - V3 and V4 region of 16S rRNA was targeted

| | |
|---|---|
| **Forward primer** | **5′-TCGTCGGCAGCGTCAGATGTGTATAAGAGACAGCCTACGGGNGGCWGCAG** |
| Reverse primer | 5′-GTCTCGTGGGCTCGGAGATGTGTATAAGAGACAGGACTACHVGGGTATCTAATCC |

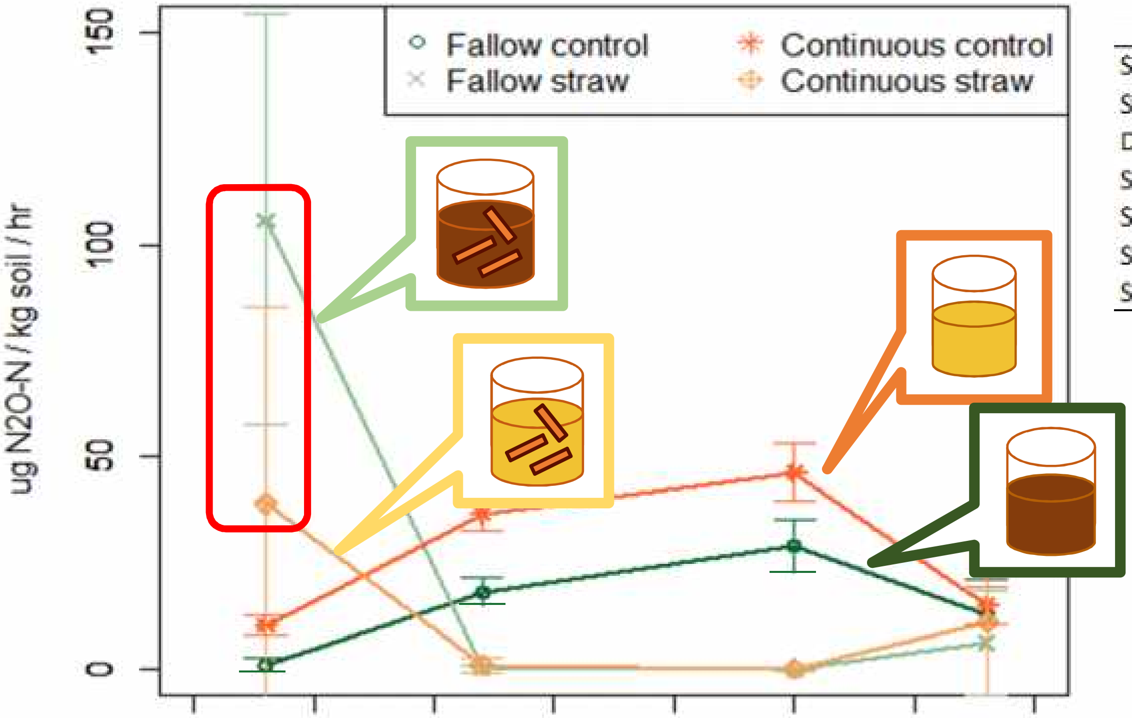
# RESULTS: $NO_3^-$ has quickly reduced after the addition of straw (the trend was similar).




| | *p value* |
|---|---|
| Soil | 0.02 |
| Straw | <0.01 |
| Day | <0.01 |
| Soil x Straw | 0.11 |
| Soil x Day | 0.96 |
| Straw x Day | 0.79 |
| Soil x Straw x Day | 0.29 |

**Immobilization occurred in continuous soil as fast as in fallow soil after the rice straw addition.**

# RESULTS: $N_2O$ emission peak was at the beginning and was higher in fallow soil (+straw).

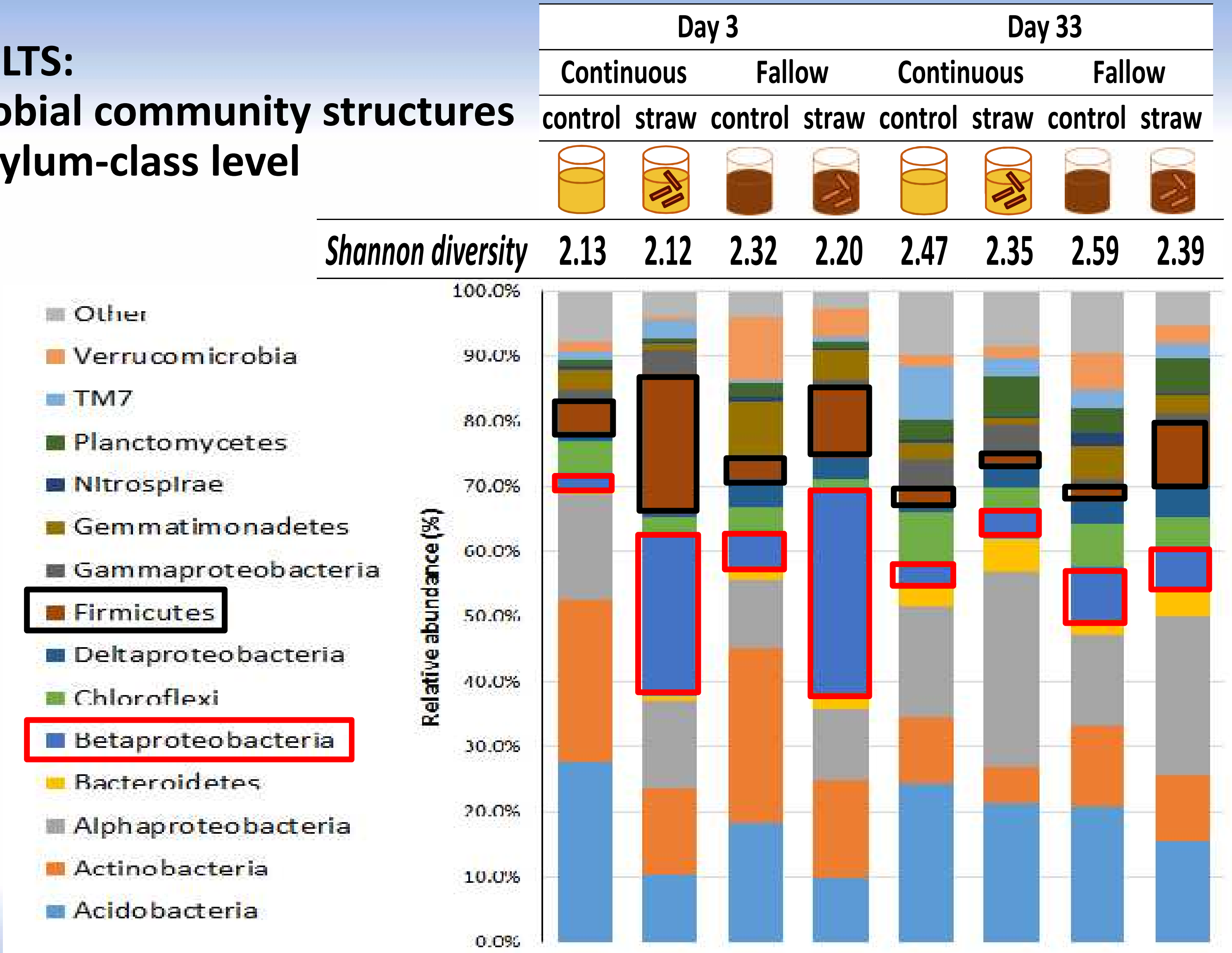



| | *p value* |
|---|---|
| Soil | 0.79 |
| Straw | 0.90 |
| Day | 0.01 |
| Soil x Straw | 0.04 |
| Soil x Day | 0.11 |
| Straw x Day | <0.01 |
| Soil x Straw x Day | 0.05 |

**Denitrification occurred in continuous soil as fast as in fallow soil after the rice straw addition.**

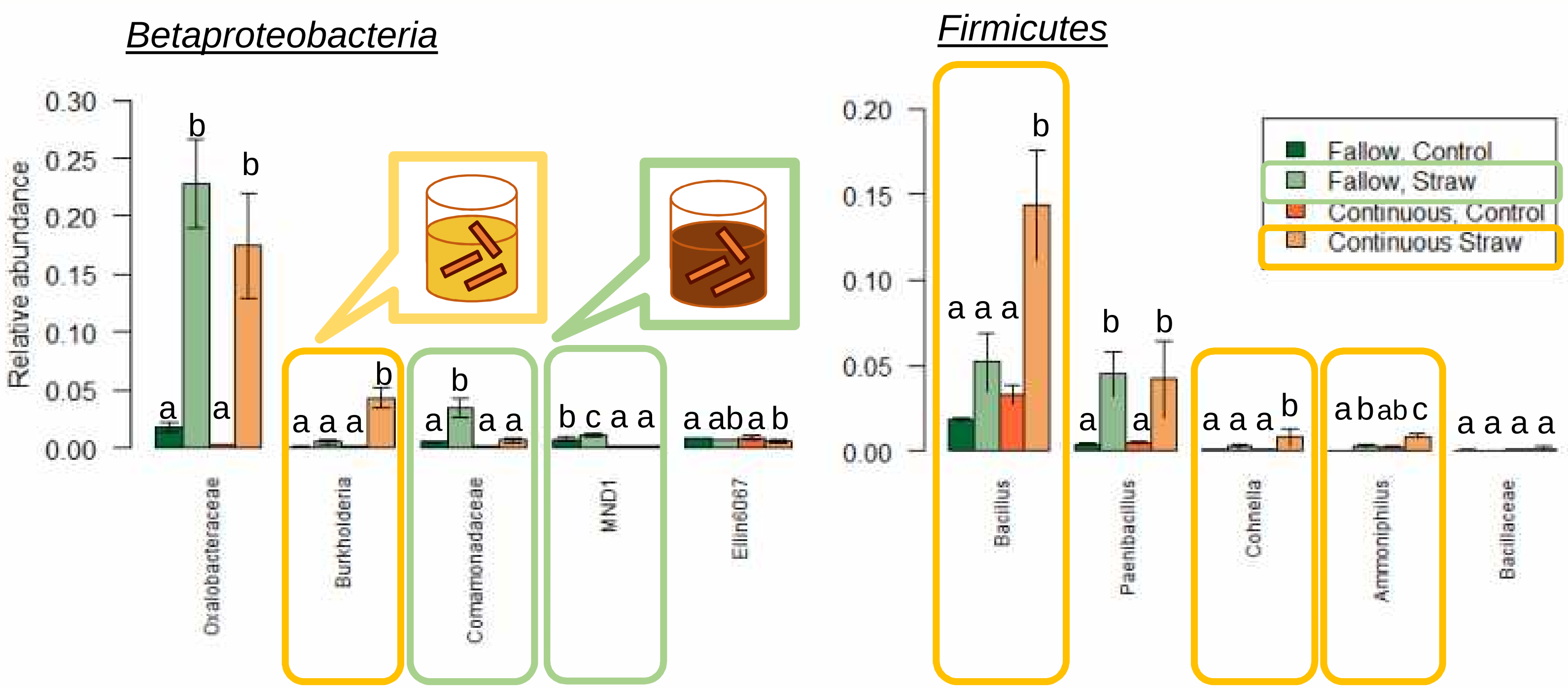
**RESULTS:**

**Microbial community structures at phylum-class level**




PERMANOVA: Day3 $p<0.01$, Day33 $p>0.05$

# RESULTS: Top 5 genera from *Betaproteobacteria* and *Fimicutes* groups




The abundance of microbes at genus level indicated that different microbes might respond to the rice straw application in each soil.

# Discussion: There is a gap between microbial activities and community structures.

1. **Microbial activities ($NO_3^-$ and $N_2O$)**
   - The application of rice straw increased immobilization and denitrification in both fallow and continuous soils.

2. **Microbial community based on 16S rRNA genes**
   - *Betaproteobacteria* and *Firmicutes* increased at Day 3 under the rice straw treatment.

> They were often detected with a high abundance during decomposition process of crop residues
> (Pascault et al.,2010; Shao et al., 2014; Fan et al., 2014)

   - In the presence of rice straw, *Bacillus (Firmicutes)* and *Burkholderia (Betaproteobacteria)* dominated in the "continuous" soil while *Comamonadaceae (Betaproteobacteria)* were abundant in the "fallow" soil.

> Nitrogen activities, such as denitrification and nitrogen fixation, were determined for each family/genus groups.
> (Gillis et al., 1995; Khan et al., 2002; Kim et al., 2005; Verbaendert et al., 2011)

## Conclusion:

- Different microbes might contribute to the nitrogen activities (immobilization/denitrification) in the fallow and the continuous soils.

- Future study should focus on functional genes related to nitrogen transformation. Additionally, long-term investigation will help us to understand the effects of fallowing on maintaining good soil fertility.

# Method : $N_2O$ emission

# RESULTS: Biomass C increased in soils(+straw).