

RELOAD 2018

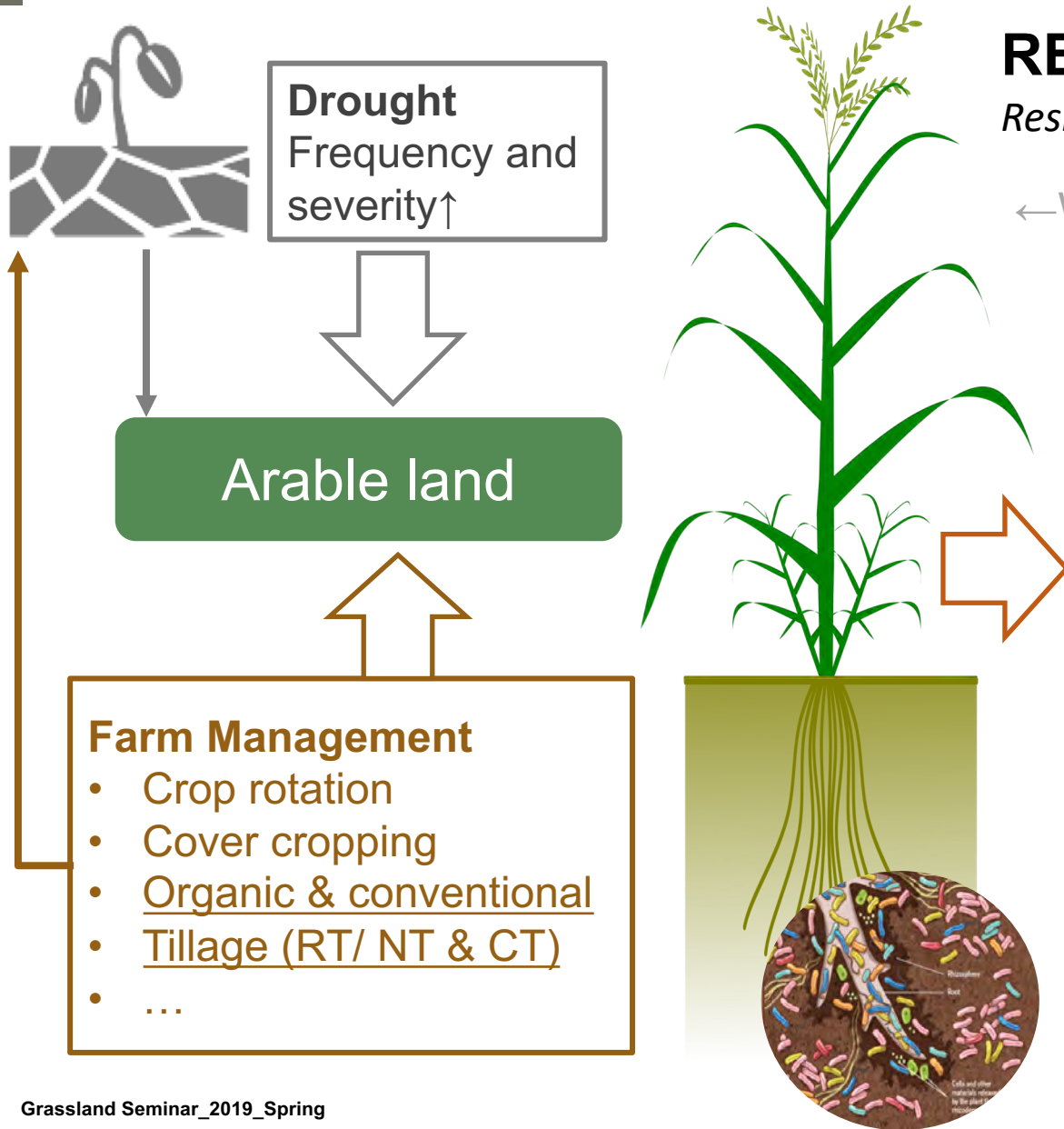


# Ecosystem services of arable land in response to drought

Yujie Liu(1), Valentin Klaus(1), Gicele S. Duarte(1), Anna K. Gilgen(1), Emily O. Hagen(2), Raphaël Wittwer(2), and Nina Buchmann(1)

(1) Institute of Agricultural Sciences, Department of Environmental Systems Science, ETH Zürich

(2) Ecological Farming Group, Agroscope Reckenholz Tänikon



# RELOAD Project

*Resilience of Organic and Conventional Production Systems to Drought*

←WP1: Crop water uptake, physiology, and vulnerability

## WP3: Multiple Ecosystem services

**Provision Services**  
 Yield/ biomass  
 Crop quality  
 Crop growth performance

**Regulation Services**  
 Nitrate leaching risk  
 Plant infection and herbivory  
 Soil coverage

**Supporting Services**  
 Soil fertility (N availability, SOC..)  
 Symbiotic N<sub>2</sub> fixation of legumes  
 Litter decomposition

←WP2: How microbial communities are affected by drought and influence crop growth?



# What is the performance of **cropping systems** facing drought considering multiple services?

- Keywords: cropping systems



# What is the performance of cropping systems facing **drought** considering multiple services?

- Keywords: cropping systems, drought



# What is the performance of cropping systems facing drought considering **multiple services**?

- Keywords: cropping systems, drought, multiple services

# Farming System and Tillage Experiment - *FAST Trial*

## Cropping Systems



**C-IT**  
Conv. Intensive Tillage

**C-NT**  
Conv. No Tillage

- Mineral fertilization
- Use of herbicides
- Pesticides (glyphosate)



**O-IT**  
Org. Intensive Tillage

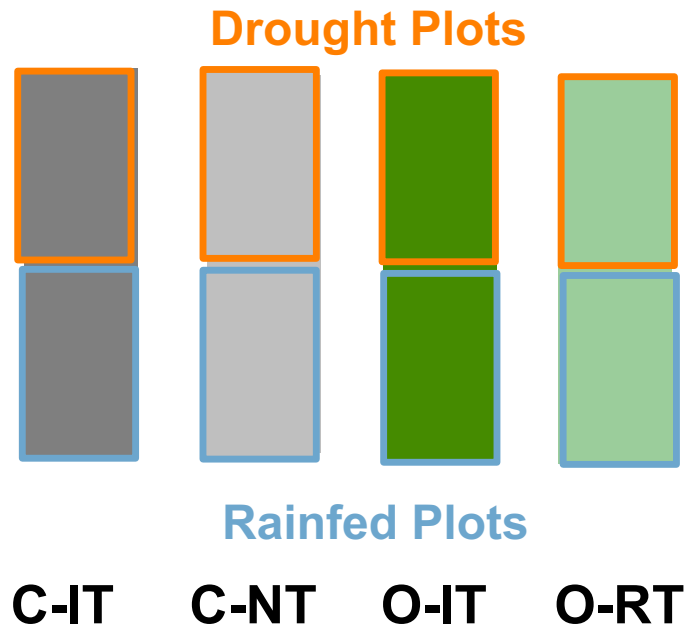
**O-RT**  
Org. Reduced Tillage

- Organic fertilizer (cattle slurry)
- Mechanical weed control

## Cropping Rotation

- Pea & barley- 2018
- Winter wheat- 2019

## Drought Treatment



## Aboveground measurement

- Crop yield/ biomass/ weed biomass
- Crop quality
- Plant height
- Leaf area and infection
- LAI (2cm)

## Belowground measurement

- Decomposition (5cm)
- Plant available N (10cm)
- Nitrate leaching (40cm)

# Drought Phases

Pre-drought

Simulated drought

Portable roof

Post-drought

Harvest

*Resistance to drought*

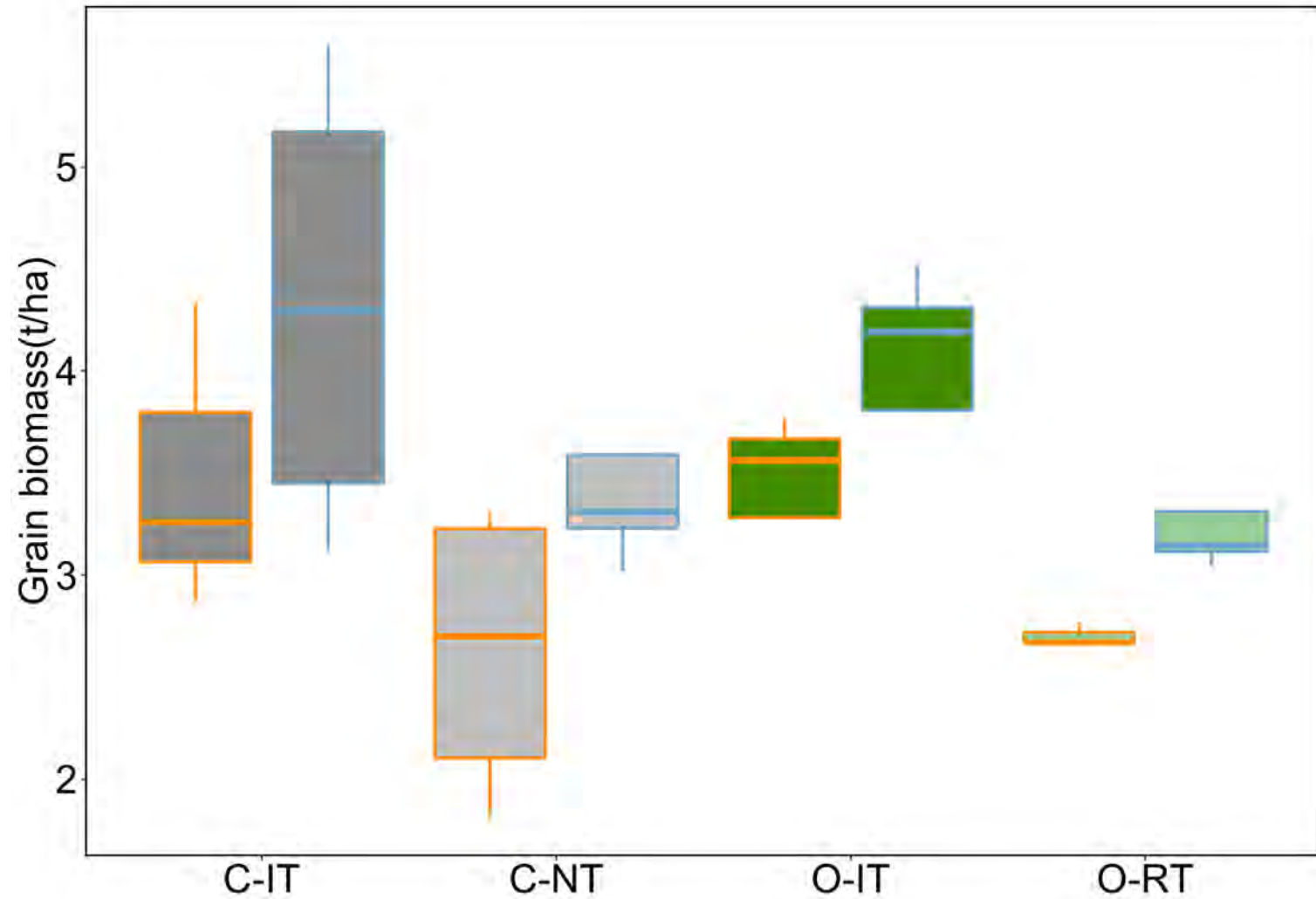
*Recovery after drought*

*Resilience to drought*



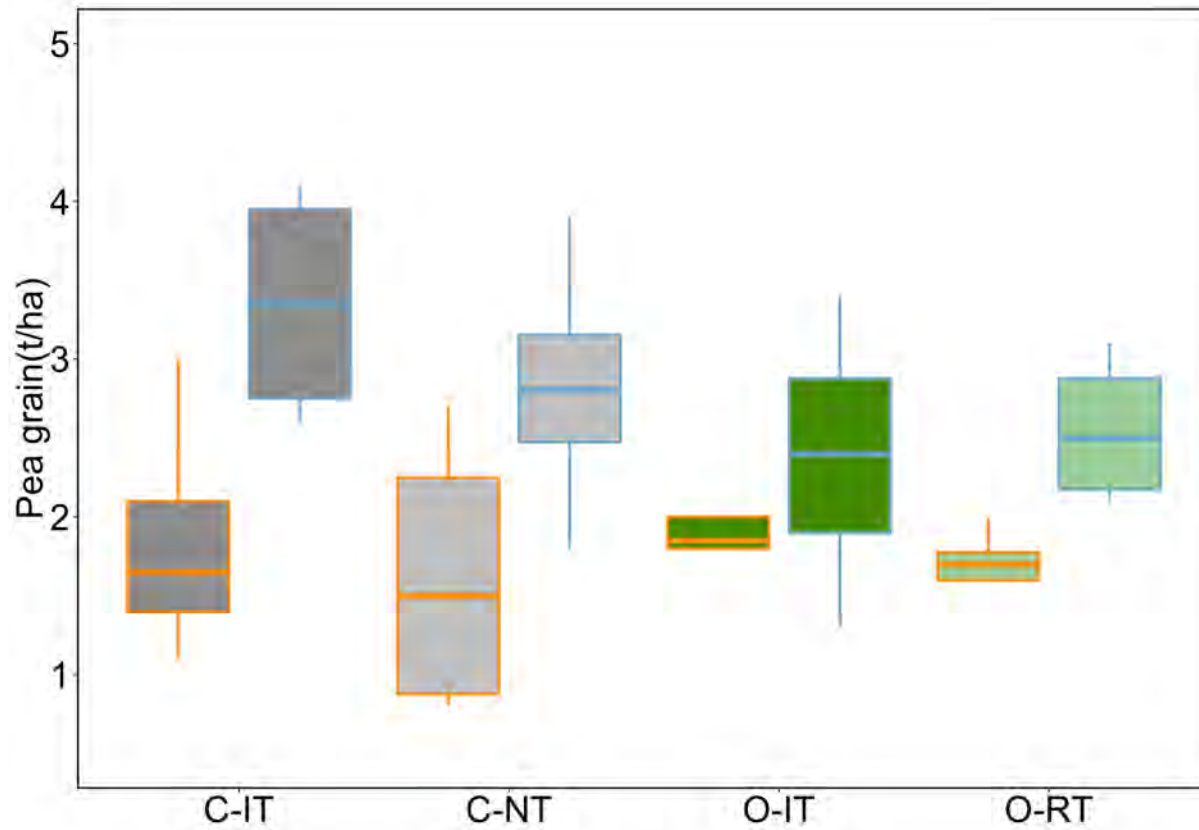


# Yield\_2018

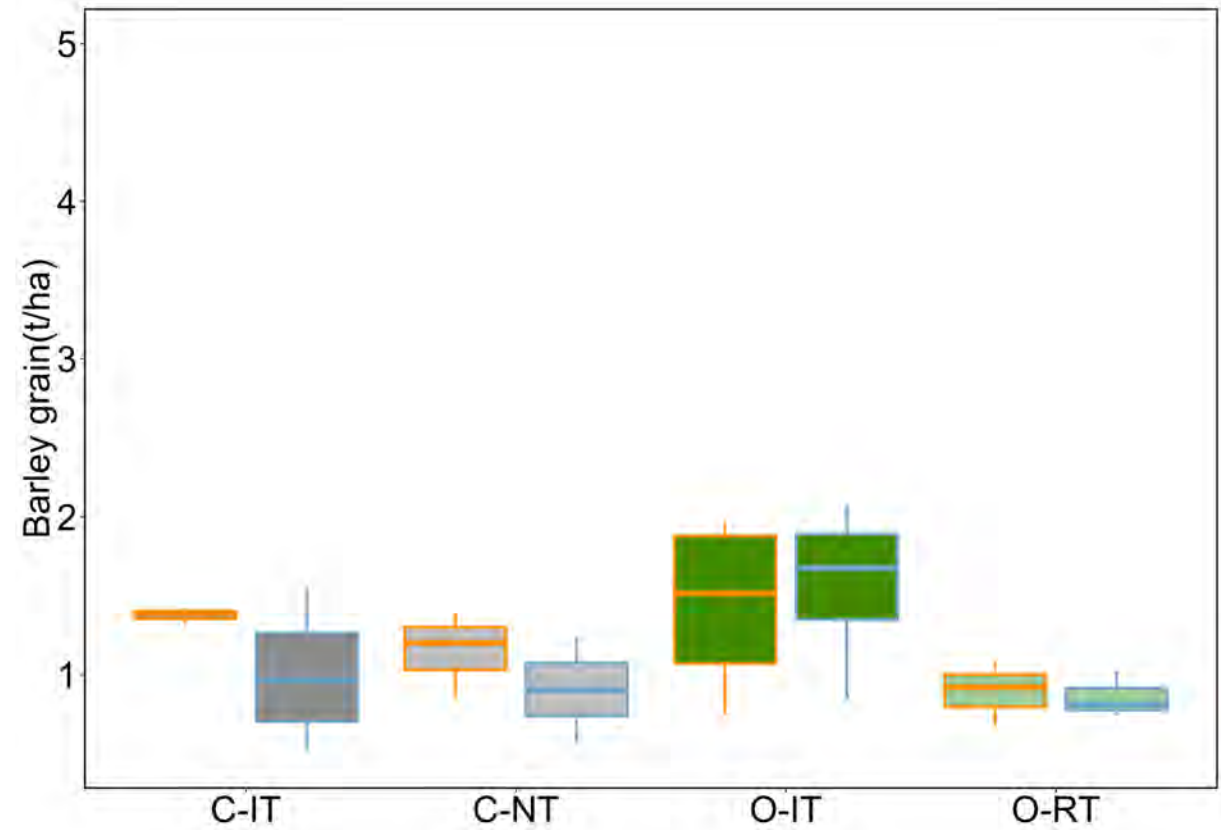


**Yield= grain biomass**  
Cropping System\*(Tillage\*\*)  
Drought\*\*

# Yield for pea and barley\_2018

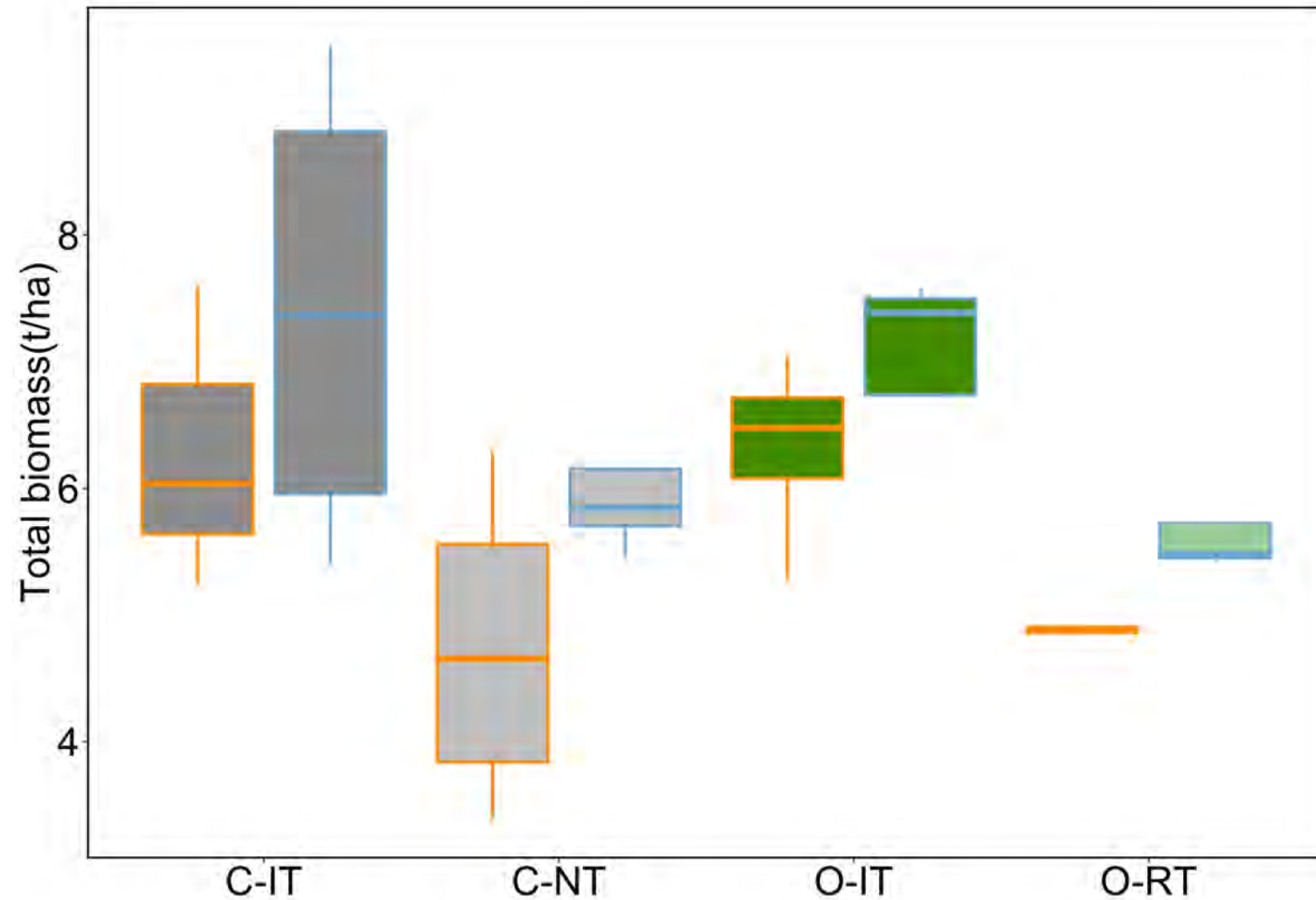


**Pea yield**  
Drought\*\*\*



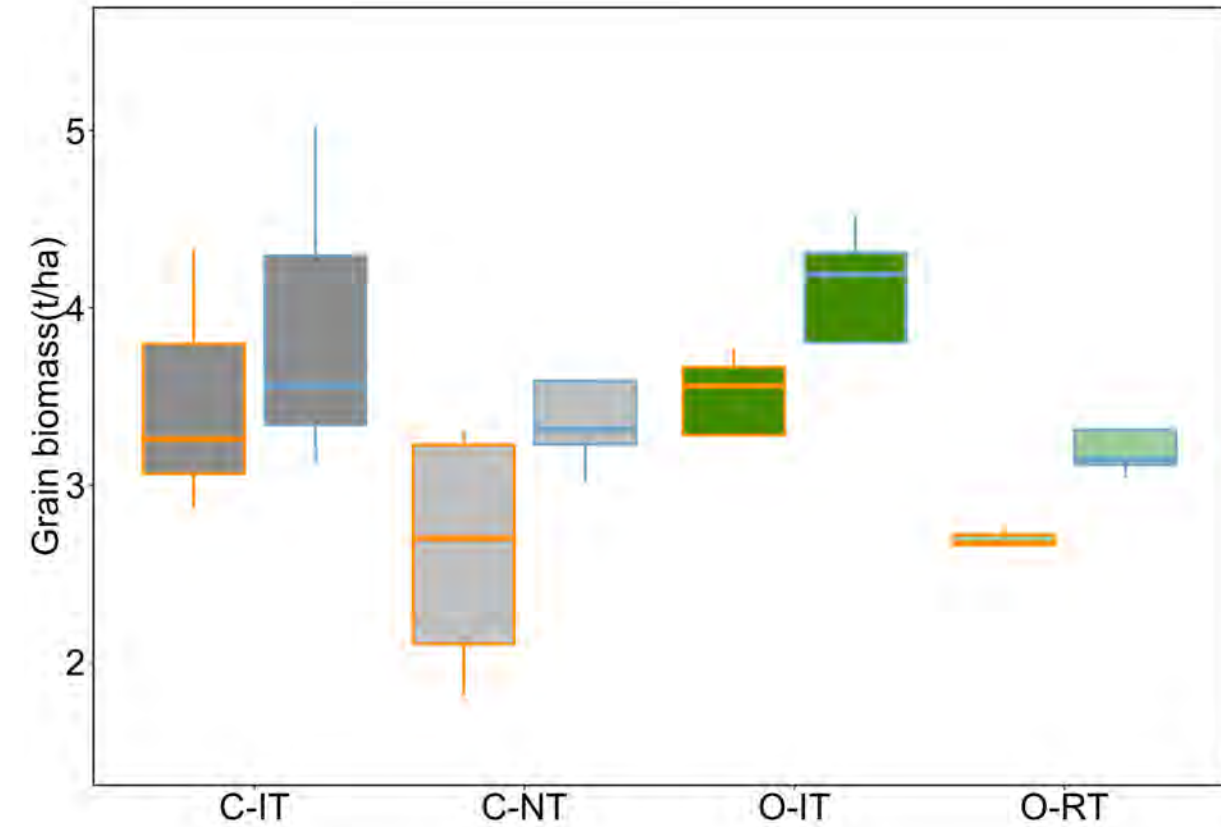
**Barley yield**  
Cropping systems\*\*(tillage\*\*)

# Total Biomass\_2018



**Total Biomass= grain  
biomass+ straw biomass**  
Cropping System\*\* (Tillage\*\*\*)  
Drought\*

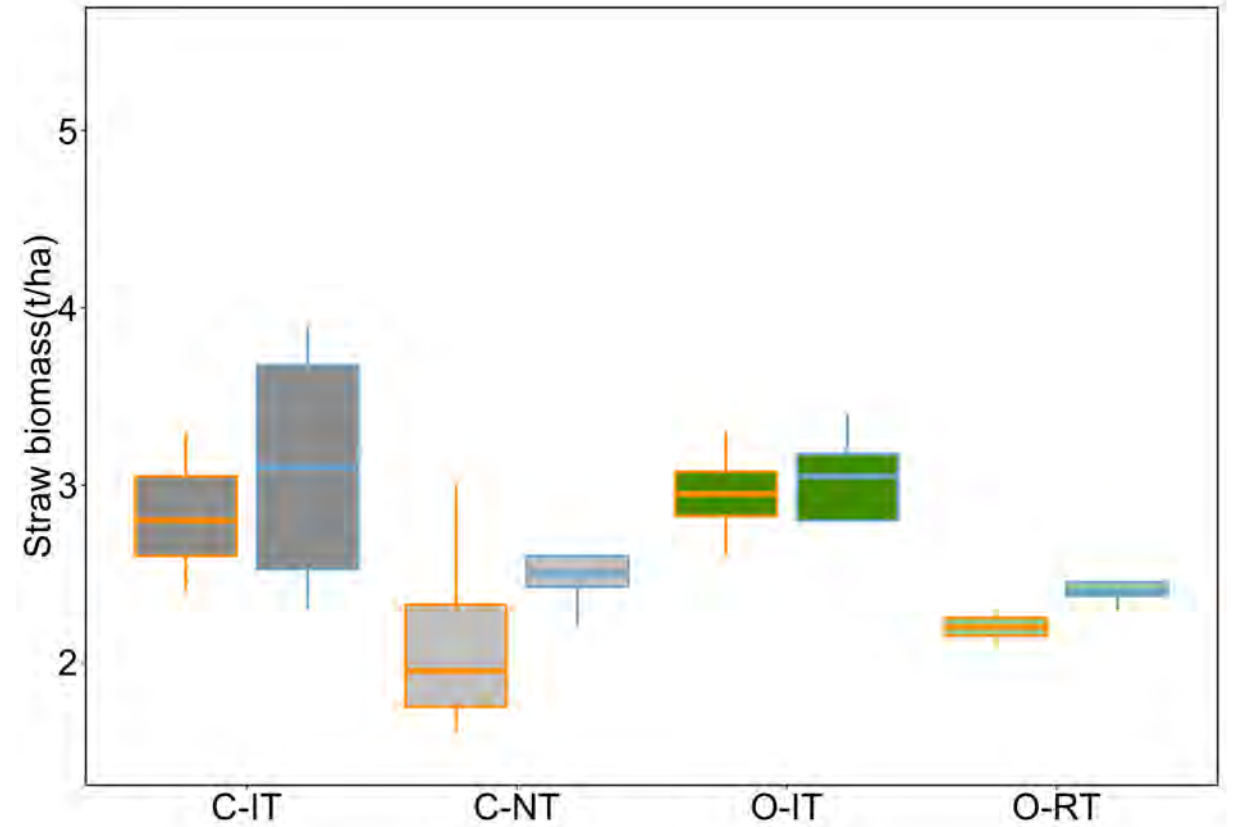
# Grain & Straw\_2018



## Grain biomass

Cropping System\*(Tillage\*\*)

Drought\*\*

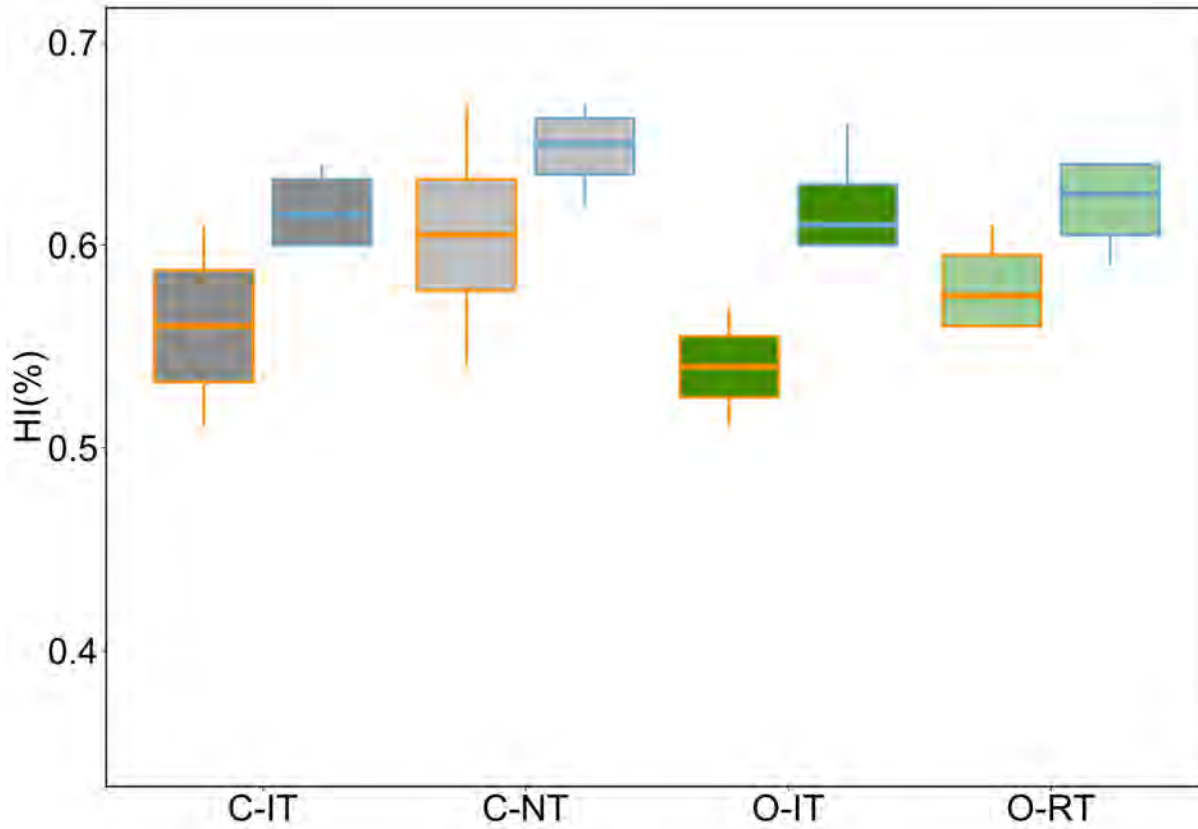


## Straw biomass

Cropping System\*\*(Tillage\*\*)

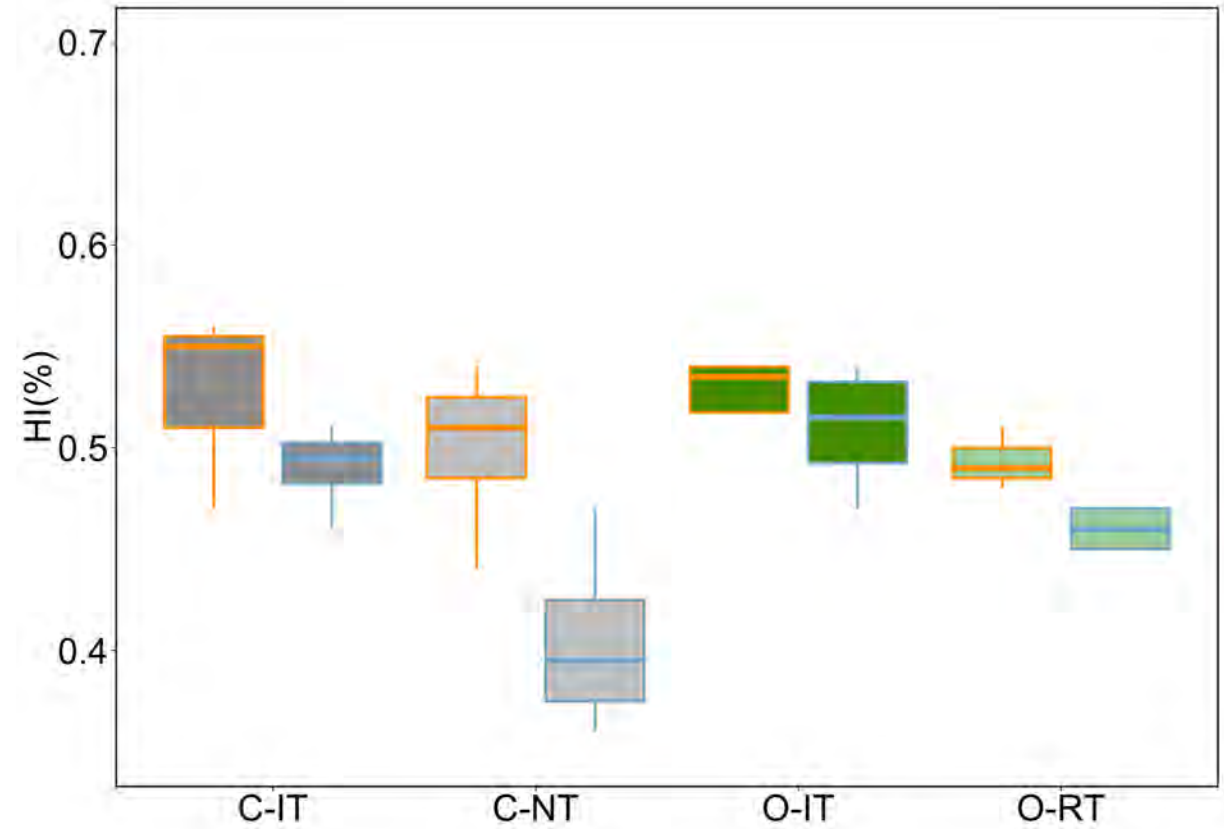
# Harvest index\_2018

■ C-IT ■ C-NT ■ O-IT ■ O-RT



## Pea

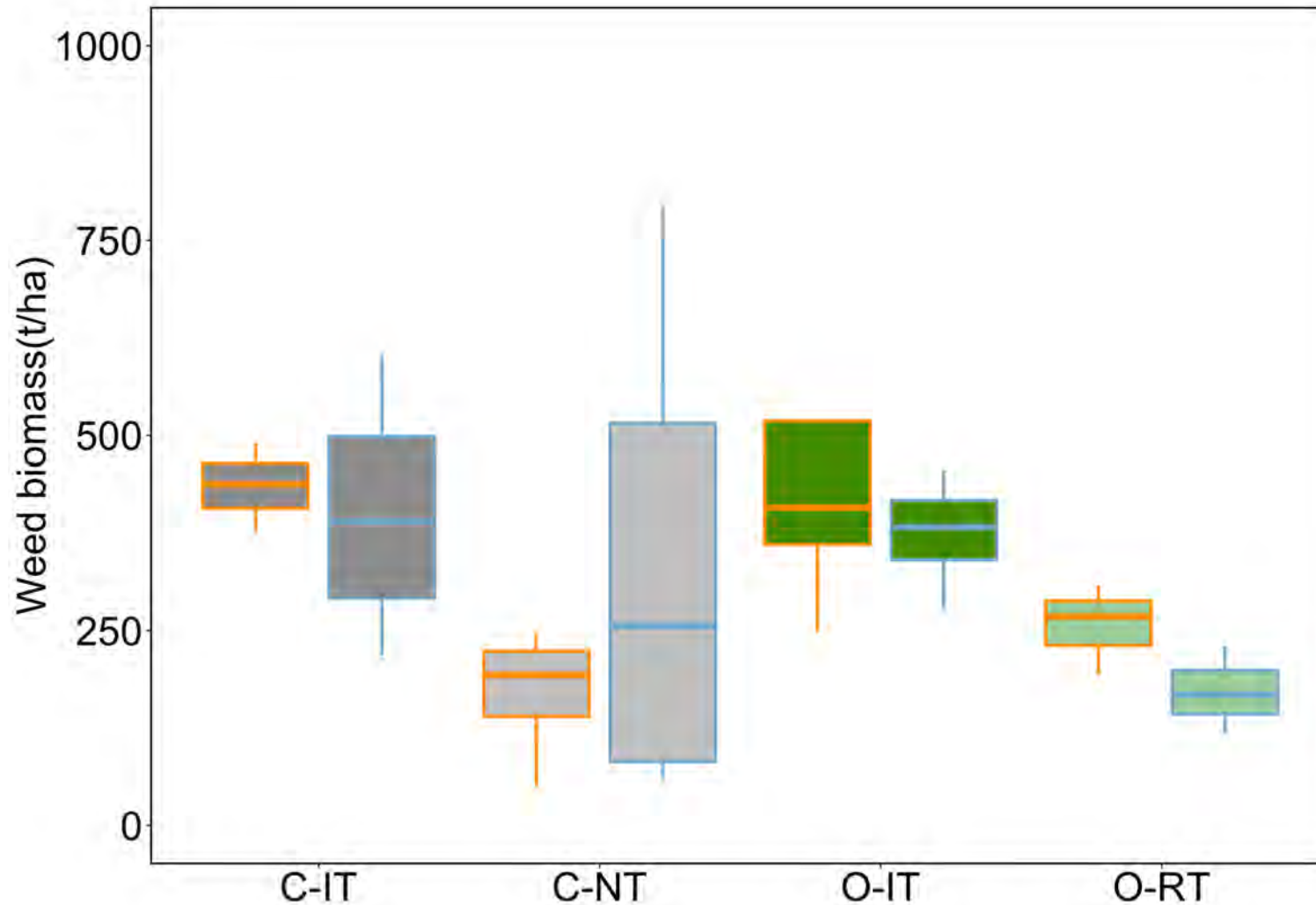
Cropping System\*(Tillage\*)  
Drought\*\*\*



## Barley

Cropping System\*\*(Tillage\*\*\*)  
Drought\*\*\*

# Weed biomass



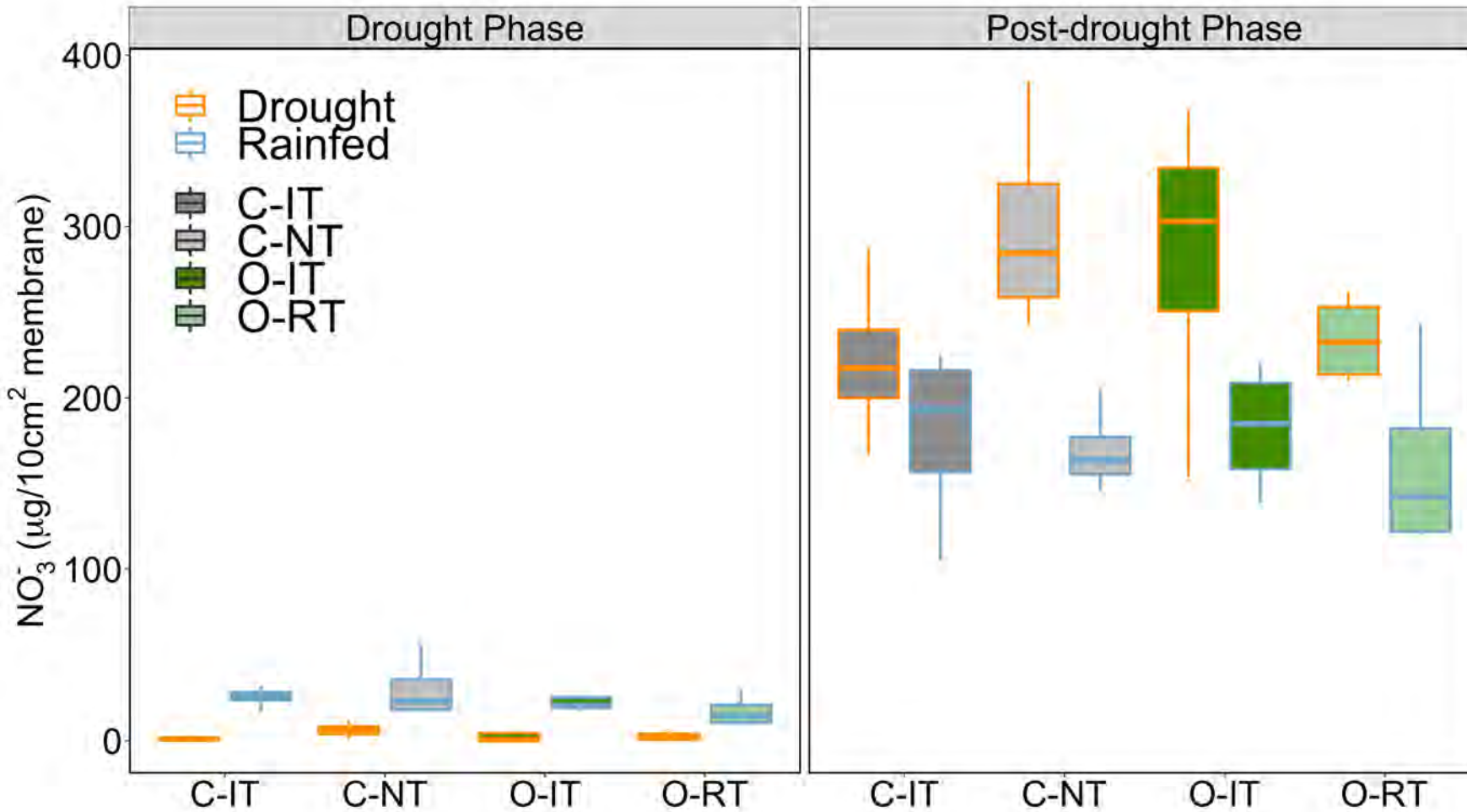
**No significant** difference among conventional and organic plots

## Plant available N ( $\text{NO}_3^-$ and $\text{NH}_4^+$ )



**Anion probes (orange):** absorb nitrate  
**Cation probes (purple):** absorb ammonium

# Soil fertility- Plant available NO<sub>3</sub>-N



**14 days for both:**

**Drought phase**

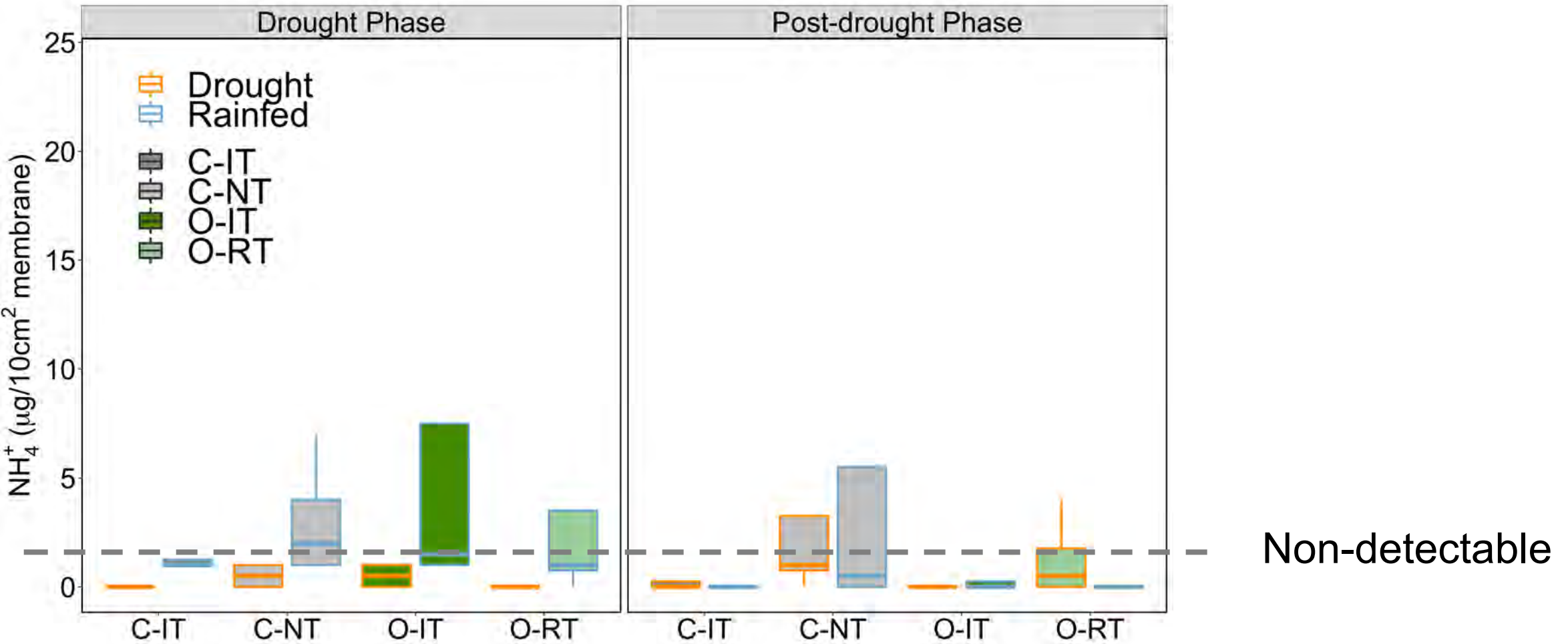
Drought<sup>\*\*\*</sup>

**Post-drought phase**

Drought<sup>\*\*\*</sup>



# Plant available $\text{NH}_4\text{-N}$

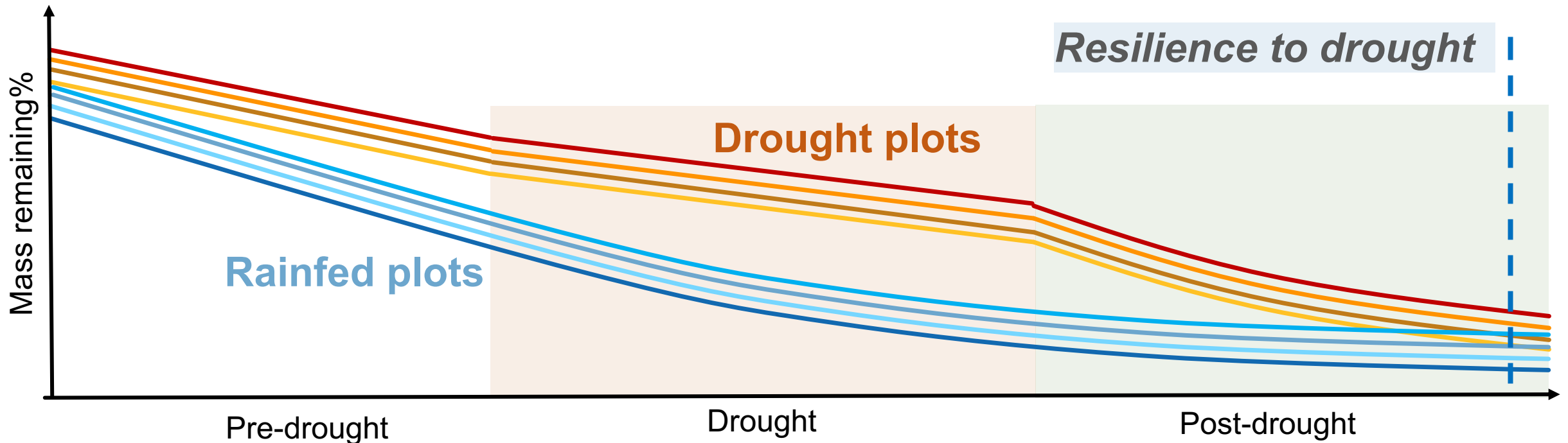


# Hypotheses for litter decomposition

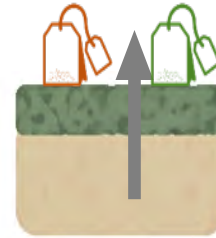
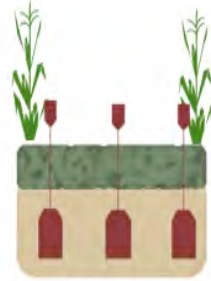
H1. Different **cropping systems** vary in litter mass remaining.

H2. **Drought** has significant effect on litter mass remaining during drought.

H3. There is a **short-term legacy effect** from drought on litter mass remaining.



# Tea bag method



Label, dry and weigh  
Primary weight

3 replicates  
5 cm in soil

Retrieve

Dry and weigh  
Final weight



Lower C:N  $\approx 12$   
Faster decomposition rate

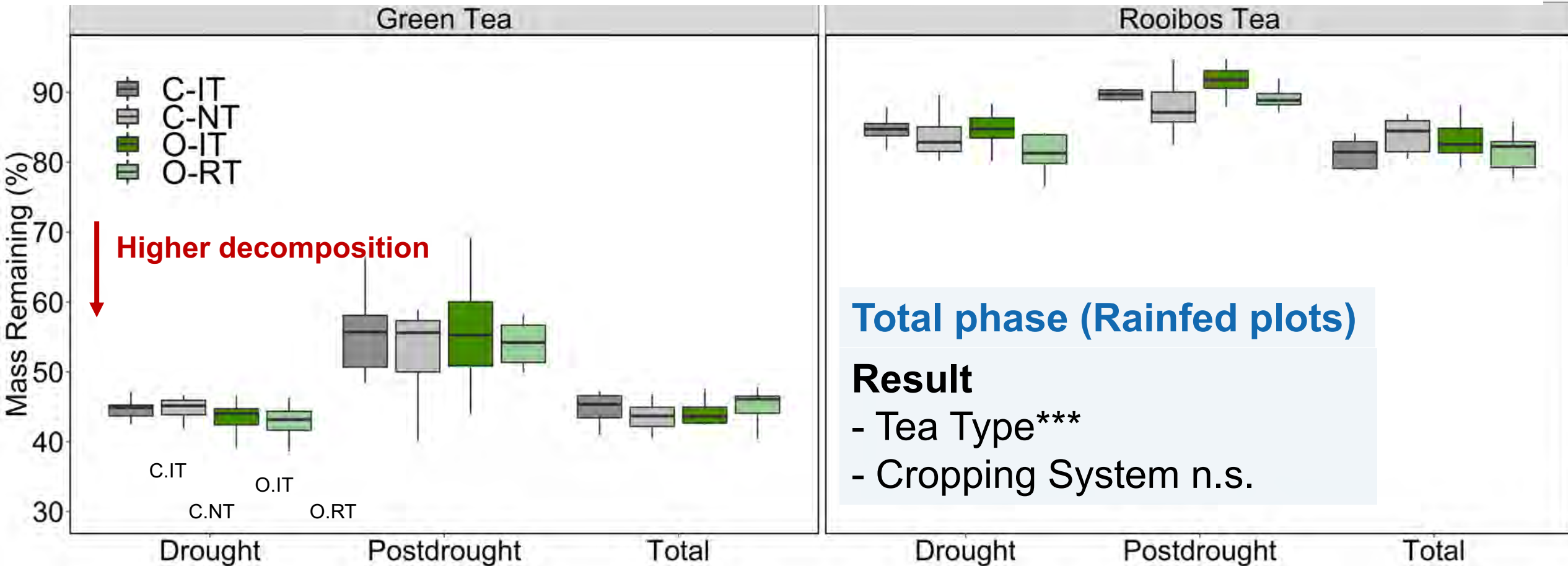


Higher C:N  $\approx 43$   
Slower decomposition rate

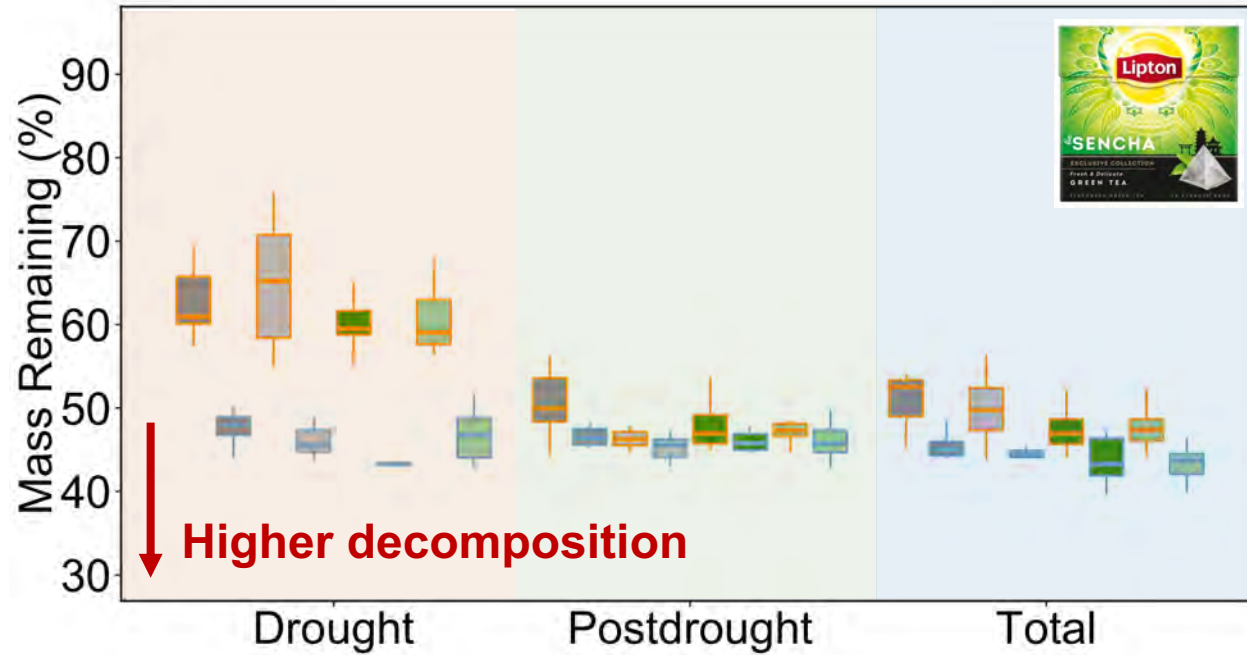


Proportional  
litter mass remaining%

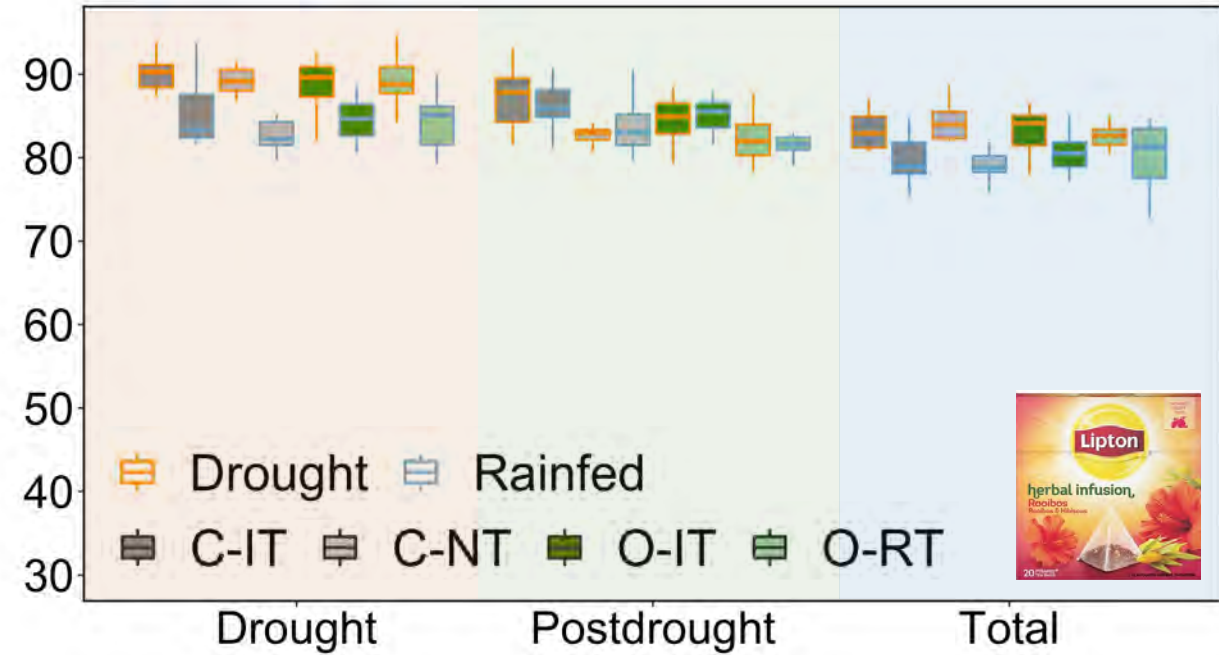
# Decomposition- Pea and barley



# Decomposition- Pea & barley



<p><b>Drought phase</b> Drought *** ↑</p>	<p><b>Post-drought phase</b> Drought*** ↑, Cropping System*</p>
<p><b>Total phase</b> Drought***↑</p>	

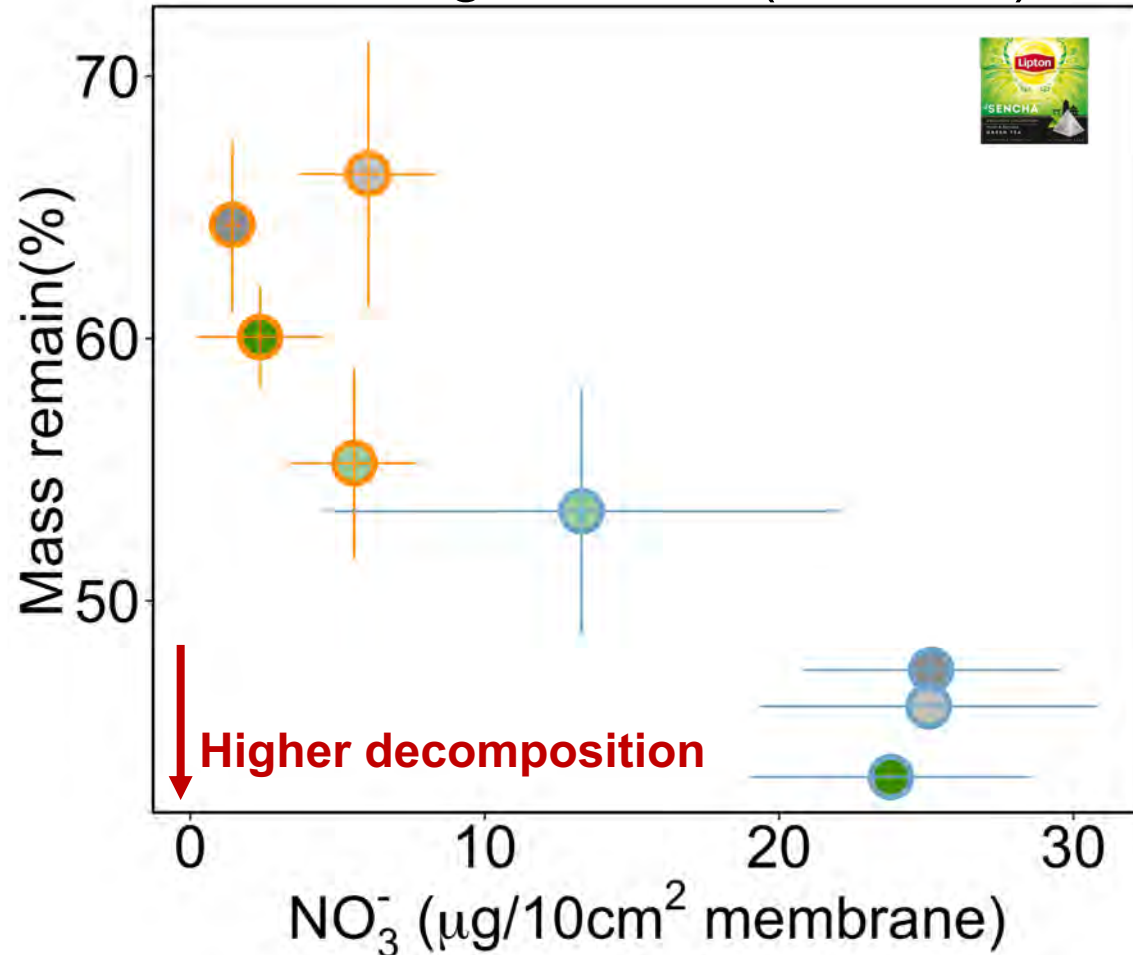


<p><b>Drought phase</b> Drought *** ↑</p>	<p><b>Post-drought phase</b> Cropping System*</p>
<p><b>Total phase</b> Drought***↑</p>	

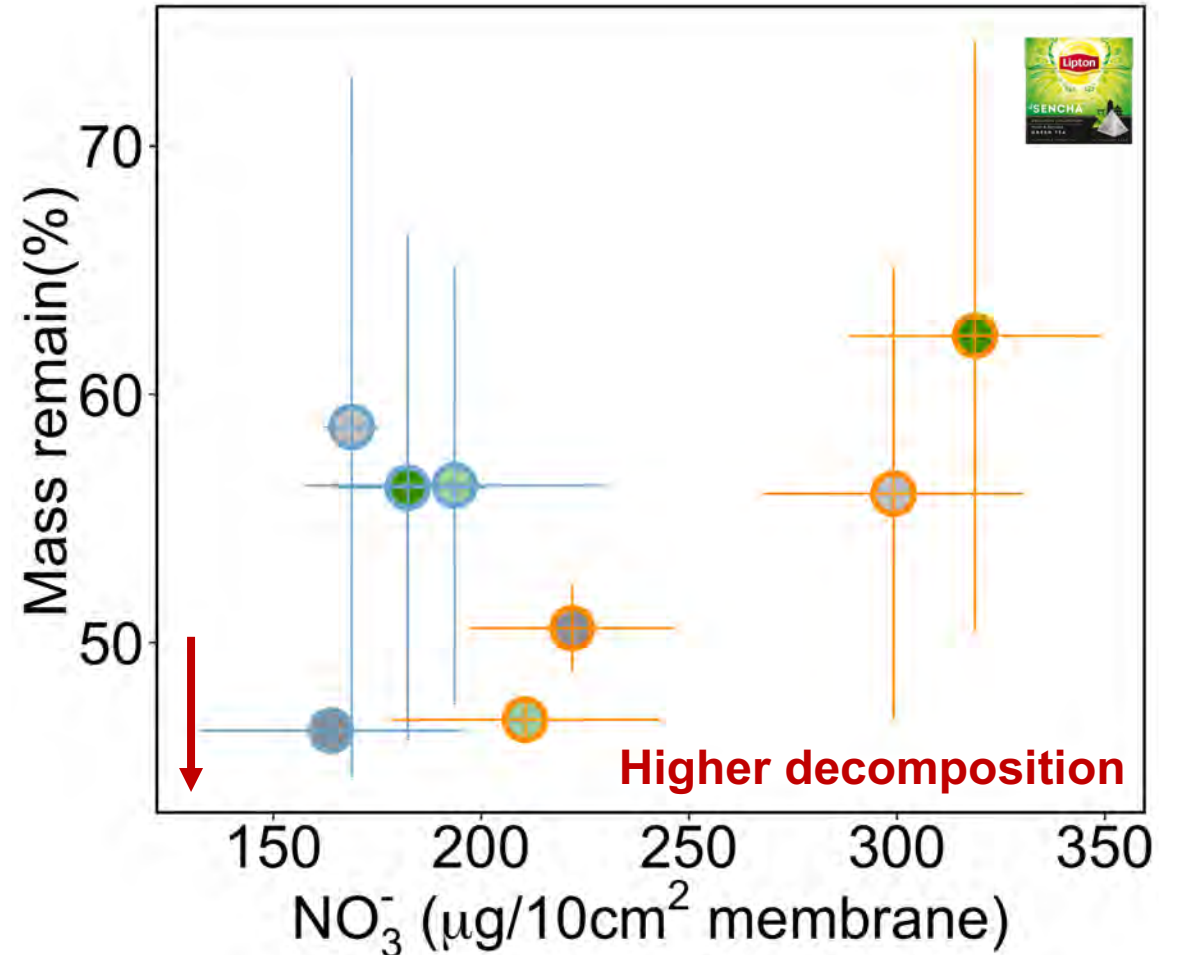
Decomposition &  $\text{NO}_3^-$ 

● C-IT ● C-NT ● O-IT ● O-RT ● Drought ● Rainfed

Drought Phase (5 weeks)

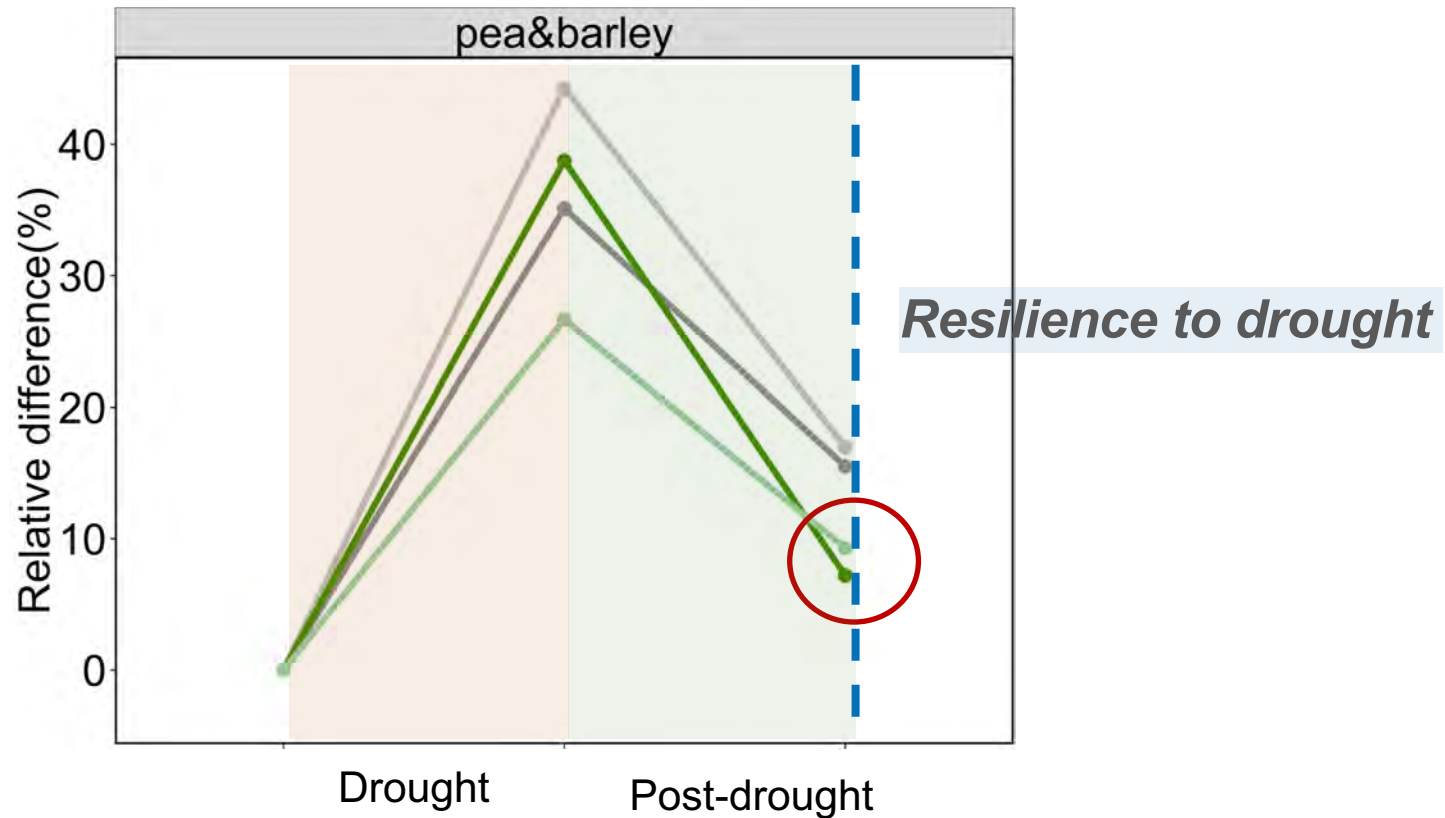


Post-drought Phase (2.5 weeks)



# Resilience of cropping systems

● C-IT  
 ● C-NT  
 ● O-IT  
 ● O-RT



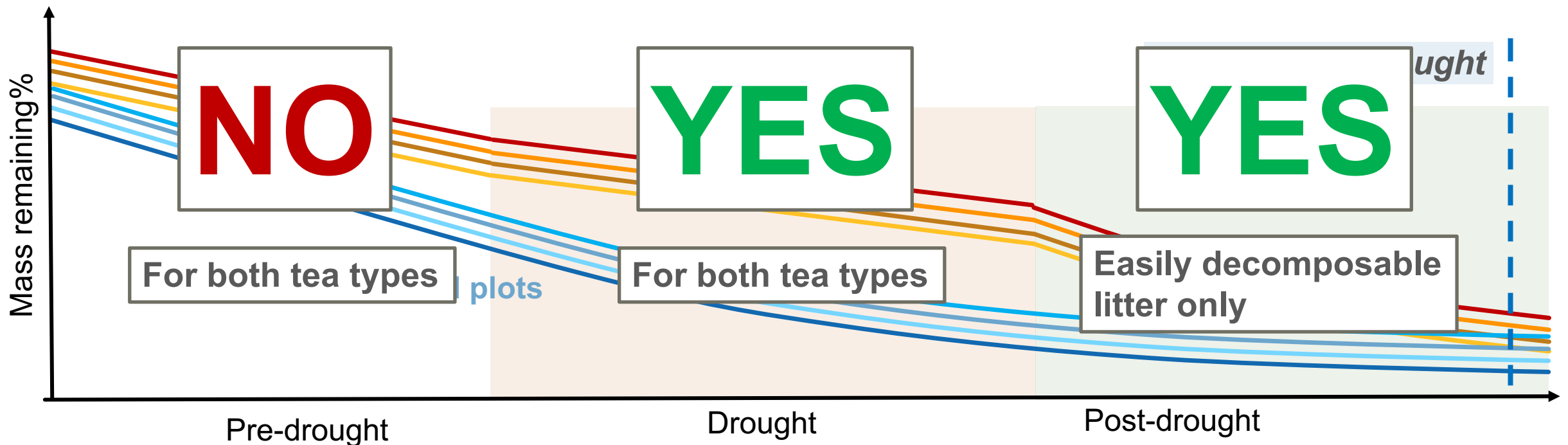
- No significant differences in resilience between cropping systems
- By tendency organic farming is more resilient in pea&barley

# Conclusion for litter decomposition

H1. Different **cropping systems** vary in litter mass remaining.

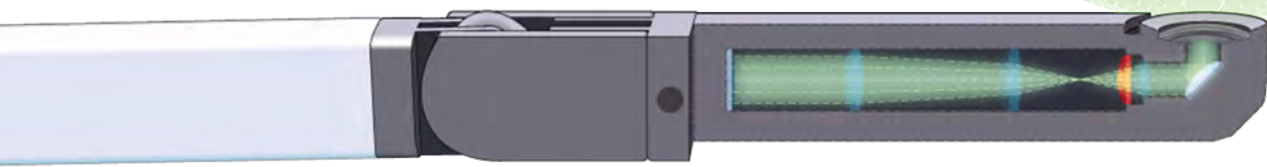
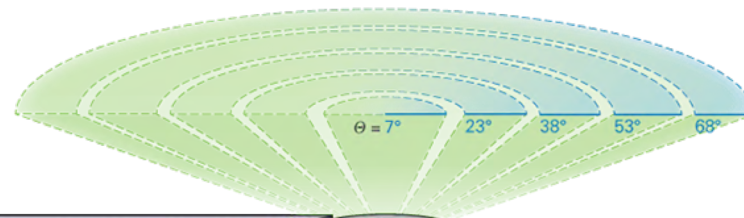
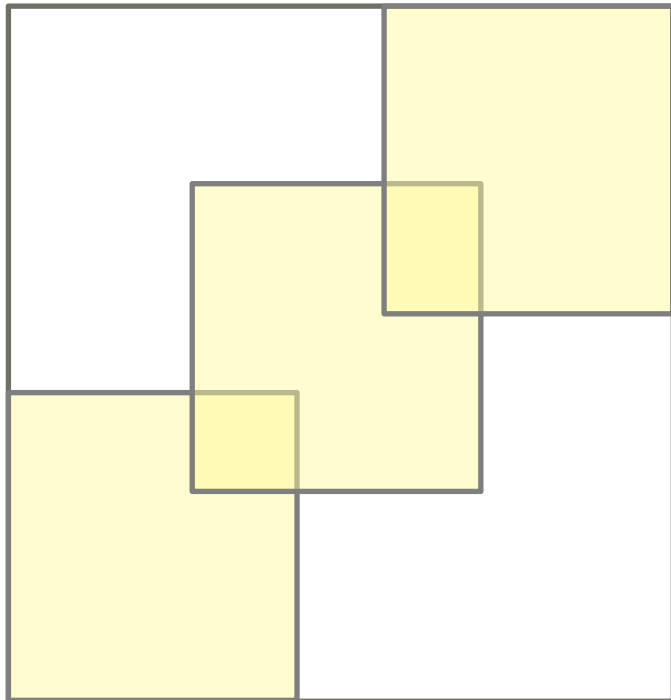
H2. **Drought** has significant effect on litter mass remaining during drought.

H3. There is a **short-term legacy effect** from drought on litter mass remaining.





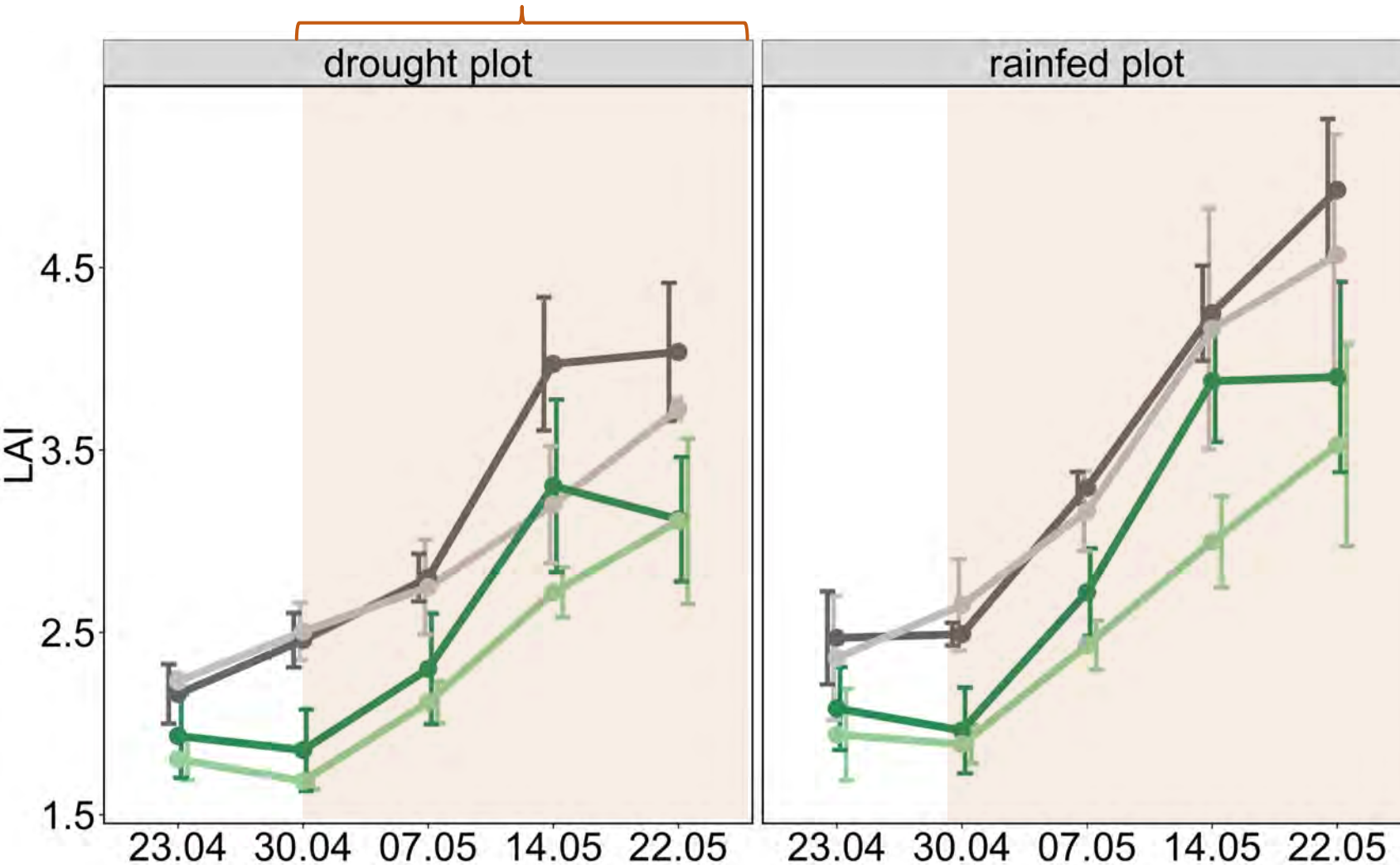
# LAI- 2019



## LAI\_2019

Drought phase

■ C\_IT  
 ■ C\_NT  
 ■ O\_IT  
 ■ O\_RT



Measured every week

**23.04**

cropping\*(organic.)

**30.04**

cropping\*\*\*(organic\*\*)

**07.05**

cropping\*\*(till\*), drought\*

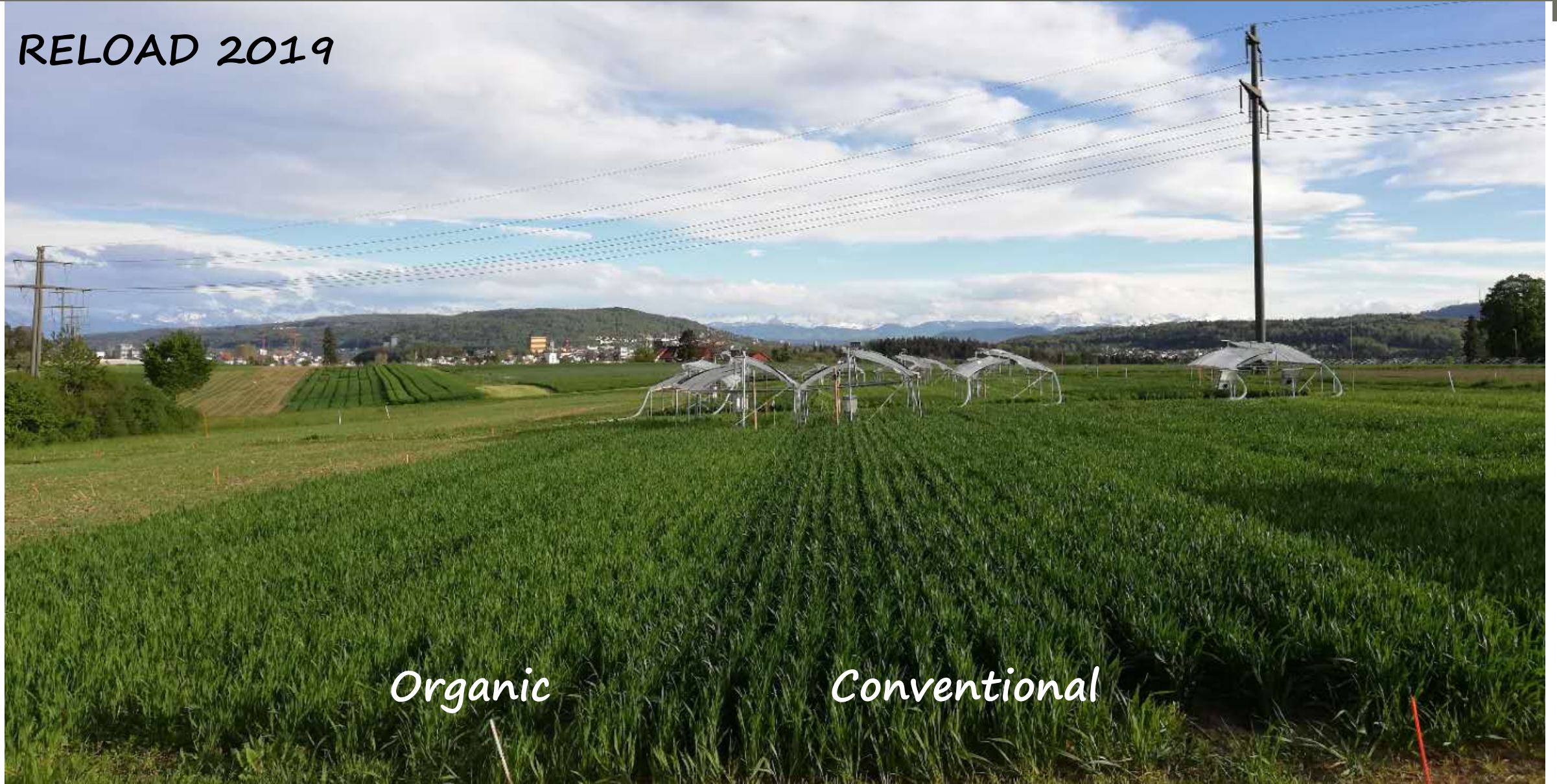
**14.05**

cropping\*\*(till\*), drought\*

**22.05**

cropping\*(organic\*), drought\*

# RELOAD 2019



*Organic*

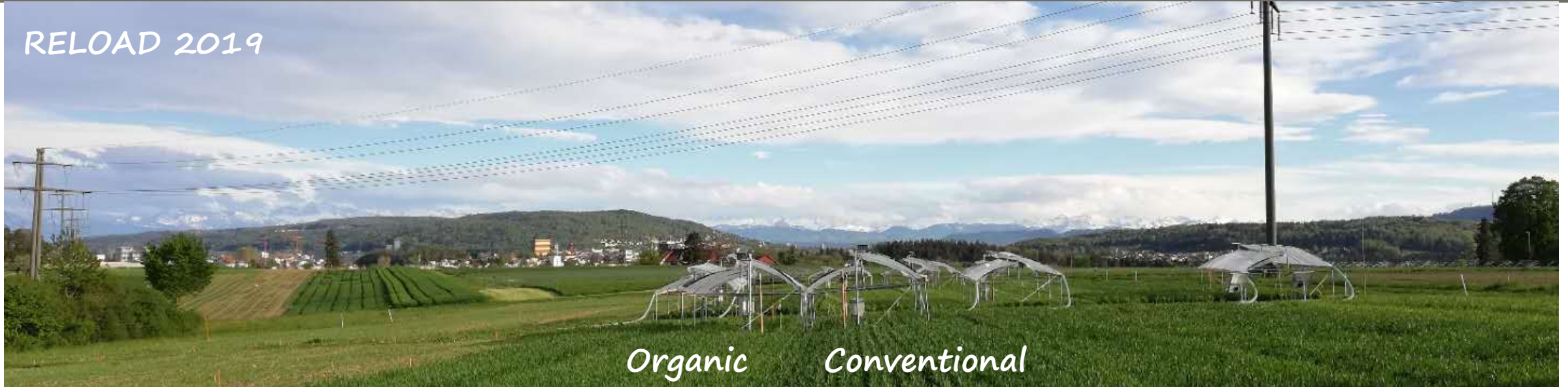
*Conventional*

## Take home message

● C-IT  
 ● C-NT  
 ● O-IT  
 ● O-RT  
 ⊖ Drought  
 ⊖ Rainfed

Services	Drought plots		Rainfed plots	
	drought	post-drought	drought	post-drought
Yield	O-IT*		C-IT*	
NO3-	C-NT	O-IT	C-IT	C-IT
Decomposition	O-RT	C-NT	O-IT*	C-NT*
Weed control	C-NT		O-RT	
LAI	C-IT*	C-IT*	N.A.	N.A.

RELOAD 2019



*Organic*      *Conventional*

**Thanks for your attention! Question?**

**Yujie Liu**

**Email: [yujie.liu@usys.ethz.ch](mailto:yujie.liu@usys.ethz.ch)**