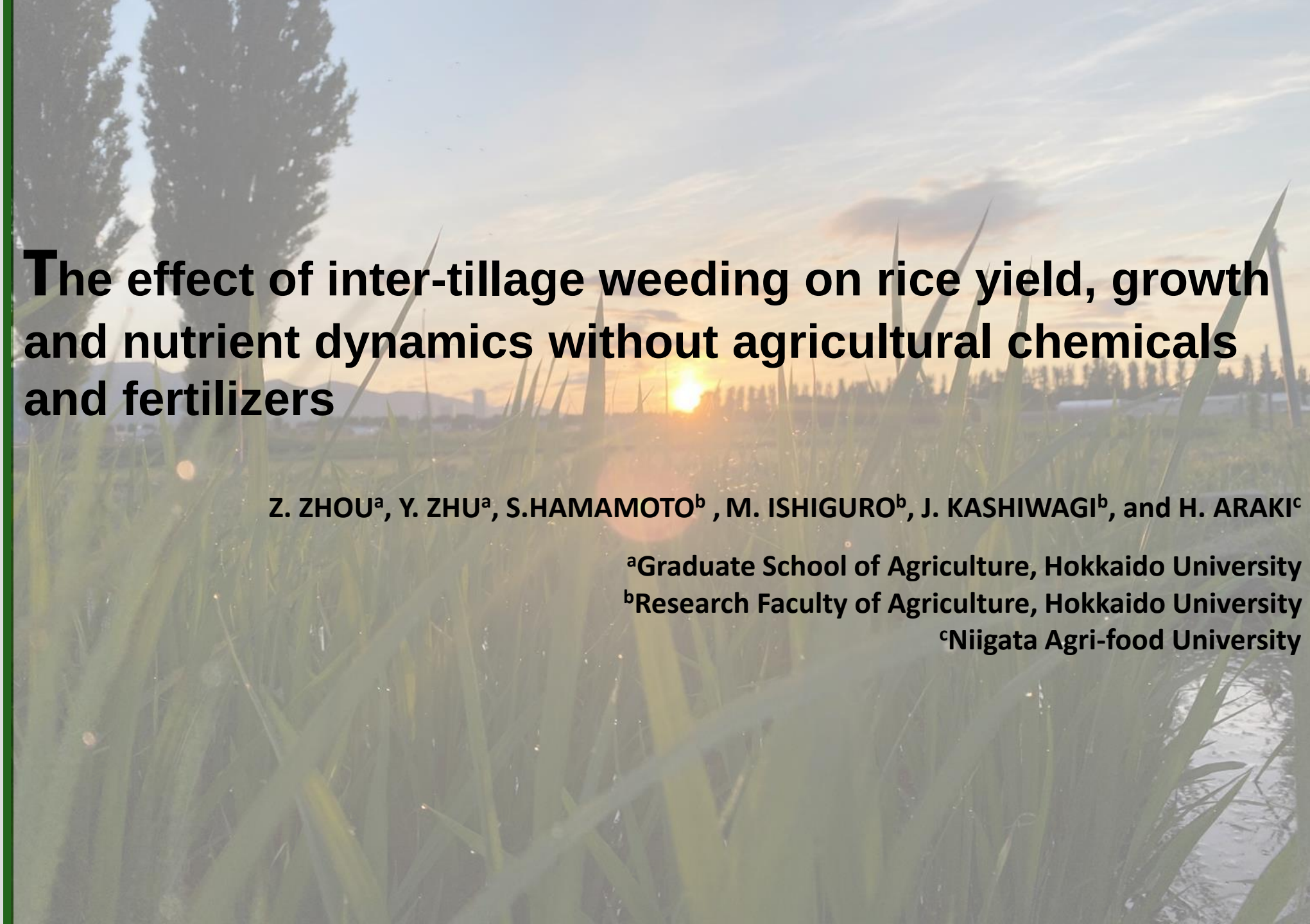

The effect of inter-tillage weeding on rice yield, growth and nutrient dynamics without agricultural chemicals and fertilizers

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[c]Niigata Agri-food University

HOKKAIDO UNIVERSITY

1. Introduction

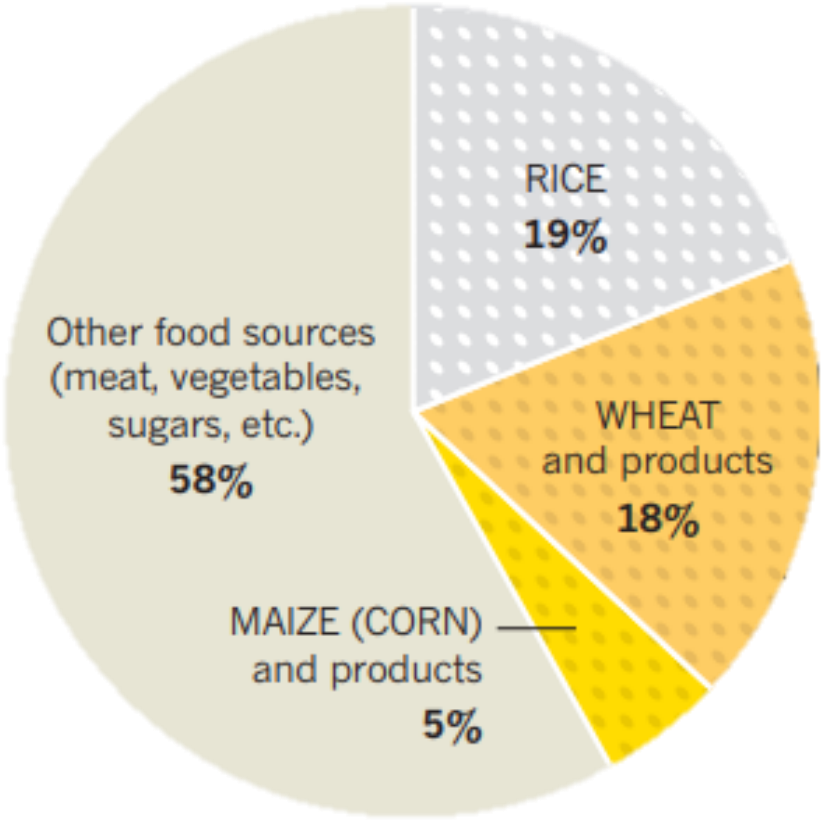


Fig. 1. Global nutrition consumption (Elter, 2014)

GLOBAL NUTRITION

On average, every day, each person on the planet consumes:

2,868 kcal

19% of daily energy supply comes from rice

1. Introduction

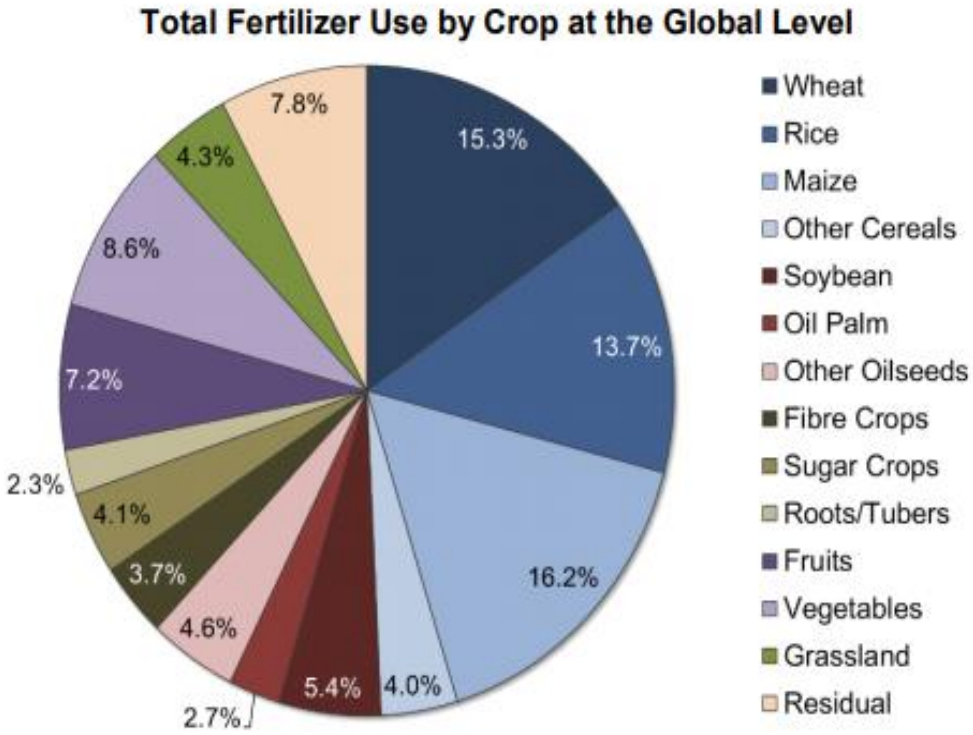


Fig. 2. Fertilizer use by crop cultivation (Heffer, Patrick, 2017)

Total world fertilizer consumption in 2014:

181.9 million metric tones

13.7% used in rice cultivation

1. Introduction

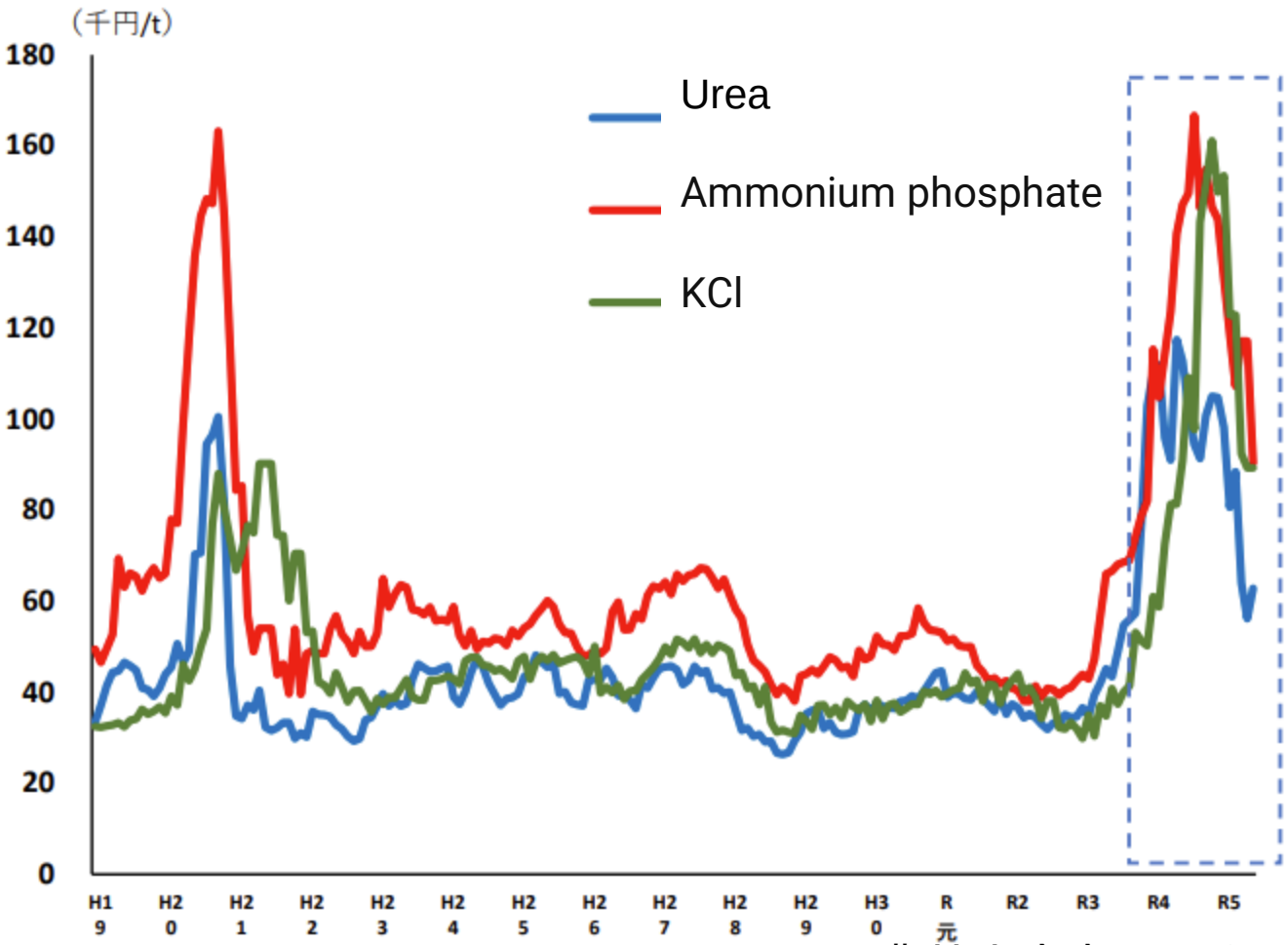


Fig. 3. The prices of fertilizer ingredients (農林水産省, 2023)

The price of fertilize
increased

1. Introduction

In Japan, every year agrochemical consumption :

180 thousand tones

about **30%** used is applied to **paddy fields**.

1. Introduction

Conventional agriculture:

Excessive use of agricultural chemicals and chemical fertilizers caused many problems

Ecosystem damage

Human health threats

Cost increase

1. Introduction

Inter-tillage weeding:

- Traditional agricultural method.
- Remove weed without chemicals
- promote the gas exchange in soil

1. Introduction

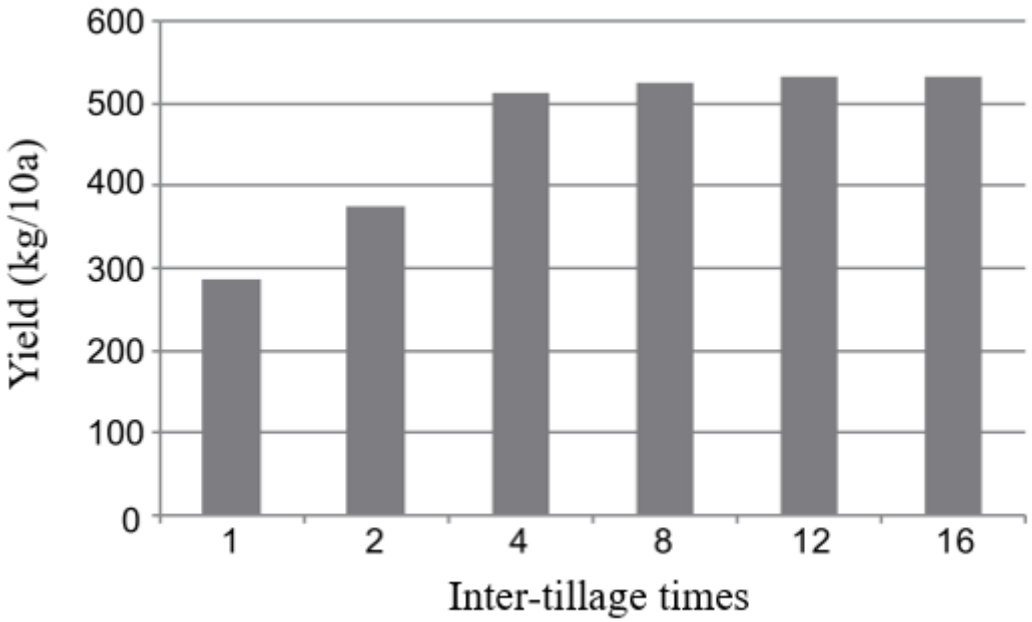


Fig. 3. Relationship between Inter-tillage weeding times and yield (Kasubuchi. 2019)

It was succussed to getting a high yield in paddy fields without agricultural chemicals and fertilizers by introducing many times inter-tillage weeding.

1. Introduction

However,

1. Introduction

Objective:

To clarify the influence of inter-tillage weeding on the
①rice growth and yield (Dry weight, number of tillering, yield components, etc.)
②nutrient dynamics (Nitrogen, phosphorus, potassium)
without agricultural chemicals and fertilizers in paddy field.

Brown rice yield

Number of tillering

Nutrient dynamics

2. Experimental design and methods

2. Experimental design and methods

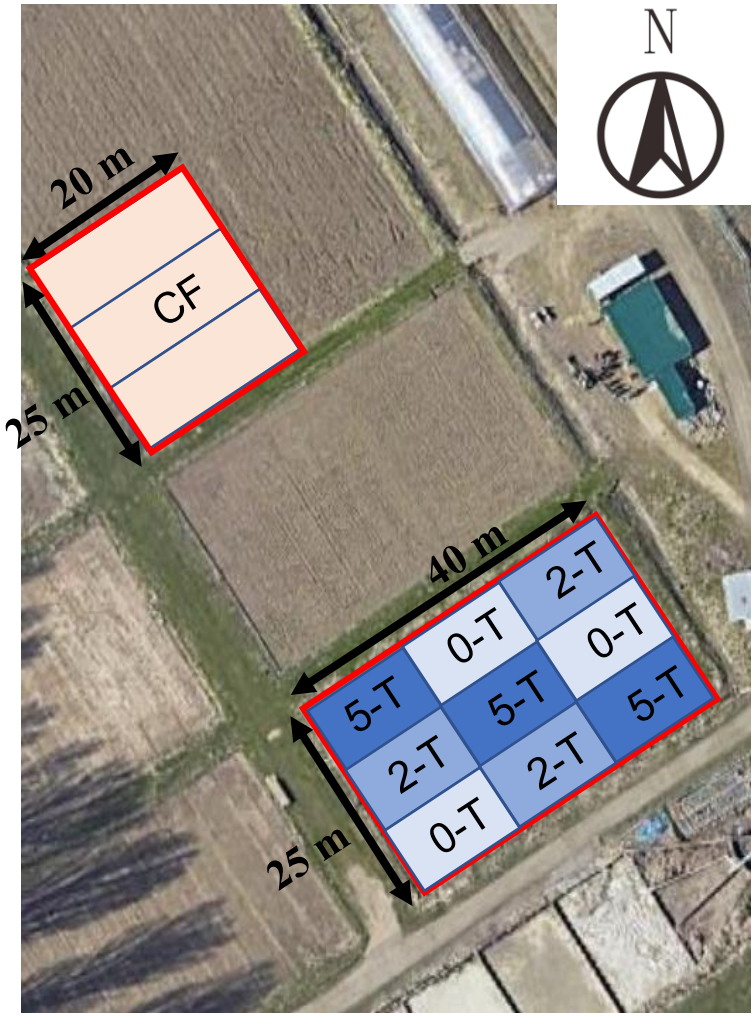


Fig. 5. Experimental location from 2018 to 2022

◆Field sites are located in Field Science Center for Northern Biosphere in Hokkaido University.

◆Average temperature and precipitation: 9.9 ℃ , 1049 mm

◆Soil type: gray lowland soil; Soil texture: light clay

◆The rice straw was returned to field every year

◆Cultivar: Nanatsuboshi

◆ **History of inter-tillage field (IF)**:

No fertilizers and chemicals application

As conventional field	Fallow with herbicide	As inter-tillage fields
Before 2015	2015-2017	2018-2022

2. Experimental design and methods

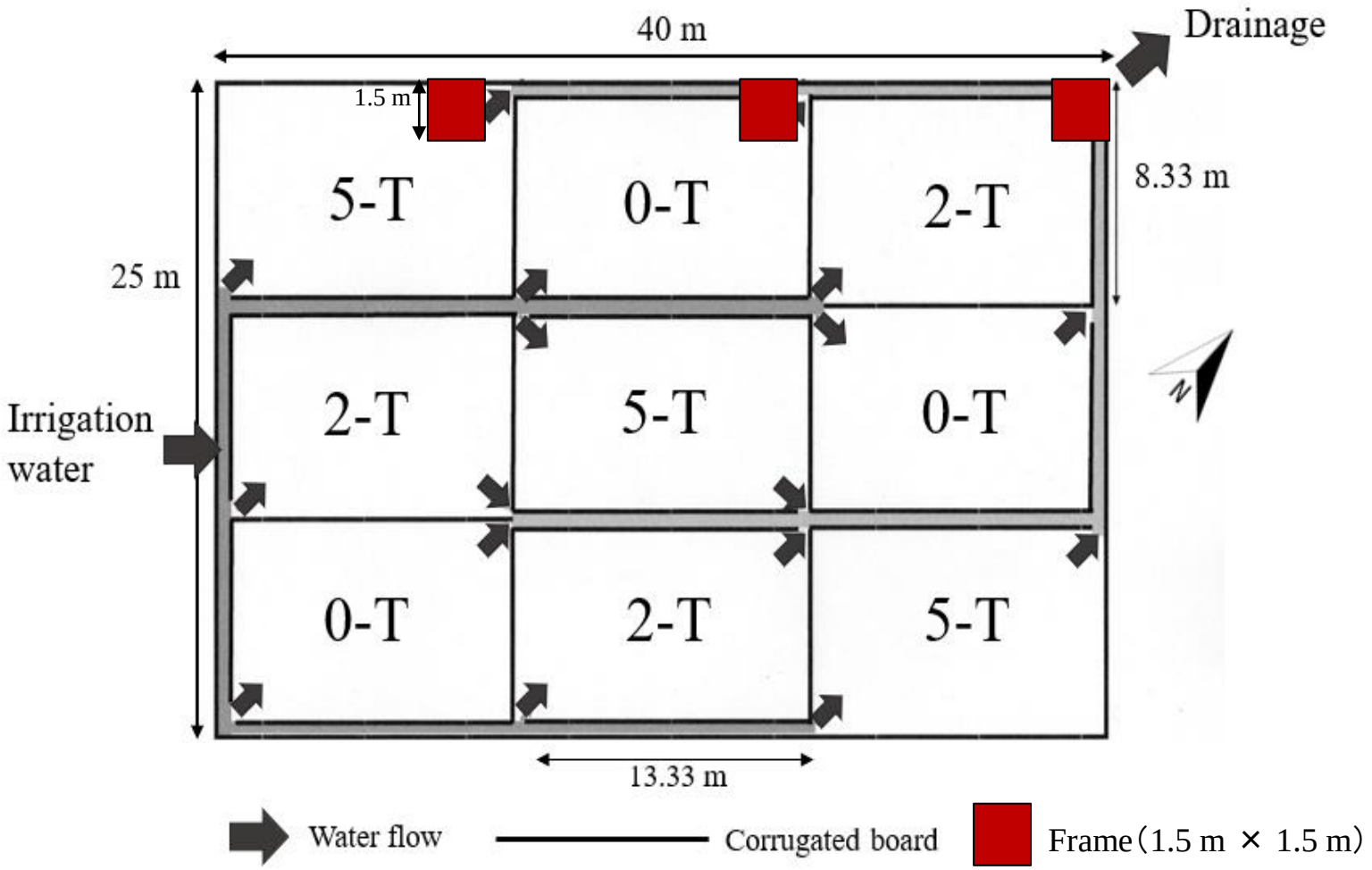


Fig.6. Layout of experimental field

- **The inter-tillage fields (IF): No chemicals, no fertilizers**

5-T (5-Time): 5 times inter-tillage after transplanting to heading stage.

2-T (2-Time): 2 times inter-tillage, the first and last inter-tillage were conducted at the same time with 5-time field.

0-T (0-Time): No inter-tillage.

CI (Frame experimental field): No inter-tillage; Conventional cultivation

2. Experimental design and methods

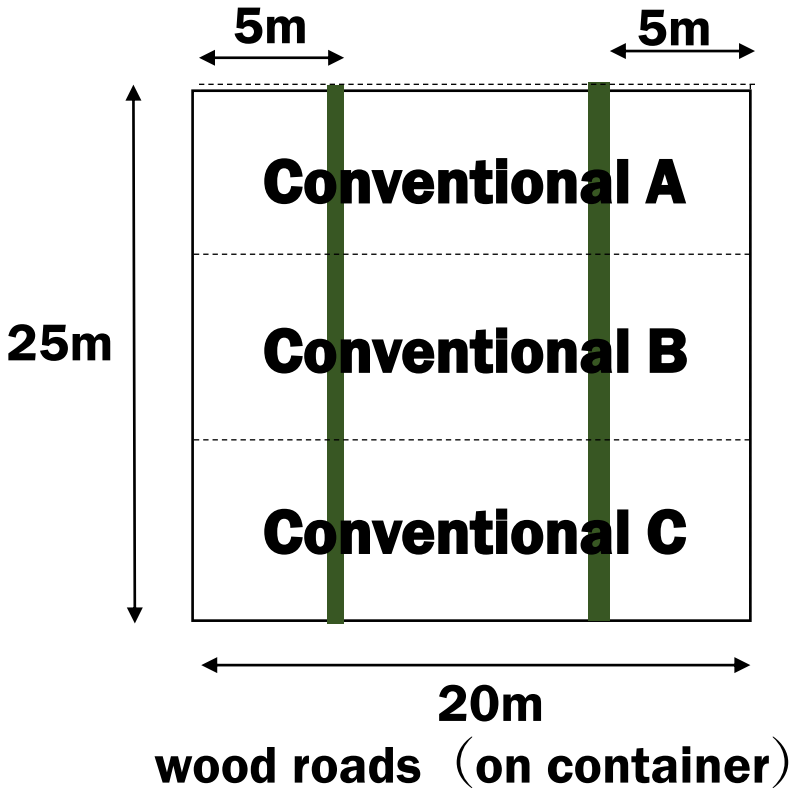


Fig.8. Layout of experimental field

➢**The conventional field**

CF (Conventional field): Conventional cultivation

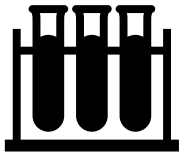
The drainage conditions and solar conditions were different from inter-tillage fields, Just as reference in result.

The application of agrochemicals in CF (2022. Jul.4)

2. Experimental design and methods

Table.1. Transplanting and harvest date

	Transplanting date	Harvest date
2018	29-May	26-Sep
2019	23-May	26-Sep
2020	29-May	30-Sep
2021	27-May	21-Sep
2022	26-May	22-Sep



From 2018 to 2022 during growth period, we collected the plant, soil and soil solution sample

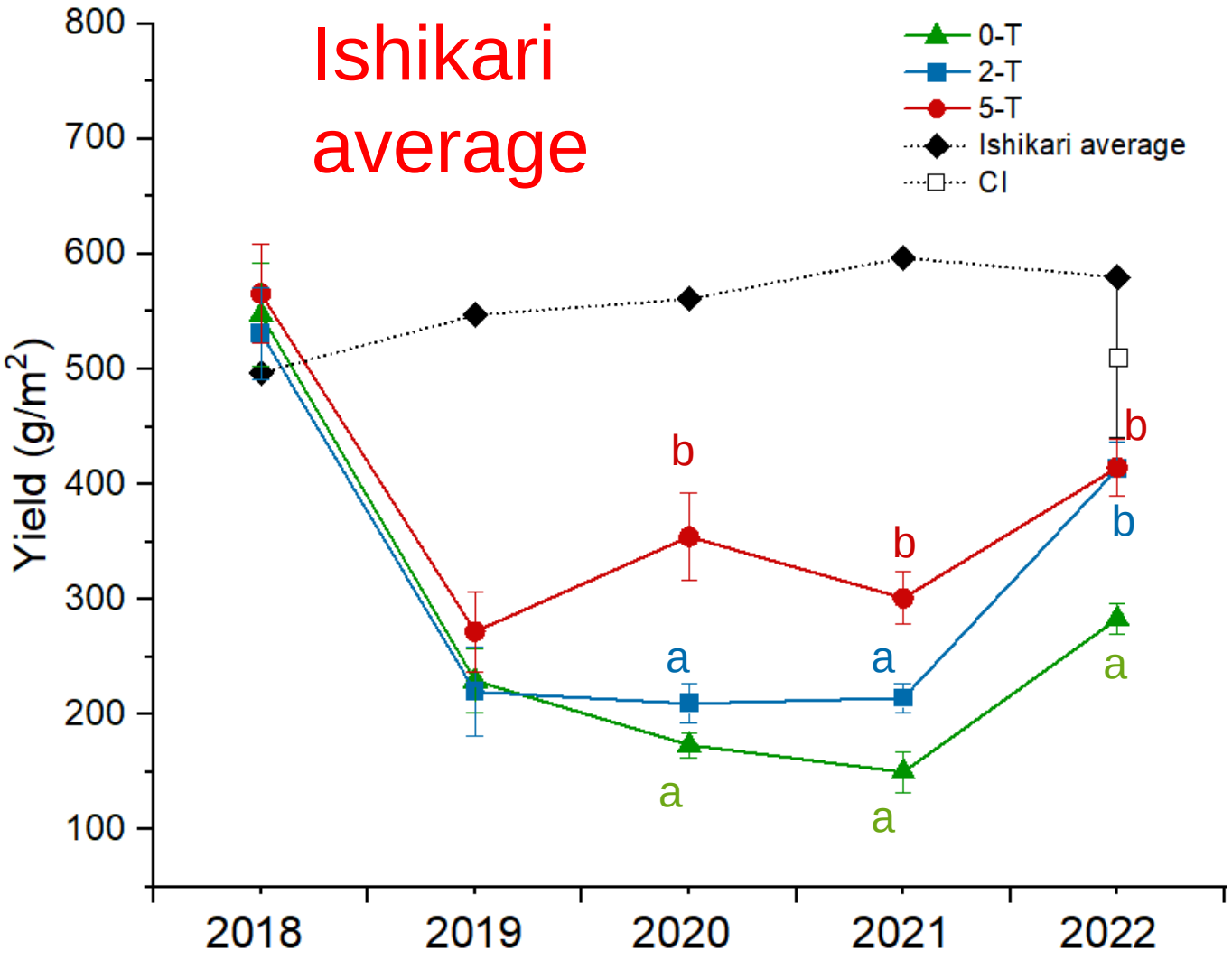
2. Experimental design and methods

Table.2. Measurement methods for soil and soil solution

	Measurement methods
Plant:	
Plant nitrogen	Dry combustion method, (CN analyzer TOC-VCPH, Shimadzu)
Plant potassium and phosphorus	Wet digestion method(Z-5010, HITACHI, UV-1280,Shimadzu)
Soil:	
Exchangeable ammonium	KCl solution exchanging method, (UV-1280, Shimadzu)
Available phosphorus	Bray's second method(UV-1280,Shimadzu)
Exchangeable K	Extracting with 1M NH4Cl
Soil solution:	
Ammonium	Indophenol absorption photometry, (UV-1280, Shimadzu)

3. Results and discussion

3.1 Yield



2020-2021 :
5-T significantly higher than 2-T and 0-T

2022 :
5-T and 2-T significantly higher than 0-T

5-T and 2-T in 2022 significantly higher than 2019

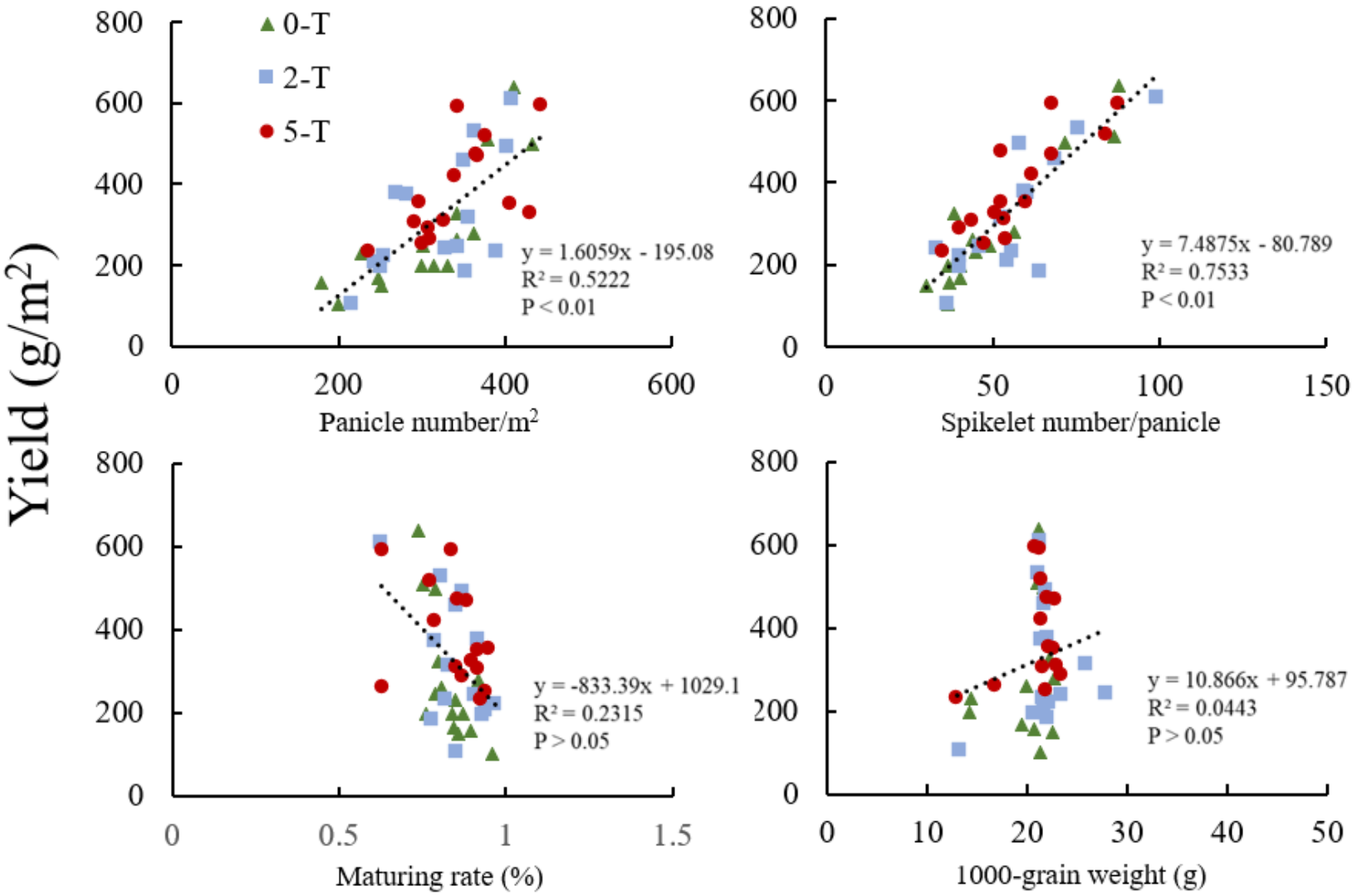
No significant difference among CI, 5-T and 2-T

Without fertilizers and chemicals application, inter-tillage weeding can make the yield reach 70% of conventional cultivation.

CI: Frame experiment in inter-tillage field which applied fertilizers and chemicals

*Bars in all graphs are standard errors.
*Means with the same letter in the same year are not significantly different at 0.05 probability level.

3.2 The correlation between yield and yield component



Panicle number: Determined during tillering stage

Spikelet number: Determined during panicle formation stage

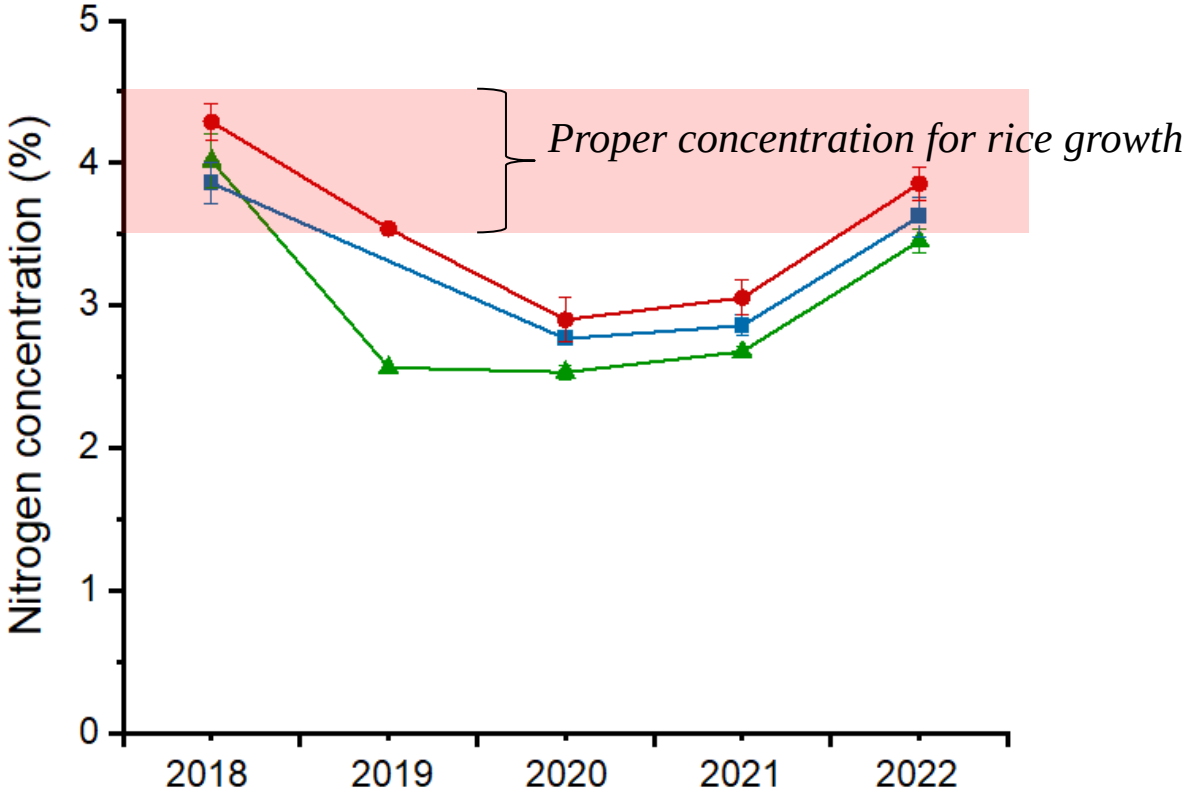
+

- The panicle number and spikelet number influenced the yield significantly.

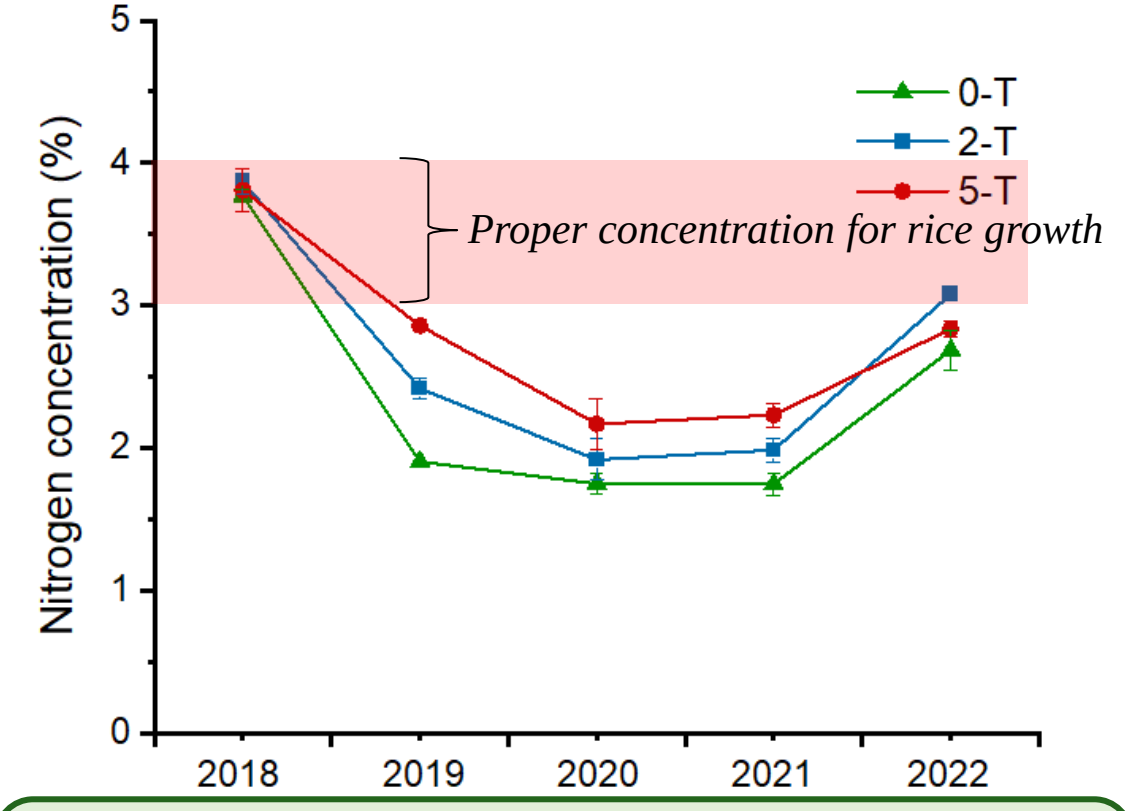
=

The yield was determined during rice early growth stage

3.3 N concentration in rice straw from 2018 to 2022 during early growth stage

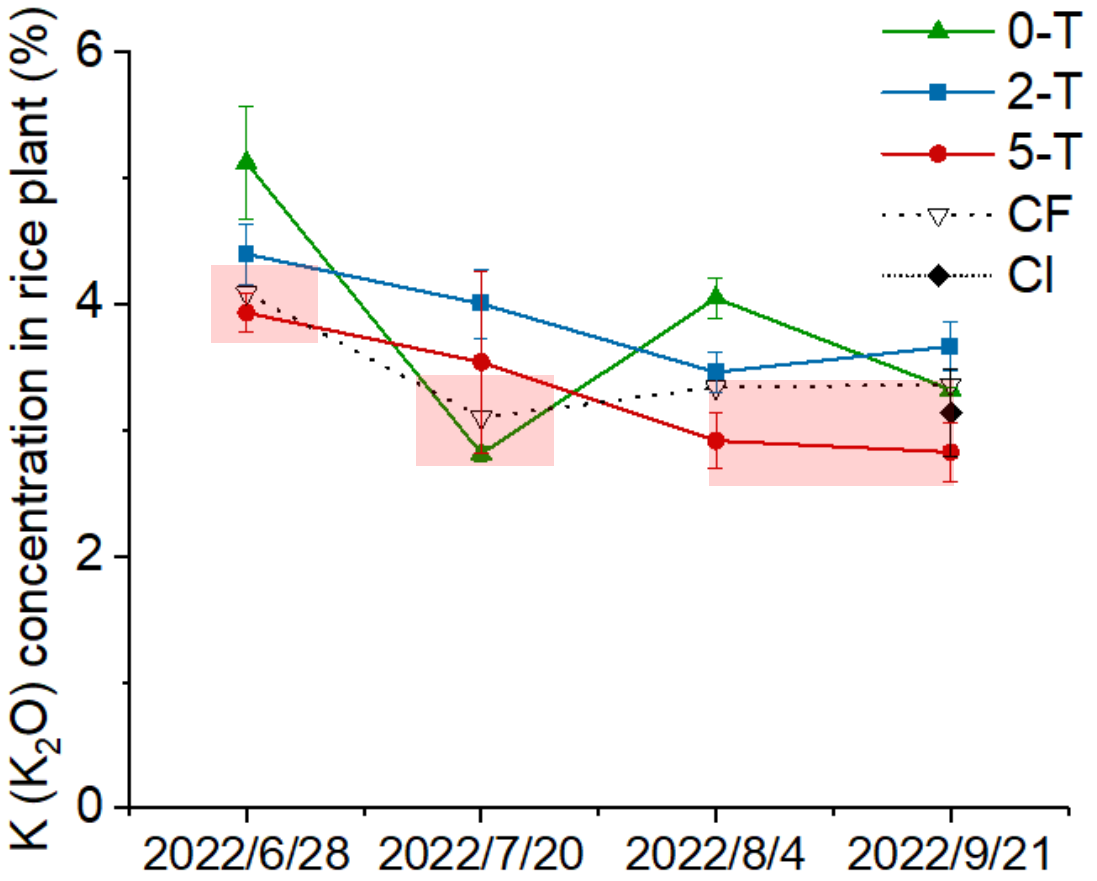


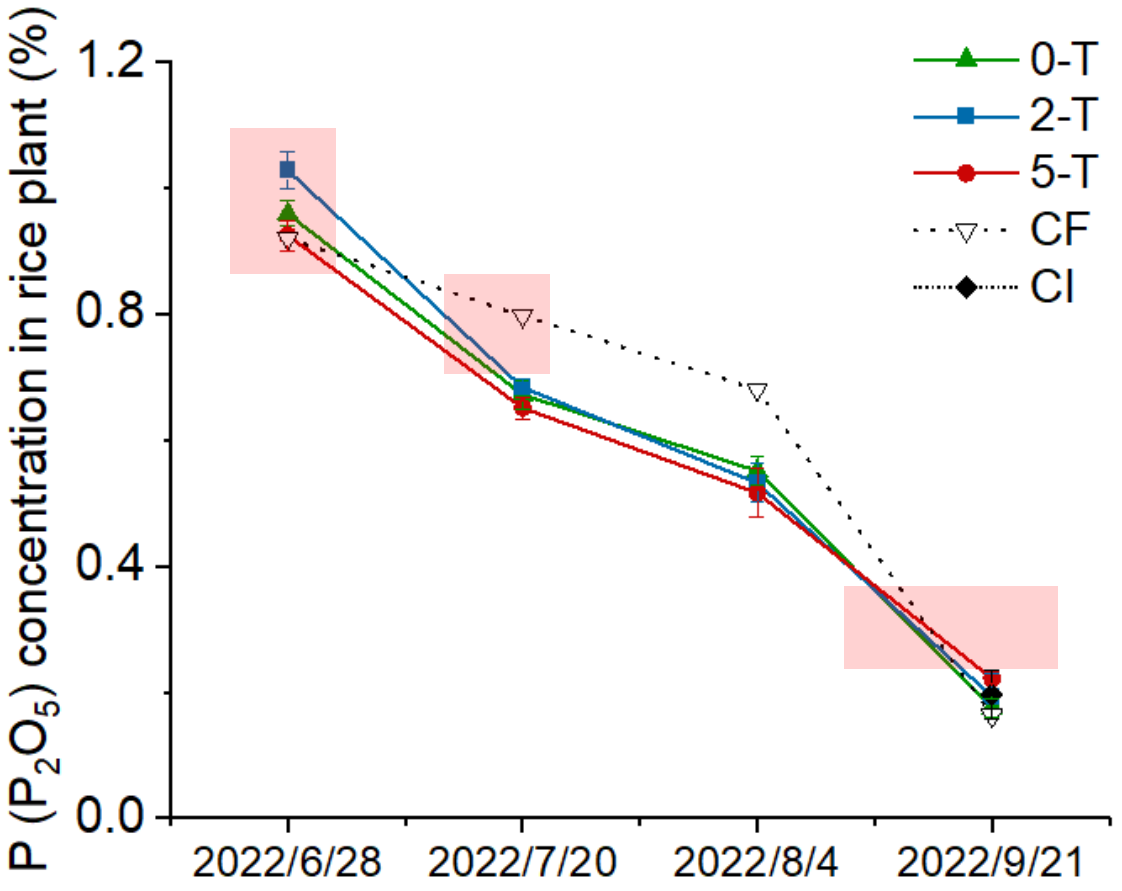
Tillering stage: 5-T > 2-T > 0-T from 2020 to 2022
The concentration recovered to standard range in 2022



Panicle formation stage:
Except 2-T, the value in 5-T and 0-T much lower than standard range. The nitrogen deficiency mainly occurred during panicle formation stage

3.4 K and P concentration in rice straw in 2022

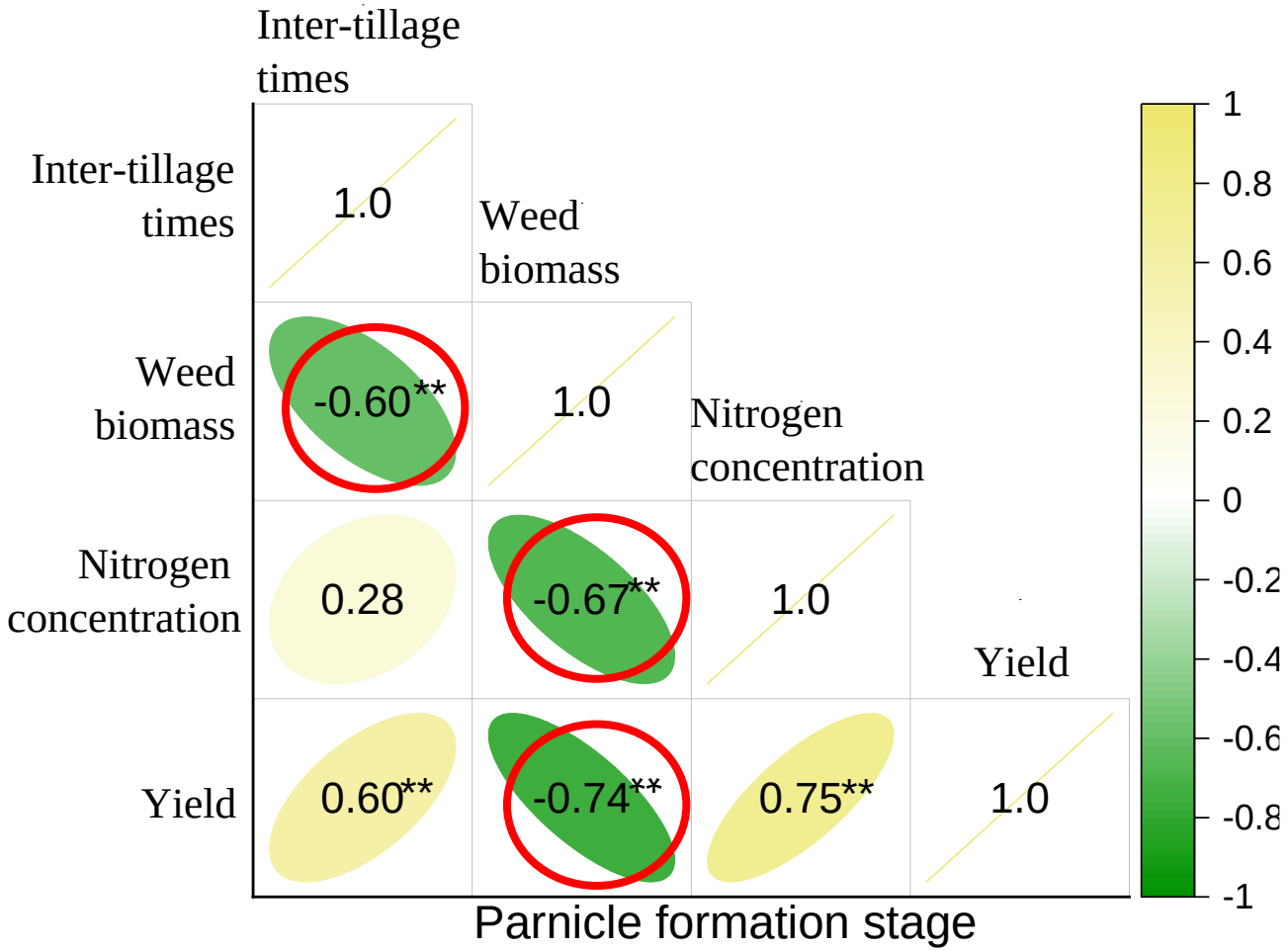




- *The pink areas are proper concentrations for rice growth*

Plant K: No deficiency + **Plant P : Minor deficiency** → **Nitrogen deficiency during panicle formation stage was the main yield limitation**

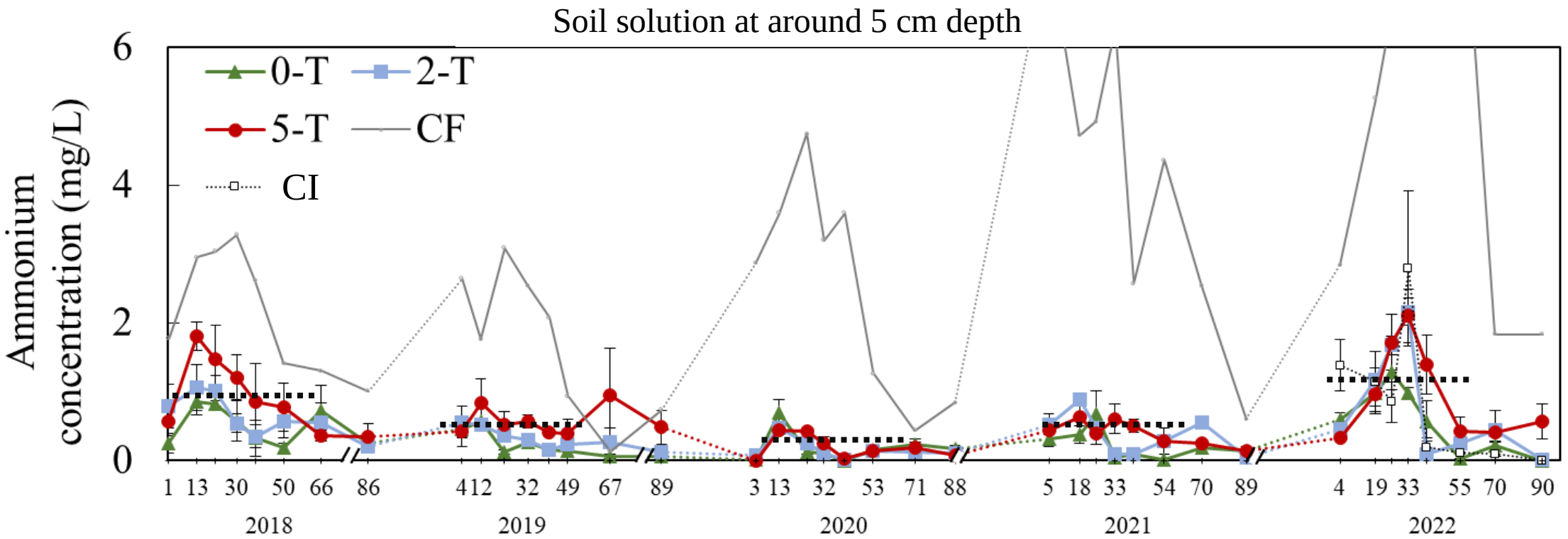
3.5 The correlation among inter-tillage frequency, weed biomass and yield



The correlation coefficient was highest during panicle formation stage

Inter-tillage can reduce the competition between rice and weed effectively during panicle formation stage

3.6 Ammonium nitrogen concentration in soil solution at 5 cm depth



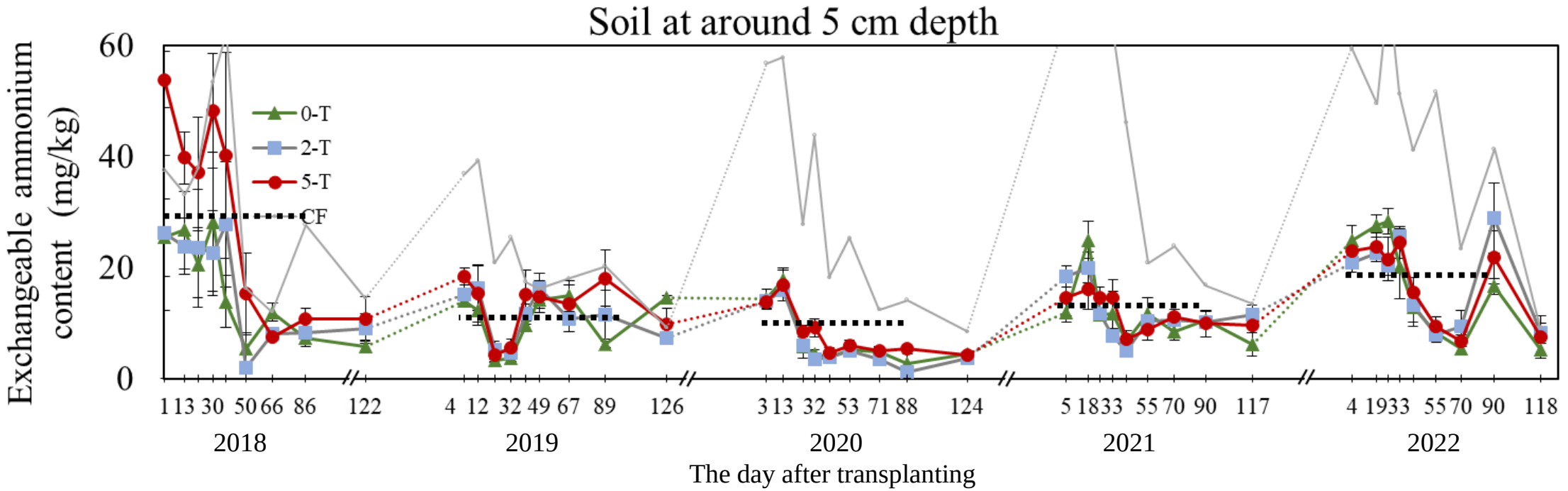
** The dotted lines are average value in inter-tillage fields during early growth period*

During inter-tillage period:

Average concentration: 5-T > 2-T > 0-T

◆ **Recovery in soil solution was observed after 2020. Seasonal average of NH_4^+-N in 2022 reached the same level as in 2018**

3.7 Exchangeable ammonium nitrogen concentration in soil at 5 cm depth

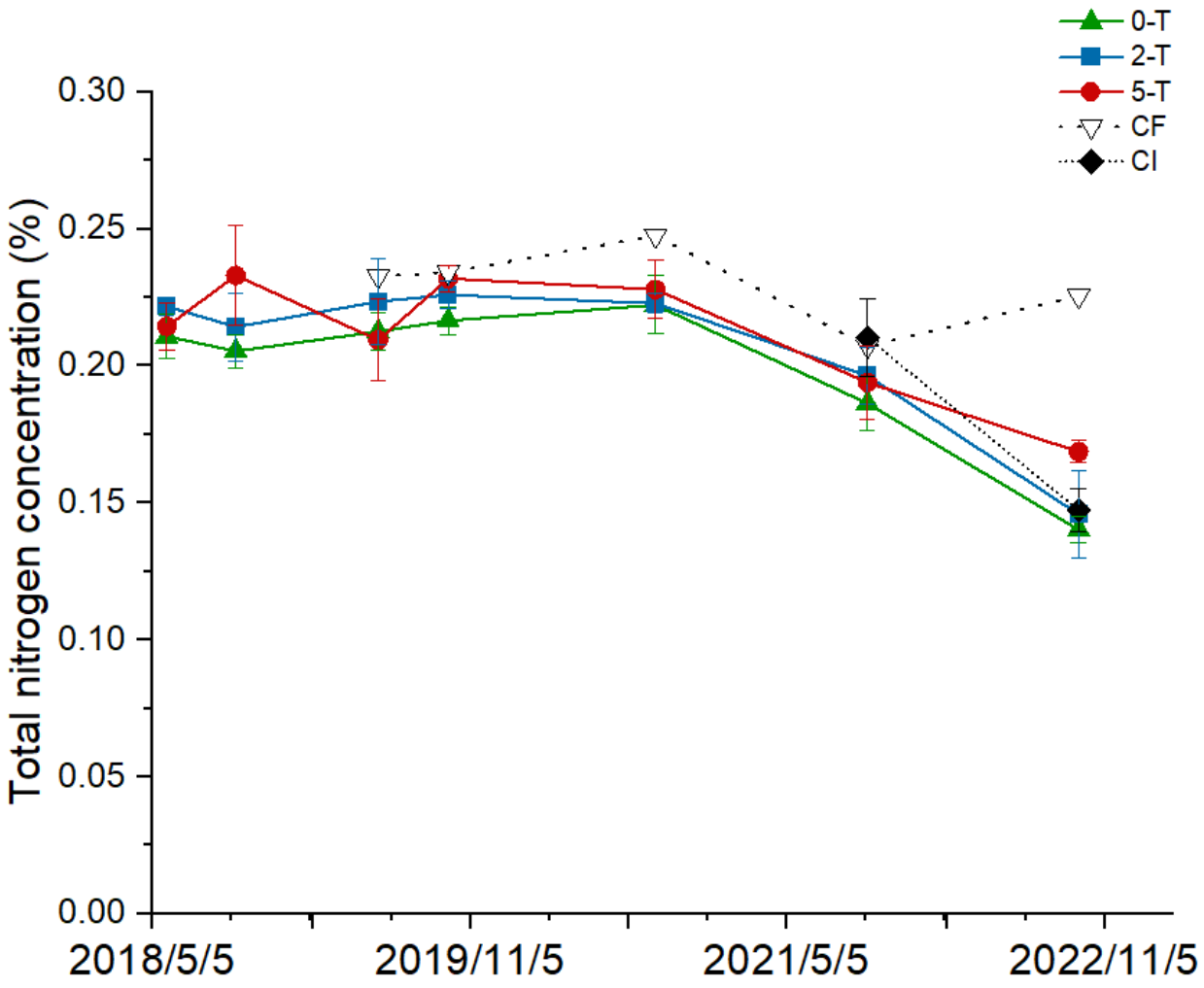


** The dotted lines are average value in inter-tillage fields during early growth period*

- **Recovery of soil exchangeable NH_4^+-N was observed after 2020.**
- Exchangeable NH_4^+-N contents was not changed by inter-tillage weeding conduction.

- The interaction of long-term rice residues incorporation and frequent inter-tillage weeding had influence on ammonium nitrogen concentration increase in soil solution .

3.8 Total nitrogen concentration in soil at 5 cm depth



5-T:

No significant decrease

2-T:

Significant decrease from 2021 to 2022

0-T:

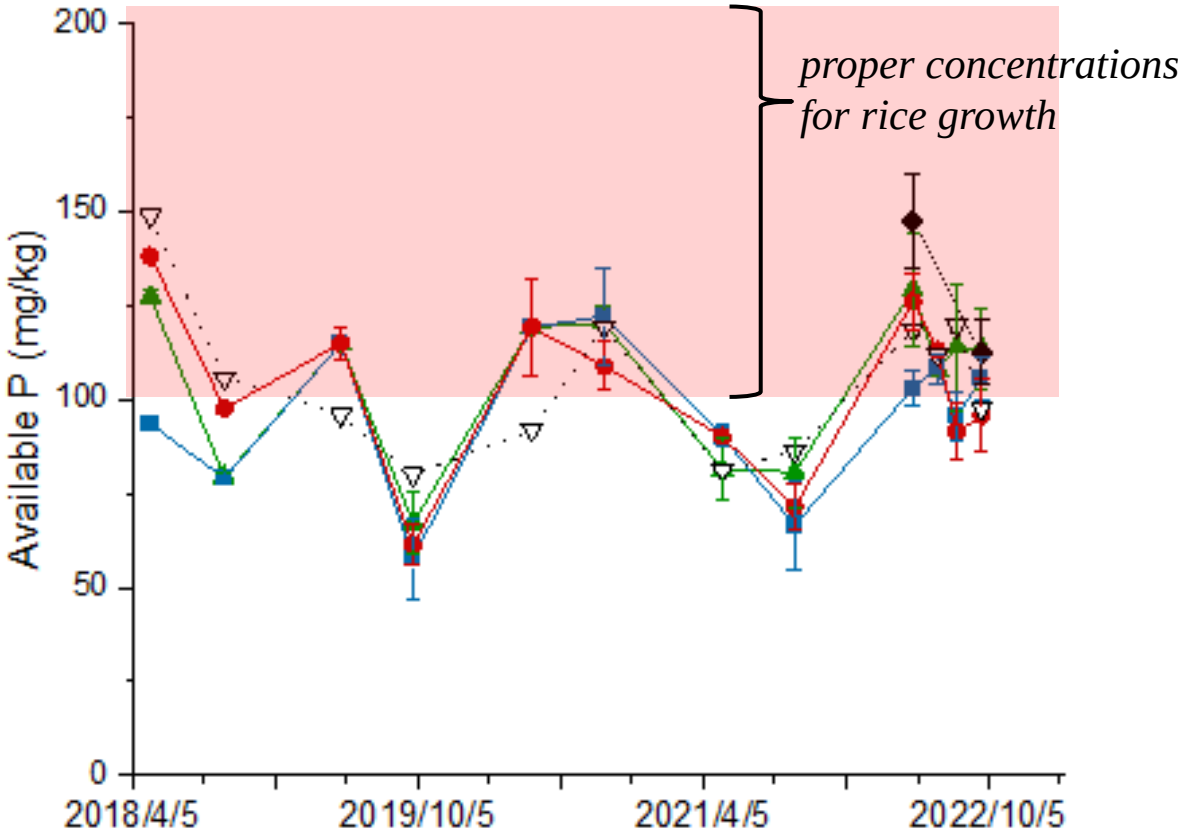
Significant decrease from 2020 to 2022 year by year

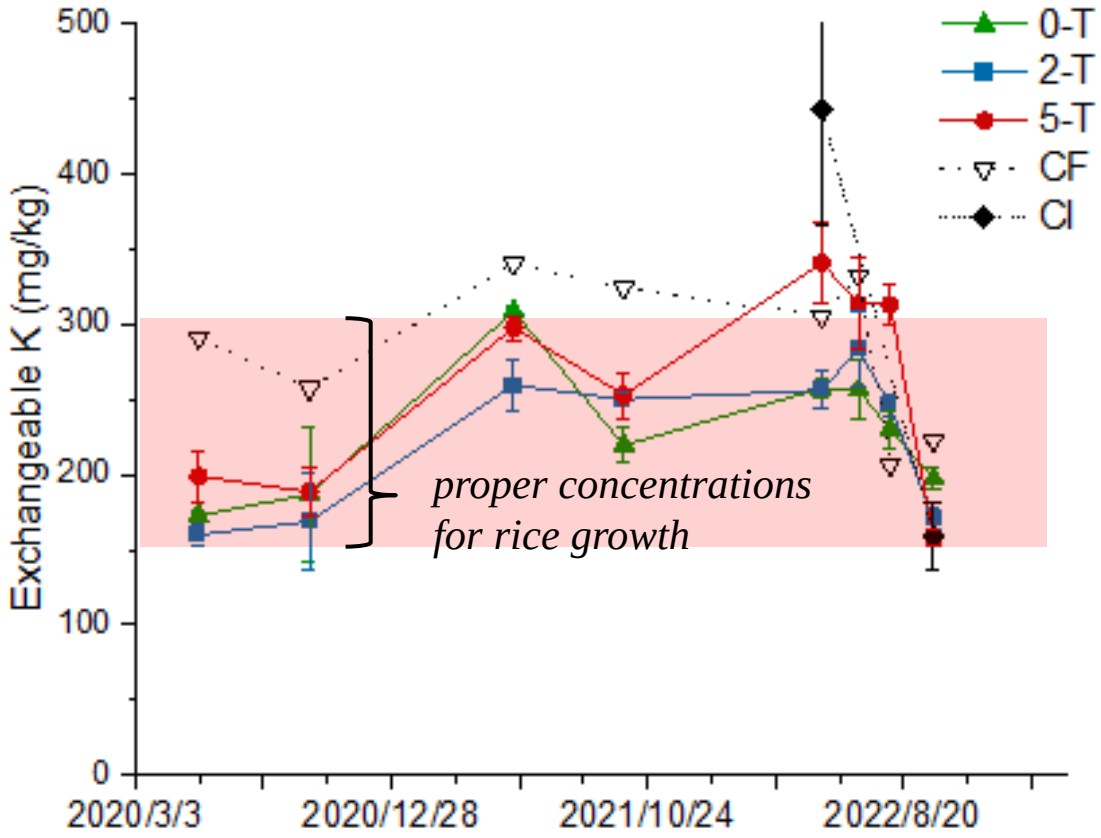
Nitrogen output by rice grain:

5-T: 27.6 g/m² > **2-T:** 21.9 g/m² > **0-T** 21.4 g/m²

High frequency of inter-tillage can make more nitrogen use in rice production

3.9 Available P and exchangeable K in soil at 5 cm depth





After constant fertilizer application, accumulated P was sufficient for rice growth for at least 5 years

K is sufficient without fertilizer application after rice straw return.

4. Conclusions

- The rice yield gradually recovered at the 5th year after conversion to natural cultivation, with the recovery of nitrogen concentration. Compared no tillage, 5 times inter-tillage can increase yield significantly.

- In cultivation without fertilizers and agrochemicals, the panicle formation stage is the key period to increase the yield. Inter-tillage weeding can decrease weed biomass effectively during this period and increase yield

- High frequency of inter-tillage make more nitrogen used in rice production and slow down the rate of nitrogen loss to environment.

- With the rice straw return, natural cycle (including the supply from irrigation and soil minerals) of potassium could apply sufficient K for rice growth

- Although without P fertilizer application, the accumulated P from former constant fertilizer application is sufficient for rice growth for several years.

Thank you for your listening