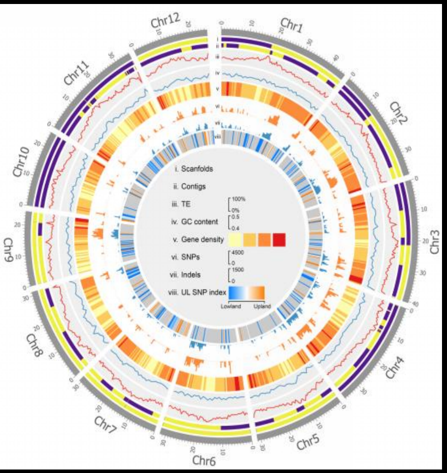
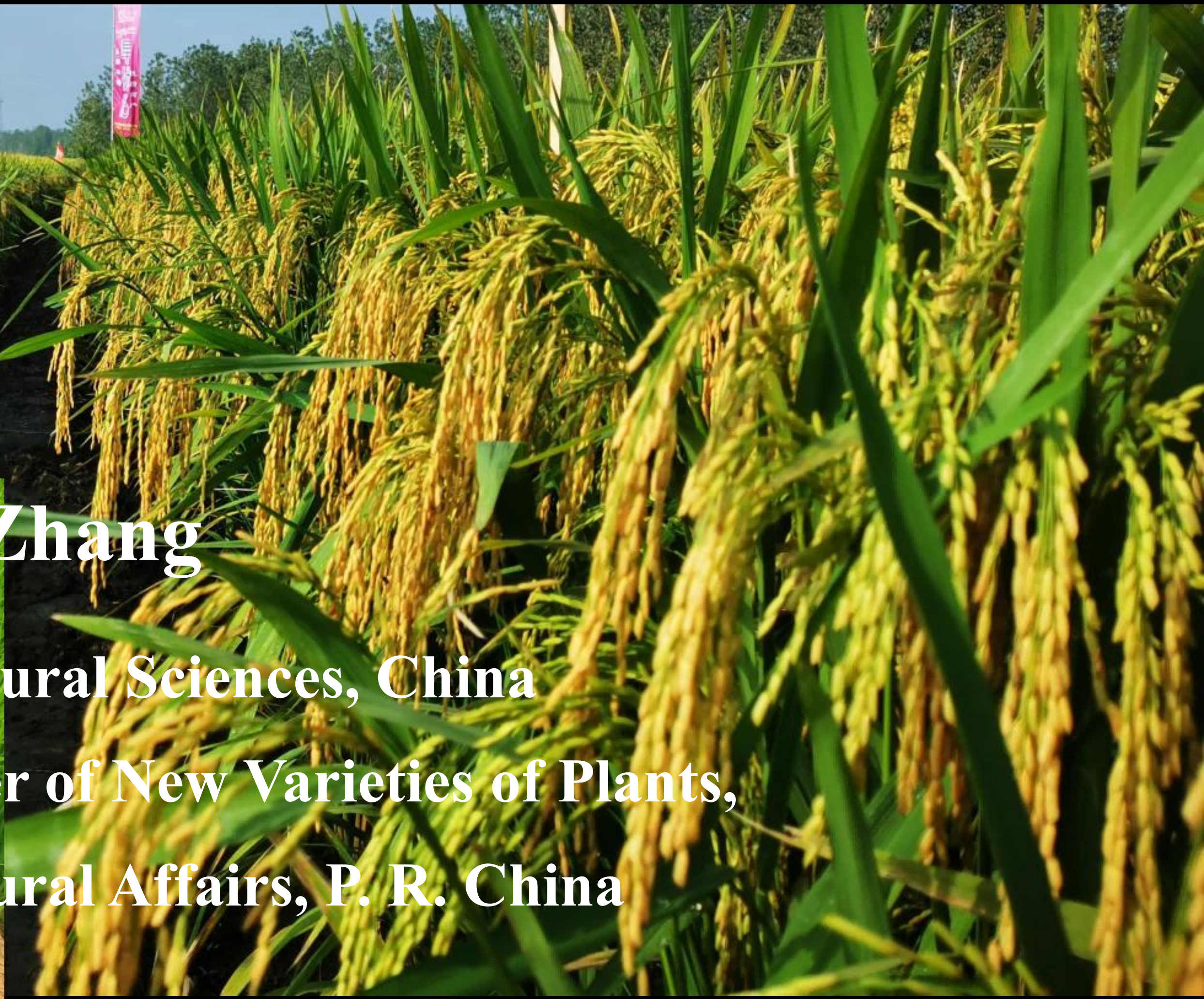
New plant variety protection system and the cultivation of water-saving and drought-resistance rice (WDR)

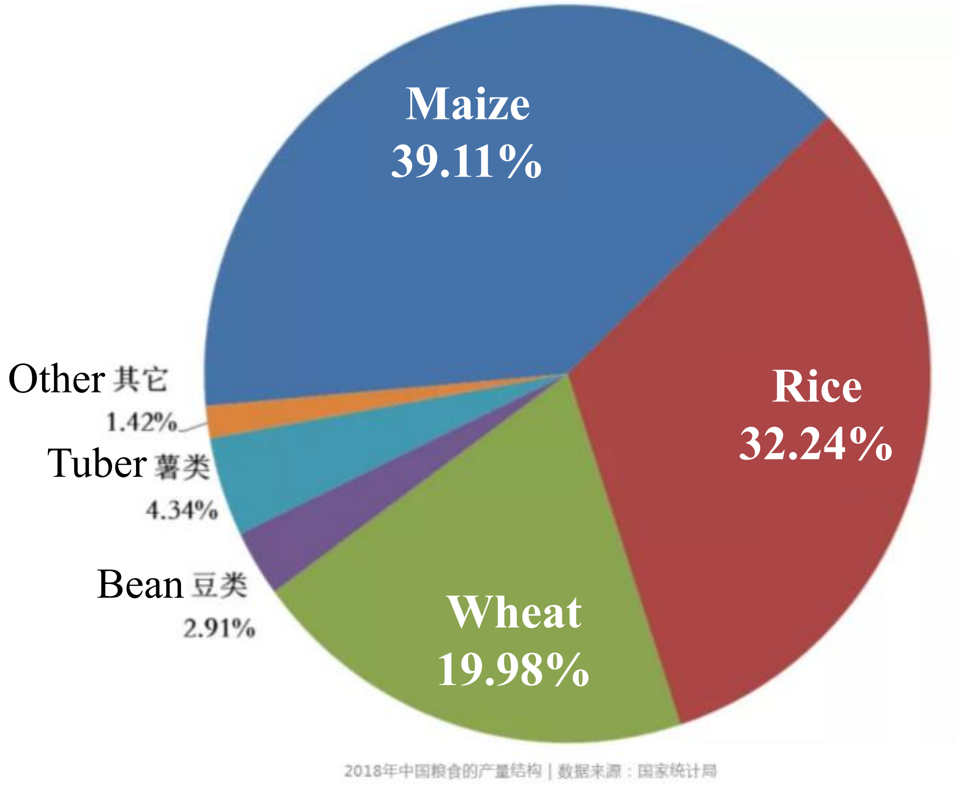




Dr. Yu Zhang

Shanghai Academy of Agricultural Sciences, China

Shanghai DUS Tests Sub-center of New Varieties of Plants, Ministry of Agriculture and Rural Affairs, P. R. China



Total grain output: 0.65 billion tons.

Cultivated land and environment bearing forward:

70% of agricultural water consumption.

One third of the world's chemical fertilizer and pesticide use.

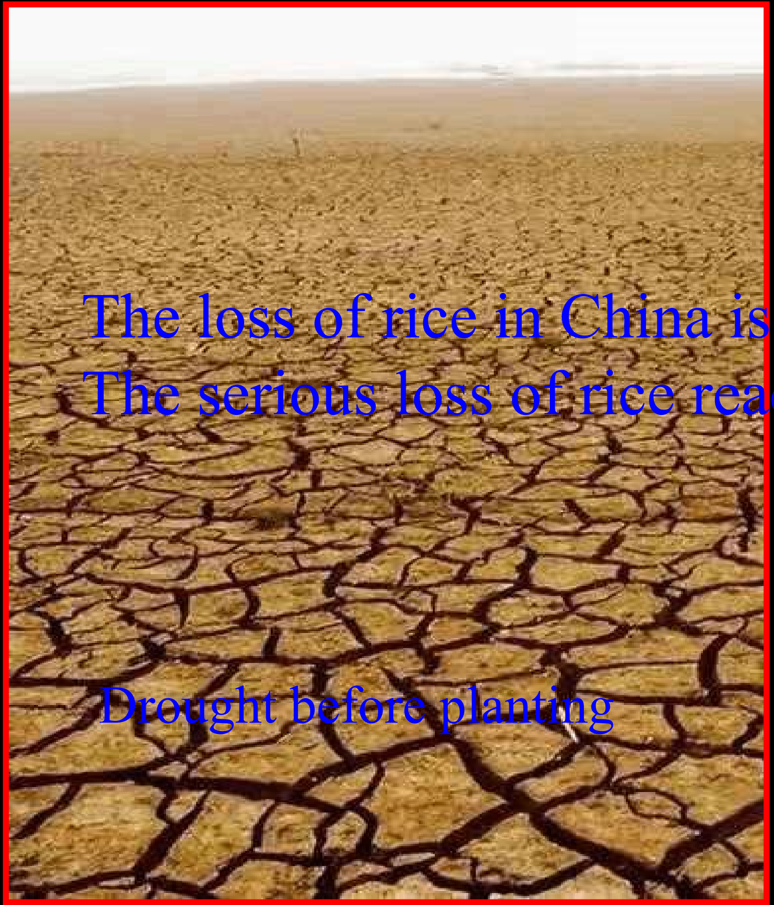
The output structure of China in 2019

Rice is the most important food crop.

1、The increase in the national average rice yield is limited

The loss of rice in China is about 143-250 kg/hm^2

The serious loss of rice reached 2700 kg/hm^2



Chen Yuping et al.2009. Agricultural economy problems. (in Chinese)

2. Rice production relay on much labor force, while the economic benefit is low



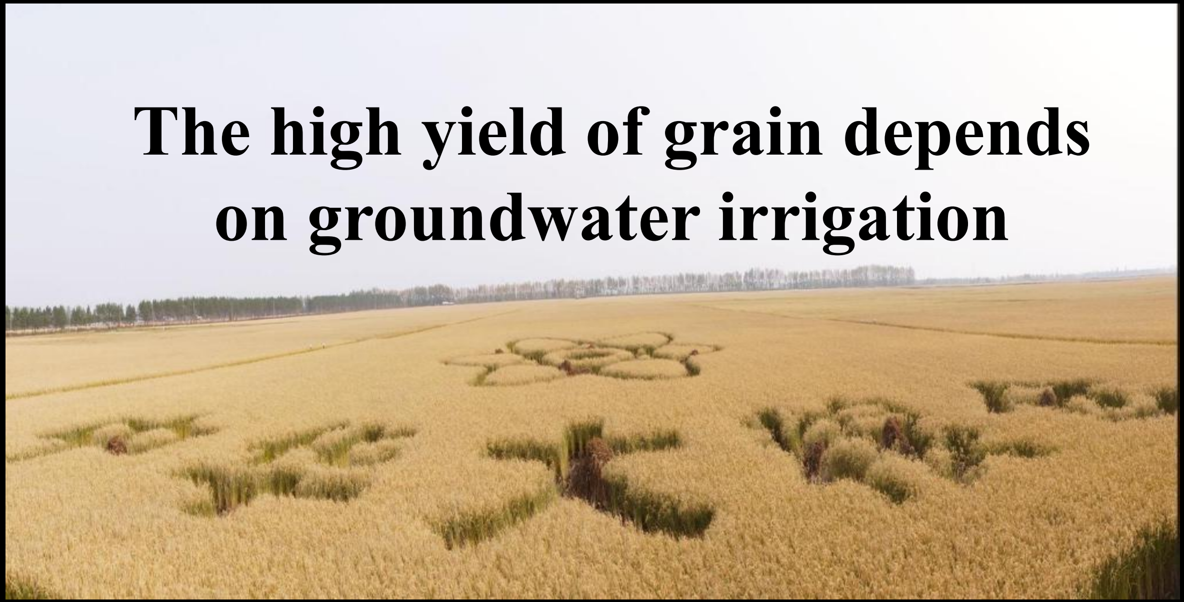
lowland rice are poor in drought resistance and not leaving water.
It is not suitable for large scale mechanization because of poorly direct seeding character.
It's getting more expensive to plant.

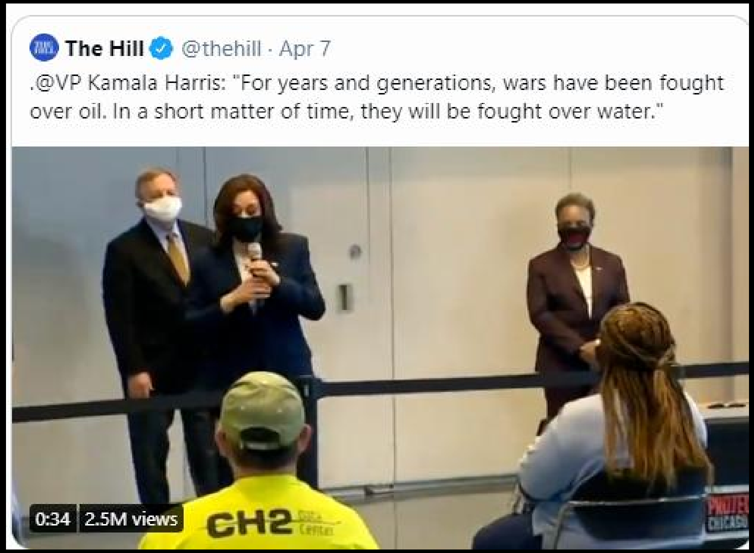
3. Rice accounts for 50% of the total water consumption

Water resources per capita are declining in a water short country

2002 2200 m³
2030 1800 m³

Irrigation water shortage exceeds 120 billion m³ every year





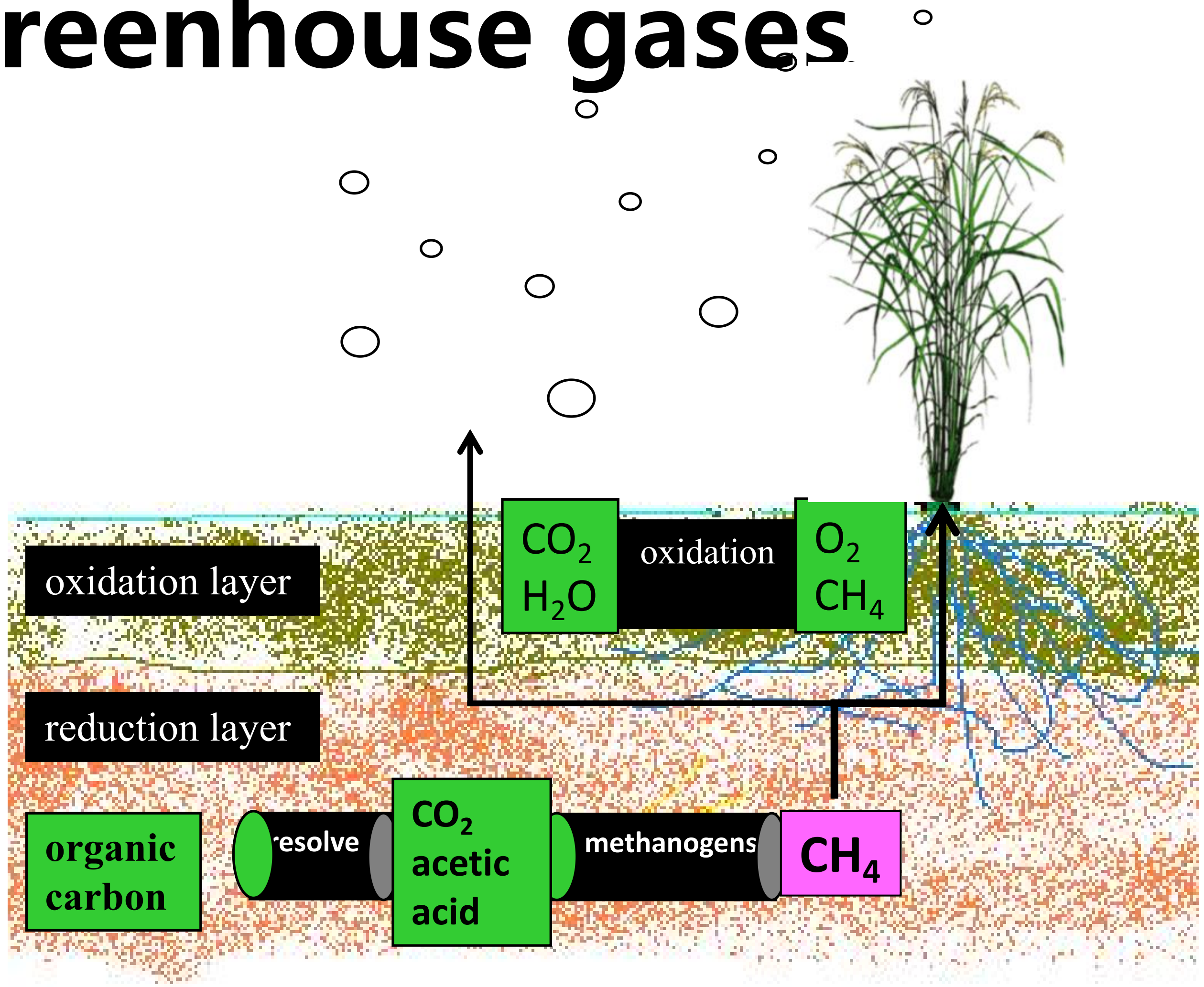
4.Traditional rice production caused serious environmental pollution

With the increase of pesticide and fertilizer application, the environmental pollution becomes more and more serious.

Low fertilizer utilization
Nitrogen fertilizer 35%
Phosphate fertilizer 25%

A lot of pesticides were used, whlie utilization rate is only 30%

5. Rice production produces a lot of greenhouse gases



Methane emission from paddy fields in China accounted for 19.73%

Slides from Yan X Y(2014)

《Climate Change Assessment report》

Year	Tm increased
2020	1.1 - 2.1 ⁰C
2030	1.5 - 2.8 ⁰C
2050	2.3 - 3.3 ⁰C


nature COMMUNICATIONS

ARTICLE

OPEN

Rice production threatened by coupled stresses of climate and soil arsenic

By 2100, yields were reduced by 39% and arsenic levels in rice tripled


MENU

nature COMMUNICATIONS

Article | OPEN | Published: 31 July 2018

North China Plain threatened by deadly heatwaves due to climate change and irrigation

Suchul Kang & Elfatih A. B. Eltahir

Nature Communications 9, Article number: 2894 (2018) Download Citation

Global temperature to exceed 35 degrees Celsius several times in 2070-2100

Troubles: 1. Rice varieties are greatly affected by extreme environment.

2. Fresh water resources are very limited.

Solution: To cultivate **drought-resistance** and **ecologically friendly** rice varieties.

Evolution and differentiation between lowland and upland rice

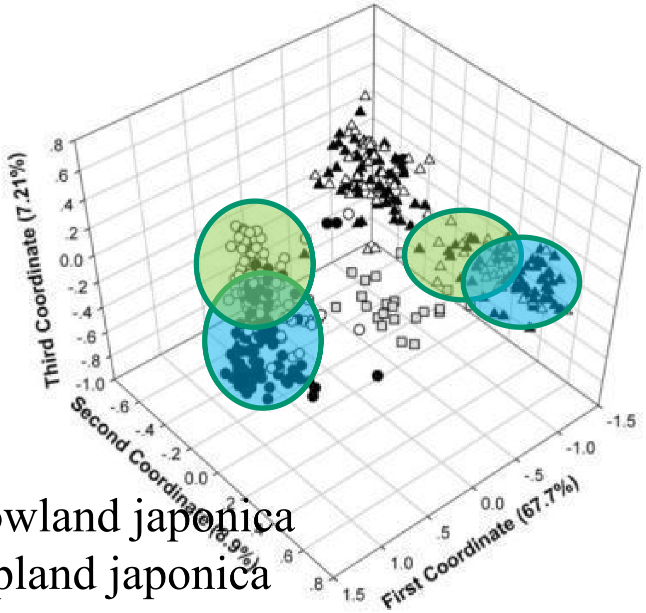
Oryza rufipogon Grif

Upland is easy to planting.
The environmental pollution was lower compared to traditional rice variety produced.

From dry land to paddy fields

Water demand increased
Drought resistance and direct seeding decreased

There was significant genetic differentiation between lowland and upland rice



- ○ lowland japonica
- ● upland japonica
- △ lowland indica
- ▲ upland indica
- □ Oryza rufipogon Grif

Table 6. Gene symbol, gene ID, and the annotated functions of the decisive selective loci detected in this study.

Locus	Gene symbol	Gene ID	Names	Predicted function
E647	Os01g0607400	4324222	hypothetical protein	Similar to STYLOSA protein
E359	Os06g0702600	4341978	hypothetical protein	Similar to Auxin response factor 7a
E1899	Os12g0563600	4352535	hypothetical protein	Protein of unknown function, DUF538 family protein
E3735	Os07g0260000	4342870	hypothetical protein	Protein prenyltransferase domain containing protein
E1238	Os10g0554200	4349339	hypothetical protein	TGF-beta receptor, type I/II extracellular region family protein
E1177	Os06g0633300	4341588	hypothetical protein	Phytosulfokines 1 precursor [Contains: Phyto sulfokine-alpha (PSK- alpha) (Phytosulfokine-a); Phytosulfokine-beta (PSK-beta) (Phytosulfokine-b)]
E4208	Os07g0546500	4343527	hypothetical protein	Conserved hypothetical protein

doi:10.1371/journal.pone.0106352.t006

Several selective Loci of drought-responding ESTs were identified to associated with the drought resistance of rice

Xia et al. 2014,Plos One

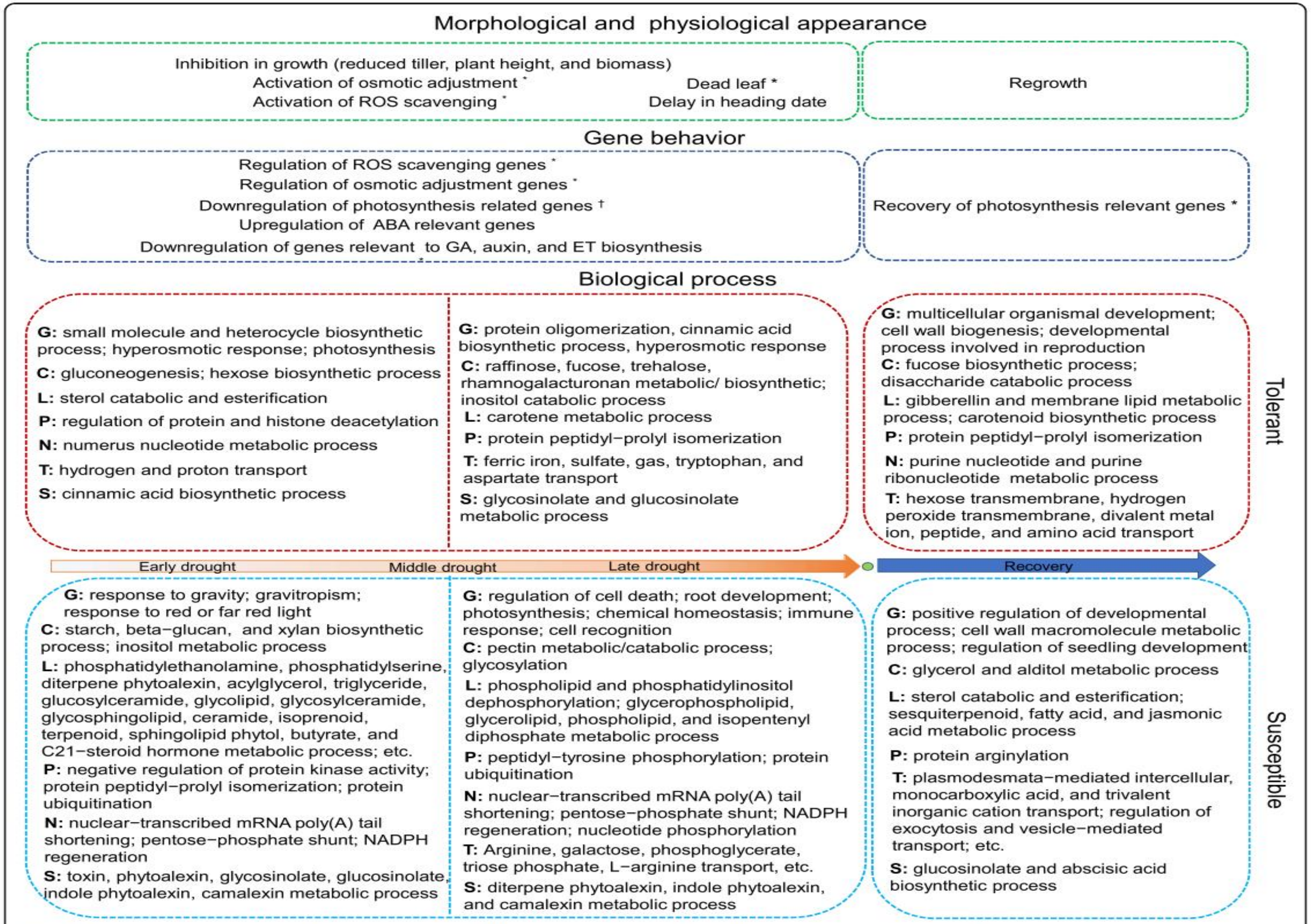


Fig. 4 Description of drought tolerance- and susceptibility- featured morphological responses, transcriptomic dynamics, and biological processes during drought and at the recovery stage. * indicates significant difference between tolerant and susceptible genotypes; † indicates different temporal patterns between tolerant and susceptible genotypes. C: carbohydrate metabolic process; G: general biological process; L: lipid metabolic process; N: nucleic acid metabolic process; P: protein metabolic process, S: secondary metabolic process; T: transport

The morphological, physiological responses, gene behaviors and biological mechanisms were different between drought-tolerant and susceptible cultivars in response to drought stress.

Xia et al. 2020 BMC Genomics

What is WDR?

From dry la … to paddy fields

Water-saving and Drought resistance Rice

Upland rice variety is easy to planting.
The environmental pollution was lower compared to traditional rice variety produced.

Water demand increased
Drought resistance decreased and direct seeding decreased

High yield, good quality and disease resistance
Poor water saving and drought resistance, adverse direct seeding

Advantages and disadvantages

The development of WDR varierty: from concept to practice and theory


Journal of Experimental Botany Advance Access published July 5, 2010

Journal of Experimental Botany, Page 1 of 9
doi:10.1093/jxb/erq185

Journal of Experimental Botany

REVIEW PAPER

Breeding for water-saving and drought-resistance rice (WDR) in China

L. J. Luo*

Shanghai Agrobiological Gene Center, 2901 Beidi Road, Shanghai 201106, China

* E-mail: ljluo@sagc.org.cn

Received 10 March 2010; Revised 25 May 2010; Accepted 3 June 2010

Abstract

Rice is the staple food and rice production consumes about 50% of the fresh water resources in China. In addition, drought is one of the most important constraints in rice resulting in large yield losses and limiting the average yield increase of the country. There is an urgent need to enhance water-saving (W) capacity or drought resistance (DR) of rice. WDR varieties can be developed through introgressing the water-saving and drought resistance capacity mainly from the traditional upland to the commercialized paddy rice cultivars. The breeding target is a high yield potential under irrigation, an acceptable grain quality, and water consumption reduced by about 50% compared with paddy rice. In a water-limited environment, a higher level of drought resistance and reduced yield loss by drought stress are required. In recent years, the field drought-resistance screening facility was established and the evaluation standard was developed. Some DR rice varieties were identified and used in both molecular mapping and breeding programmes. Several WDR varieties were developed and released to farmers. This article describes our initial achievement towards this goal and provides some details on the rationale and the specific steps and methods used.

Key words: Breeding, drought resistance, gene/QTLs, hybrids, rice variety, water-saving, WUE.

Introduction

《Journal of Experimental botany》Published concept and cultivate strategies

- **Paddy field direct seeding with drought management, water saving 50%, reduce pesticide fertilizer, stable rice yield**
- **Dry land direct seeding with drought management, expand rice planting area.**
- **Save labour and plant easily, and greatly reduce diffuse pollution and greenhouse gas emission.**

2013

Second Prize of National Science and Technology Invention

2016

The Ministry of Agriculture promulgates industry standards related WDR

2020

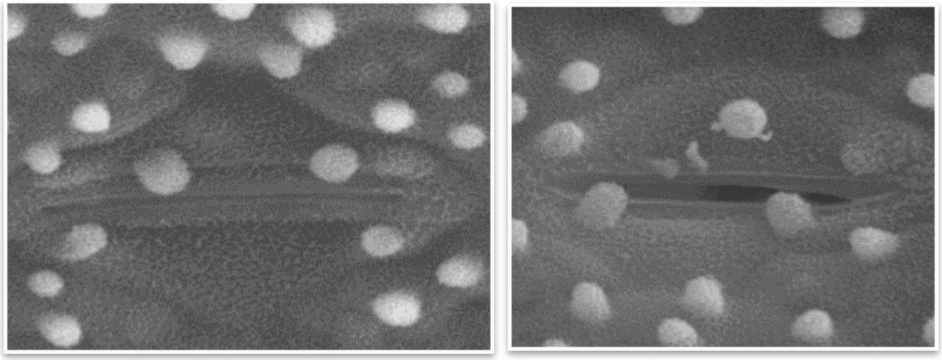
First Prize of National Scientific and technological progress

Drought resistance of crops

1. Drought Avoidance, DA
2. Drought Tolerance, DT
3. Drought Recovery, DR

Luo Lijun. 2010 JXB

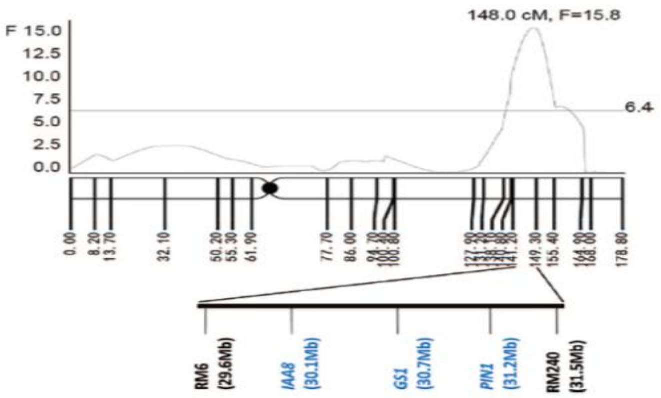
Drought avoidance



Deep root ratio (RDR) is an important index to measure drought resistance

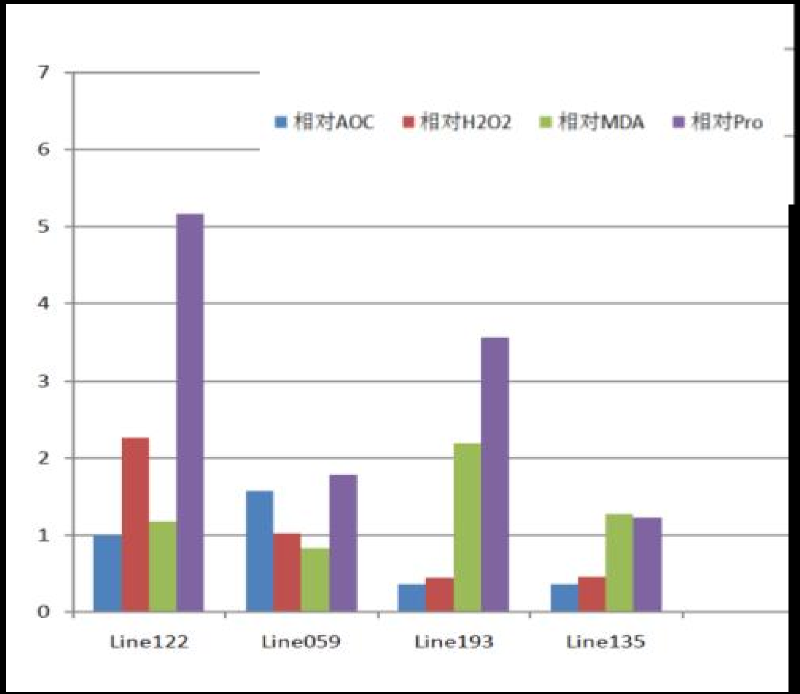
IRAT 109, a upland rice cultivar from Africa, was found with higher RDR and DA, was widely used in both gene identification and WDR breeding program

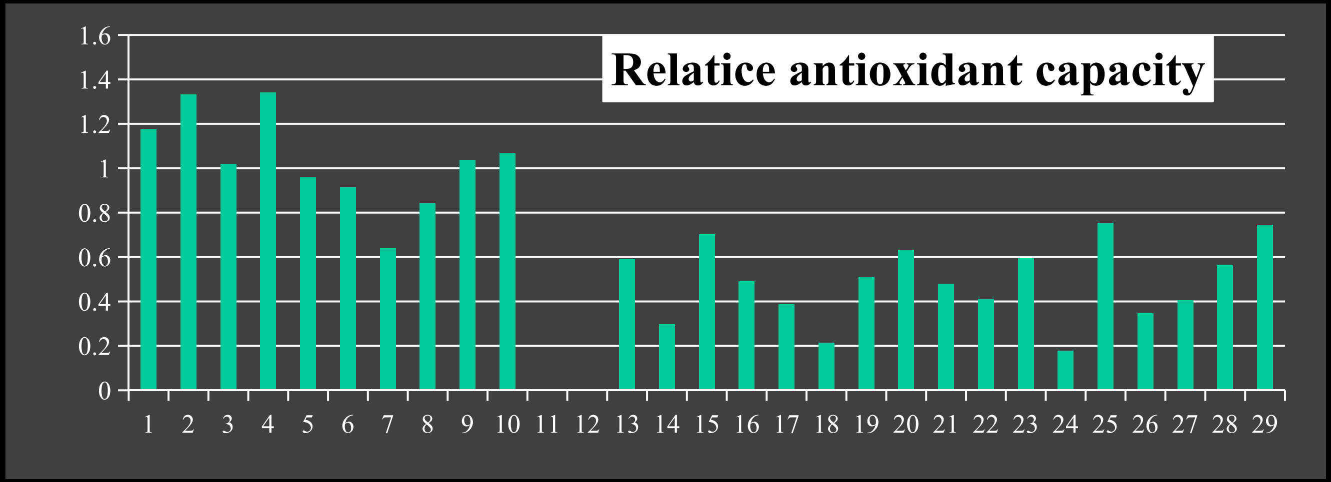
Fig. 1. Root architectures of the parents of the RILs.



Lou et al. 2015 JXB

Drought tolerance





Drought recovery

Stop water for 22 days

Recovery 3 h

Recovery 6.5 h

Achievements

There are 27 certified varieties, including 5 Chinese certified varieties and 22 provincial certified varieties. The research has been published in many journals such as in Cleaner Production, Molecular Plant, Plant Biotechnology Journal, Journal of Environmental Botany, Sciticific Report, Frontiers in Plant Science and so on.

HanYou73: Application for plant variety rights

综合查询

植物种类	水稻 Oryza sativa L.
品种名称	旱优73号
申请号	20110870.0
申请日	2011年11月11日
申请人	上海市农业生物基因中心
共同申请人	上海天谷生物科技股份有限公司
目前状态	授权
申请公告日	2012年3月1日
授权日	2016年3月1日
品种权人	上海市农业生物基因中心
共同品种权人	上海天谷生物科技股份有限公司

植物种类:	水稻
品种名称:	旱优73号
申请号:	20110870.0
申请日:	2011-11-11
申请人:	上海市农业生物基因中心
审查状态:	授权
申请公告日:	2012-03-01
授权号:	CNA20110870.0
授权日:	2016-03-01
公告号:	CNA007031G
品种权人:	上海市农业生物基因中心
品种权地址:	上海市北翟路2901号(201106)

HanYou73: was certification in Anhui, Hubei and Guangxi provience

High yield and quality

Water-saving drought-resistant

high temperature tolerance

and direct seeding

The character of WDR variety

Easy cultivation

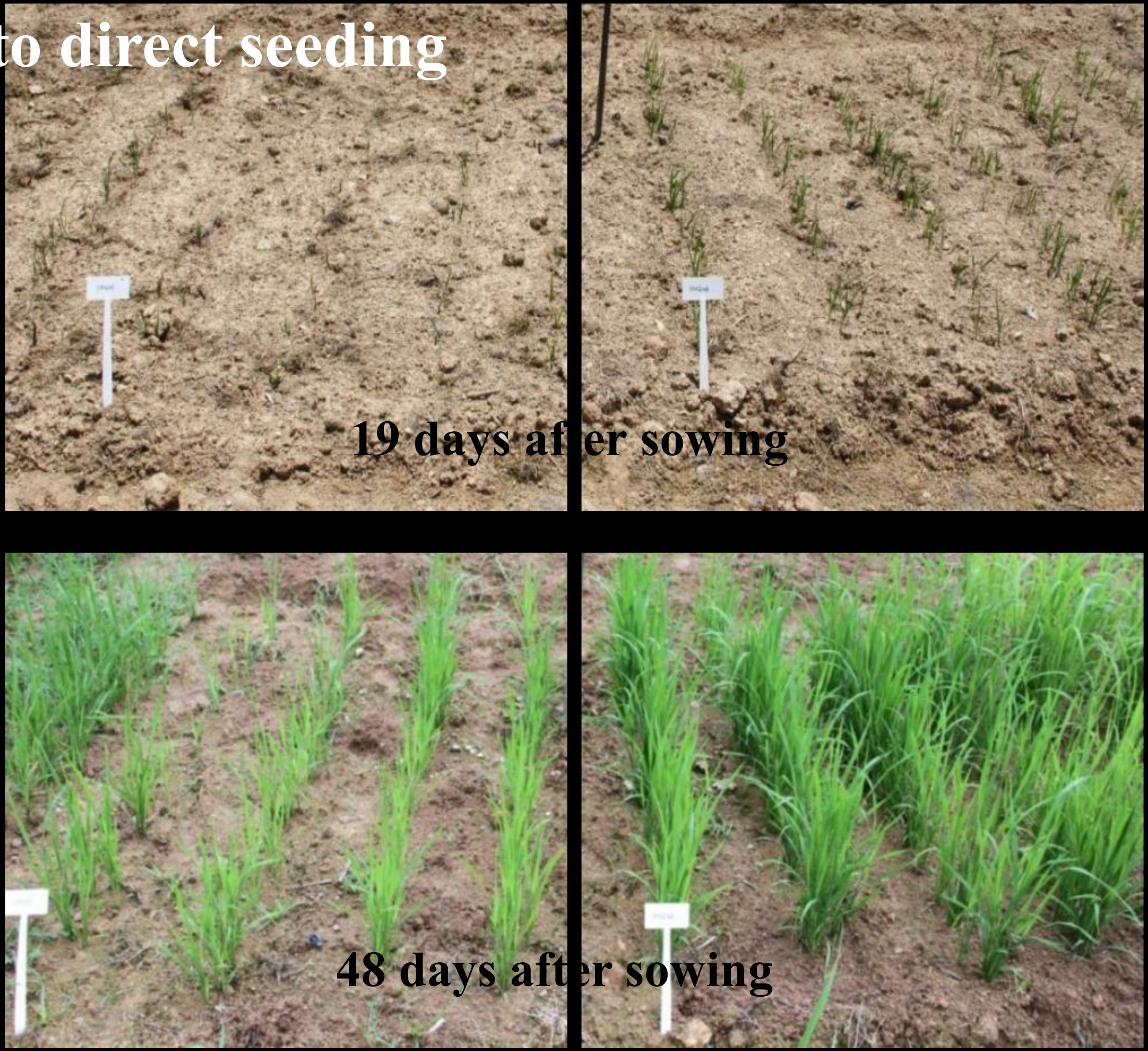
Resistance to direct seeding

Rooting capacity, flooding tolerance, weeds (rice)

Efficient use of fertilizer

Environment friendly.....

Resistance to direct seeding



HanHui3 HanYou73

High efficiency use of phosphate fertilizer

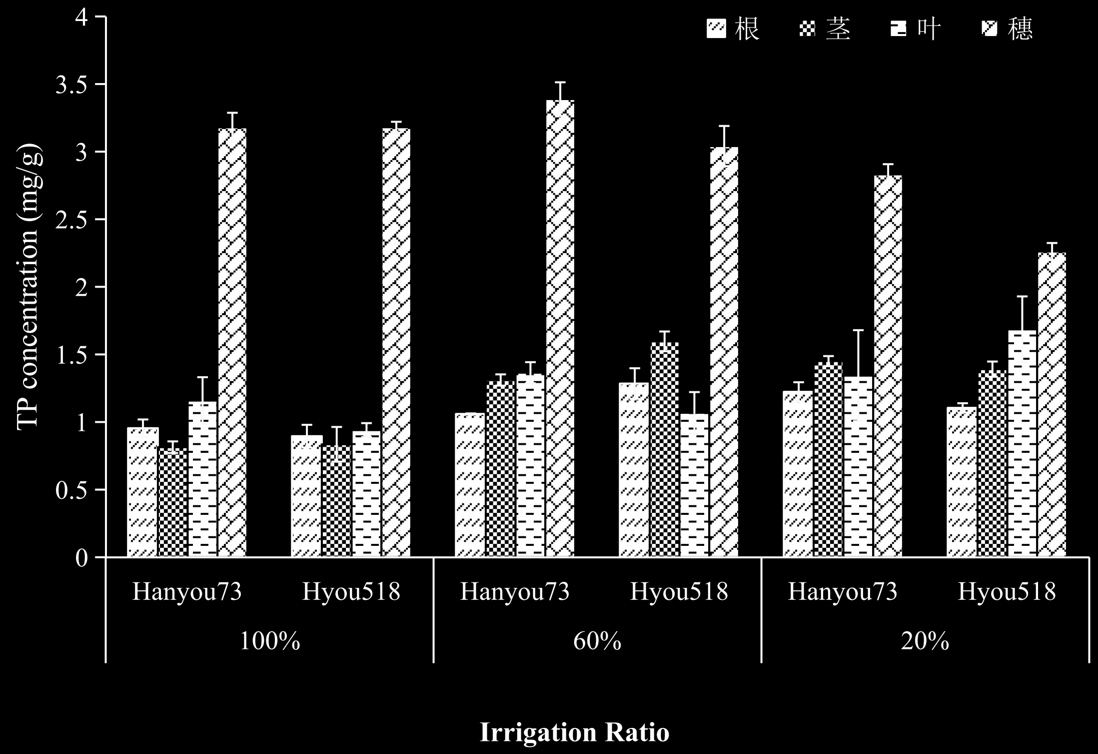


Fig.1 The effect of irrigation quantity on phosphorus (P) accumulation of WDR

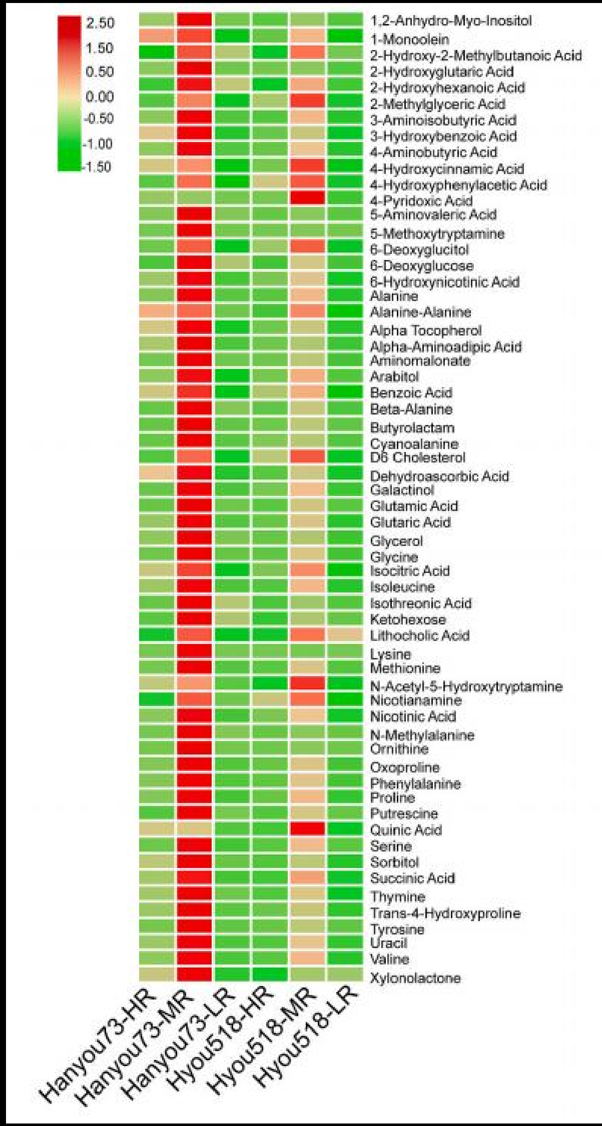
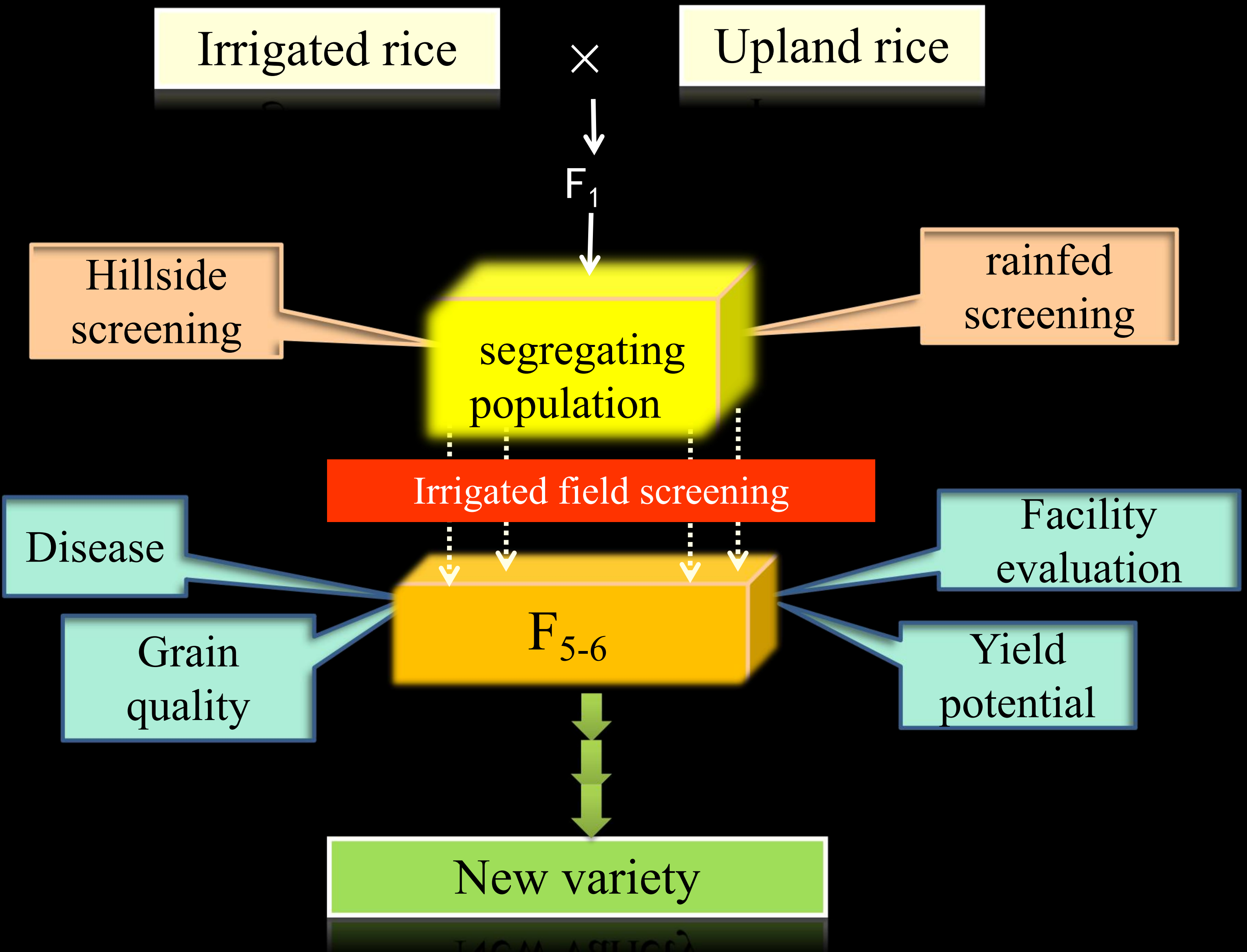


Fig. 3 The heat map of organic acids from root of the WDR and lowland rice variety

Bi et al.2021 J. Cleaner Production

How to cultivate WDR variety?



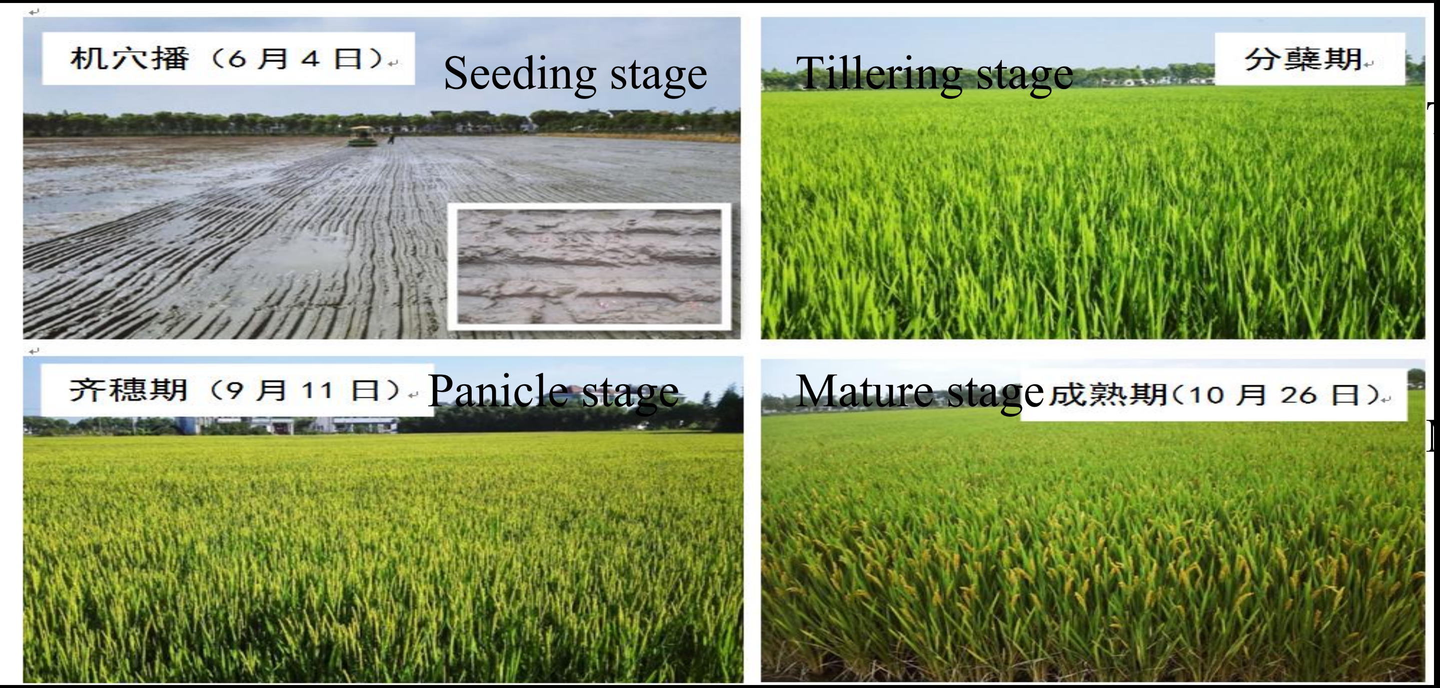
The goal of developing WDR variety

1. For paddy fields: Change cropping methods
2. For dry land: adjust planting structure
3. For new land: expand rice production area

Areas for developing WDR variety

I. Paddy field: water (drought) direct seeding and drought management

Changing the traditional way of growing rice
Realize resource saving and environment friendly!



Areas for developing WDR variety

II. Upland cropping (prone to waterlogging)

Adjust crop planting structure

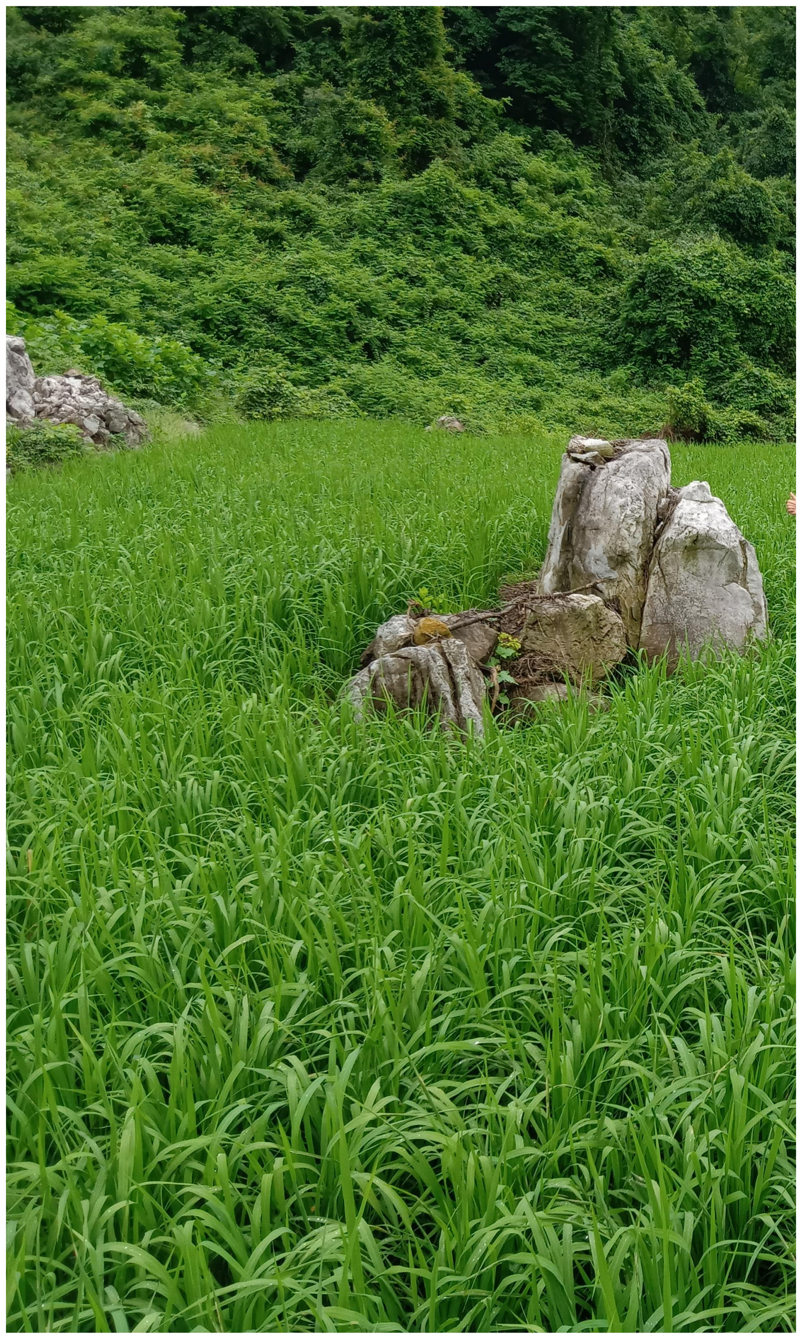
Realizing value-added farmland to increase farmers' incomes

Target areas for WDR variety

III farmlands abandoned

Basic farmland will go up the mountain

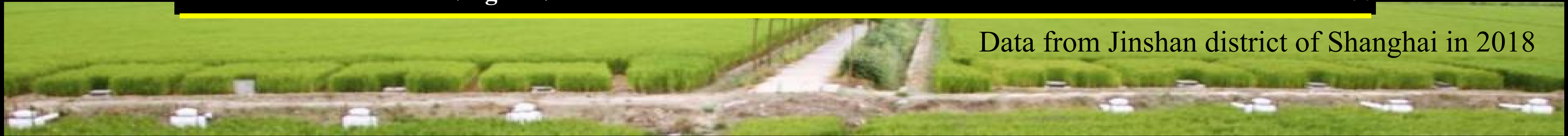
hillslope



The performence of WDR variety Hanyou3 in Guangxi provence in 2021

Reduction emission demonstration of WDR variety direct seeding in lowland field

		Huhan61（WDR）	Xiushui134（CK）	（%）
Input	Water（m^3/mu）	210	450	-53.30%
	Urea（kg/mu）	6	25	-76.00%
Output	yield（kg/mu）	717.9	679.1	5.40%
	grain quality	excellent quality	general	
Emission	nitrogen（g/mu）	19.63	68.05	-71.20%
	phosphorus（g/mu）	7.2	11.68	-38.40%
	CH_4（mg/mu）	100	500	-80.00%
	2methyl4chlorodicarbonamide（mg/mu）	0	27.24	-100.00%
	orthene（mg/mu）	0	4613.1	-100.00%
	avilamycin（mg/mu）	0	172.9	-100.00%
	indoxacarb（mg/mu）	1.14	9.92	-88.50%
	nitenpyram（mg/mu）	124.82	1004.94	-87.60%
	bentazone（mg/mu）	0	4687.9	-100.00%



Data from Jinshan district of Shanghai in 2018

WDR are going international

中国新闻 新民晚报 | 9

新民网:www.xinmin.cn 24小时读者热线:962555 编辑邮箱:xmywb@xmwb.com.cn 读者来信:dzlx@xmwb.com.cn 2019年10月16日/星期三 本版编辑/王文佳 视觉设计/竹建英

节水又抗旱 减排又保土

“沪生”稻南北丰收播撒全球

本报讯（记者 马亚宁）今天是第39个世界粮食日。金风送爽，在安徽蚌埠附近的产粮大县，田野间一片金黄，来自上海的节水抗旱稻正在等待收割。不仅仅是在这里，这颗改变了水稻传统种植方式的“沪生”新稻种，已推广到江西、湖南、河南等我国水稻主产区。推广面积累计近600万亩，是我国成百上千个水稻新品种中一颗冉冉升起的绿色明星。

绿色环保是当今人类发展的新需求。在我国，水稻生产用水占农业用水量的70%，消耗了我国总用水量的50%左右，工业和城市用水及其他农业用水的增长使得水稻的灌溉越来越难以保证；为追求高产而加大的施肥和用药量加剧了稻田土壤富营养化、水土流失等环境问题；水稻田也是温室气体甲烷排放的重要来源……越来越多的中国科学家在寻找两全其美的解决之道，努力平衡粮食安全与生态环境。

上海市农业生物基因中心罗利军研究员团队，率先提出“节水抗旱稻”的理念。节水抗旱稻兼具水稻高产优质和旱稻节水抗旱特点。经过近20年的探索，在遗传研究、品种培育和推广应用中取得重大进展。与常规水稻依赖“水种水管”相比，节水抗旱稻在育种阶段增强了抗旱天性，比普通水稻节约用水50%，即使缺水仍能确保高产稳产，像种麦子一样种水稻也成为可能。特别是在没有灌溉条件的中低产田里，节水抗旱稻依然实现增产稳产。

2016年，上海市农业生物基因中心主持制订的《节水抗旱稻术语》和《节水抗旱稻抗旱性鉴定技术规范》两个行业标准由农业部颁布实施。2018年，农业部启动“国家节水抗旱稻区域试验”。目前，上海选育的节水抗旱稻品种在安徽、江西、湖南、河南、福建等各地推广，表现优异。

水稻作为我国百姓的重要主粮，新品层出不穷。但是，单一品种的推广面积整体较少，约八成新品种仅能推广种植几万亩。“沪生”节水抗旱稻家族却出类拔萃，仅“旱优73”这个品种，已通过浙江、江西、湖南、河南、福建等多个省份引种，种植带从海南延绵至山东。全国南北种植面积达到约500万亩。在安徽，旱涝保收的“旱优73”更成为年推广面积最大的杂交稻品种。

与此同时，节水抗旱稻也已走出国门，在东南亚的越南、缅甸、巴基斯坦、老挝和非洲的乌干达、加纳、马达加斯加等地展开了实质性的推广工作，表现出较强的增产优势，国际影响力不断增加。

UN environment programme

21 OCT 2020 I STORY I EC

New strains of rice could address climate change

To tackle such issues, the United Nations Environment Programme (UNEP) has been working with the Shanghai Agrobiological Gene Center to develop strains of rice that are drought resistant and don't need to be planted in paddies. The research, say, experts, could help bolster food security at a time when COVID-19 is threatening to propel more people into hunger.

One strain, dubbed WDR 73 by scientists, proved particularly promising. During trials in Uganda, researchers found that it helped boost yields by about 30 per cent compared to locally grown varieties.

Consideration

Environmental factors, such as drought, direct seeding, high temperature and flooding resistance, make it more and more urgent for agriculture to breed superior varieties. In the process of DUS testing, it is necessary to evalute the drought resistance of plants to cope with the climate change. Whether these stress-related traits can be selected for testing which needs further discussion in the future.


谢谢大家! Thanks for your attention !