13th International symposium of potassium-Kunming, 2019.11.6

Potassium use efficiency and fertilization limit standards of cereal crops in China

我国主要粮食作物钾肥效率及其施肥限量标准

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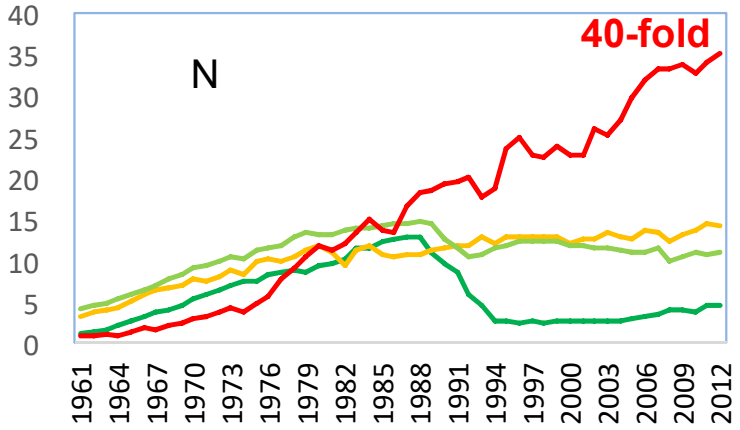
College of resources and environment, China agricultural university

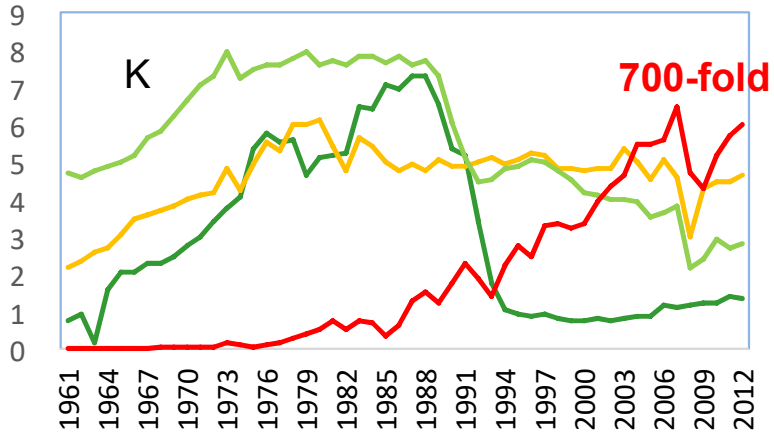
2019-11-5

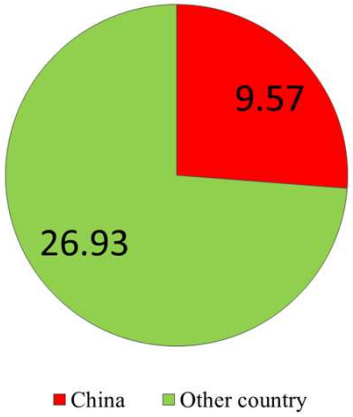
Main content:

- Background and current K management
- Yield response to K application and K use efficiency
- K fertilization limit standards of cereal crops in China

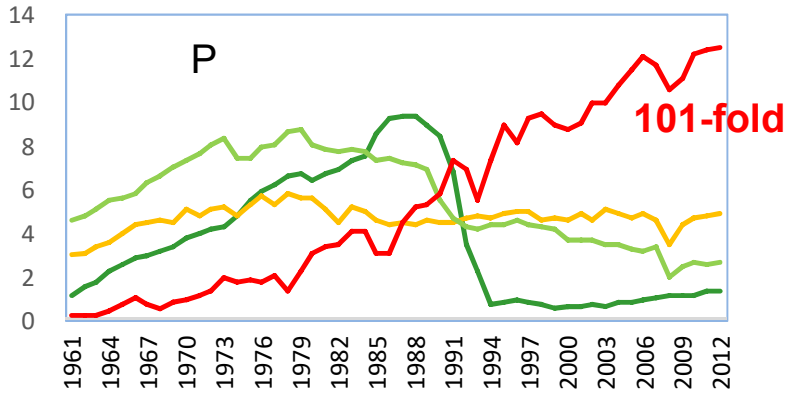
N, P and K Fertilizer consumption in China

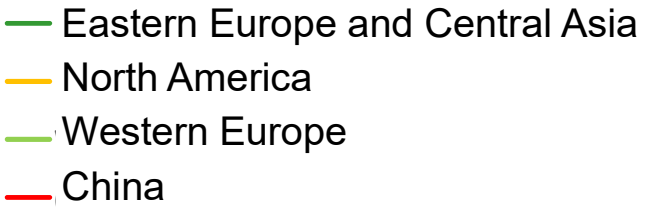




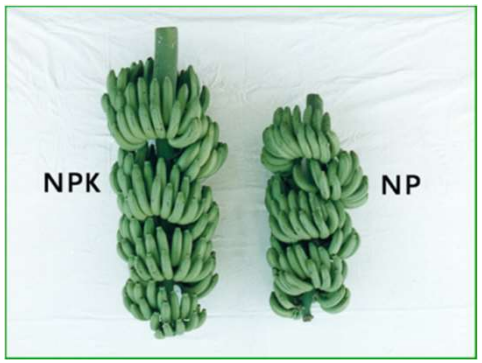


(Year, 2017)





(Adopted from IFA)



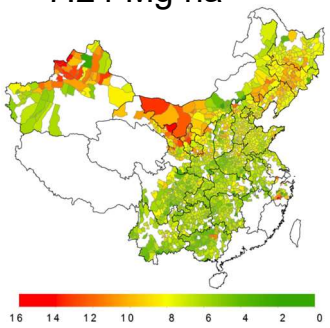
Current farmers' practice

(Maize, *n* = 2.89 millions)

(2005-2014)

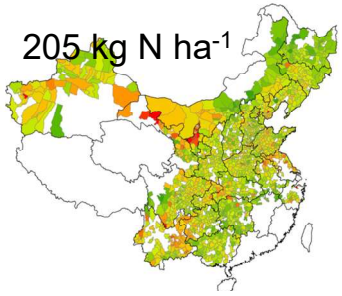
Grain yield

7.24 Mg ha^{-1}

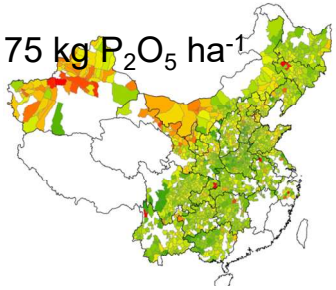


Nutrient rate

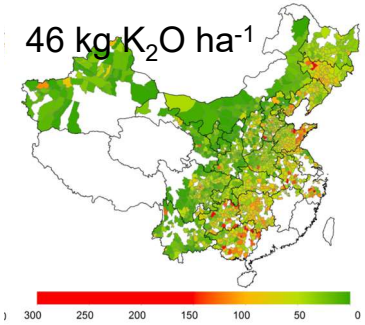
205 kg N ha^{-1}



75 kg P_2O_5 ha^{-1}



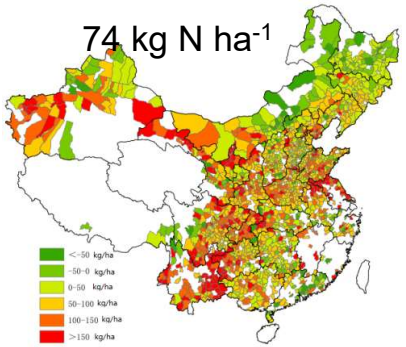
46 kg K_2O ha^{-1}



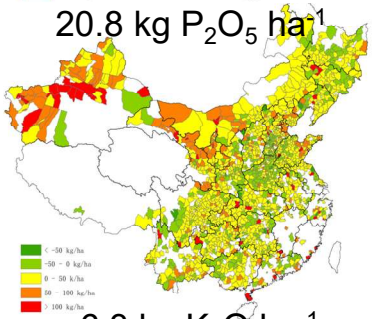
70% straw return

Estimated nutrient balance

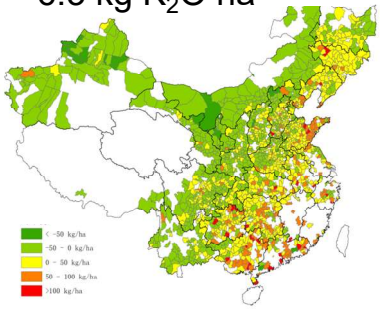
74 kg N ha^{-1}



20.8 kg P_2O_5 ha^{-1}



6.3 kg K_2O ha^{-1}

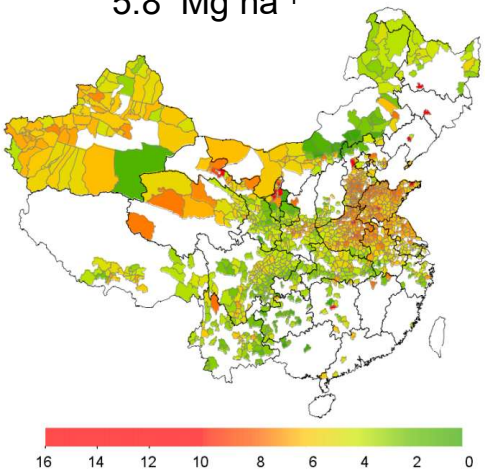


Current farmers' practice

(Wheat, *n* = 2.2 millions, 2005-2014)

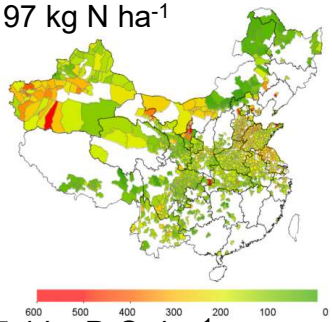
Grain yield

5.8 Mg ha^{-1}

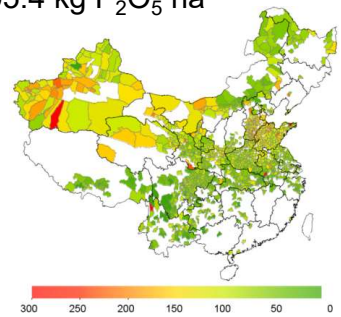


Nutrient rate

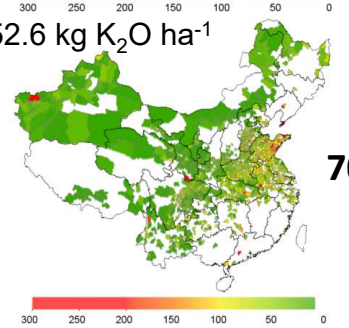
197 kg N ha^{-1}



95.4 kg P_2O_5 ha^{-1}

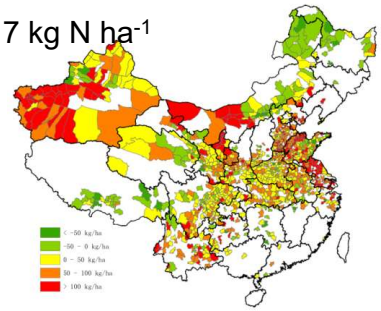


52.6 kg K_2O ha^{-1}

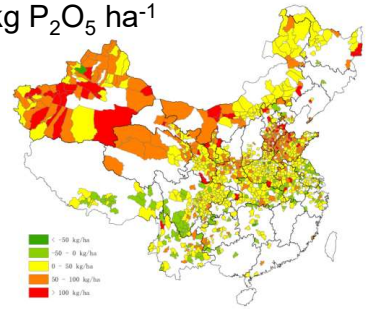


Estimated nutrient balance

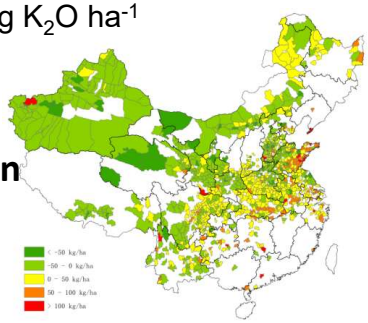
51.7 kg N ha^{-1}



37.8 kg P_2O_5 ha^{-1}



1.5 kg K_2O ha^{-1}



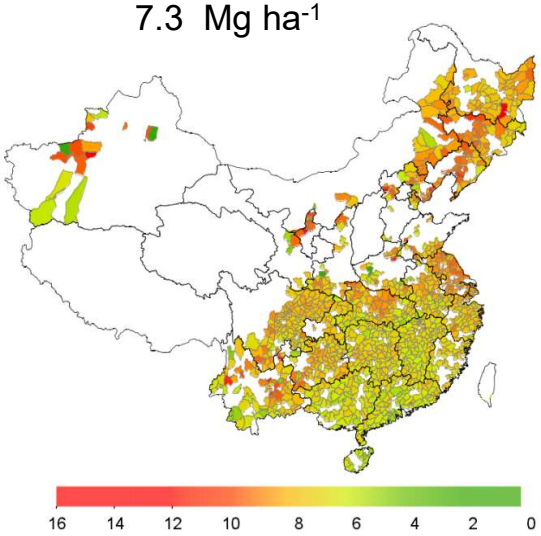
70% straw return

Current farmers' practice

(Rice, *n* = 3.5 millions)

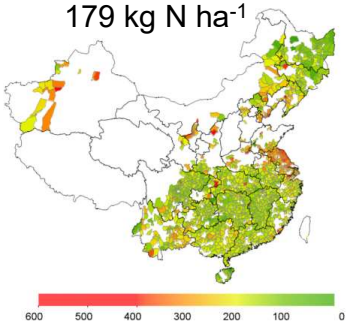
Grain yield

7.3 Mg ha^{-1}

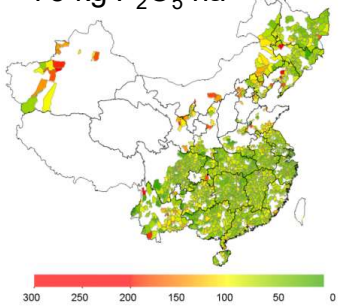


Nutrient rate

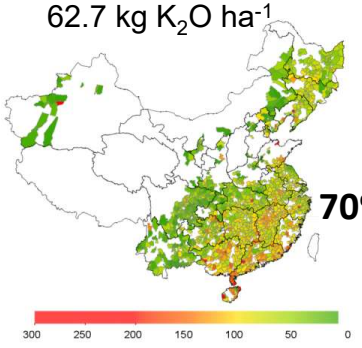
179 kg N ha^{-1}



75 kg P_2O_5 ha^{-1}

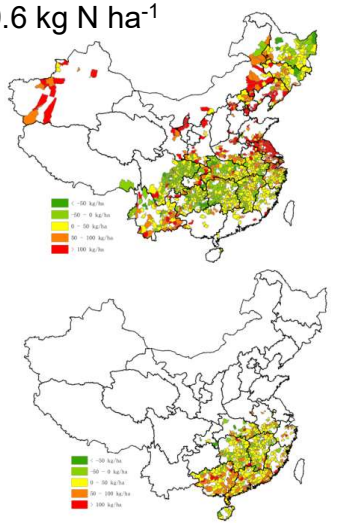


62.7 kg K_2O ha^{-1}

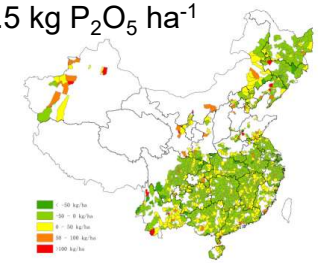


Estimated nutrient balance

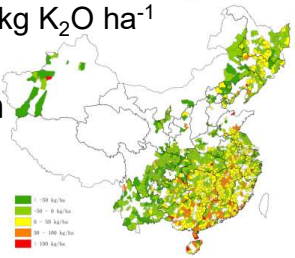
39.6 kg N ha^{-1}



-5.5 kg P_2O_5 ha^{-1}



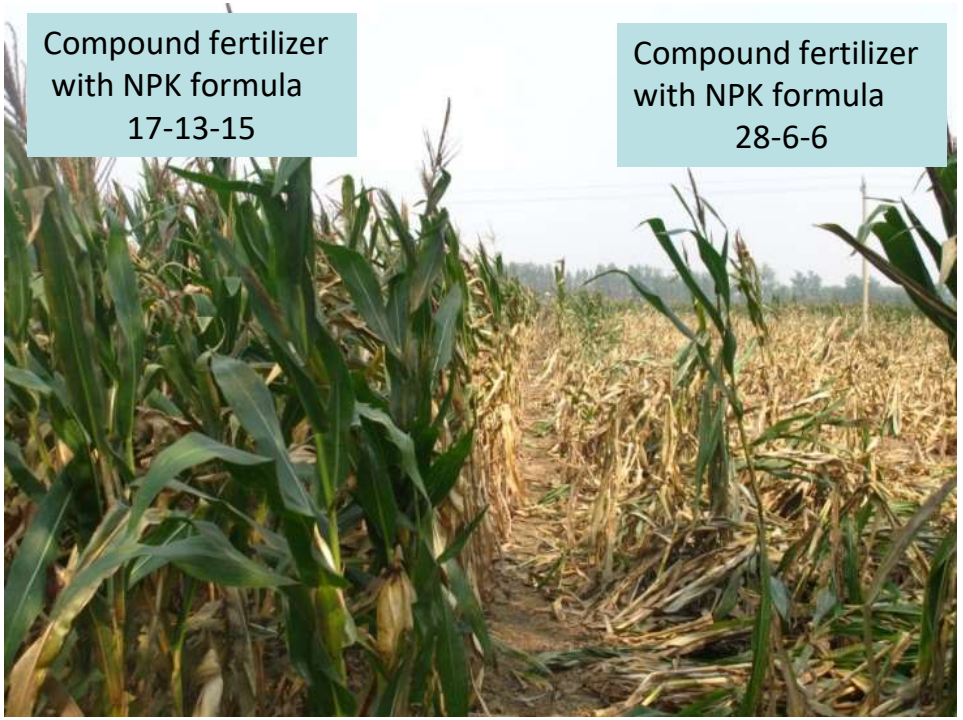
-2.2kg K_2O ha^{-1}



70% straw return

Misuse and overuse K fertilization

Wrong products with wrong application method resulted in 20% more fertilizer input without crop yield increase



Study of the application of K fertilizer in super high yield maize in Laizhou, Shandong Province（Wang，2007）

Treatments	K fertilizer rate (kg/ha)	Yield (kg/mu)	K uptake (kg/ha)	K uptake per 100kg grain (kg/100kg grain)
Super high yield field	882	21	654	3.74
Average yield field	60	8.9	129	1.92

(photo from Anhui，2011)

The objective

Address the limits and uncertainties of the current understanding of yield response of K fertilizer application and K use efficiency to develop a robust and county-level regional K management.

(a) How do climates, soil properties, and management factors influence yield response to K applied and the K recovery efficiency?

(b) How do yield responses and the K recovery efficiency changes in cereal crops vary in different regions across the China?

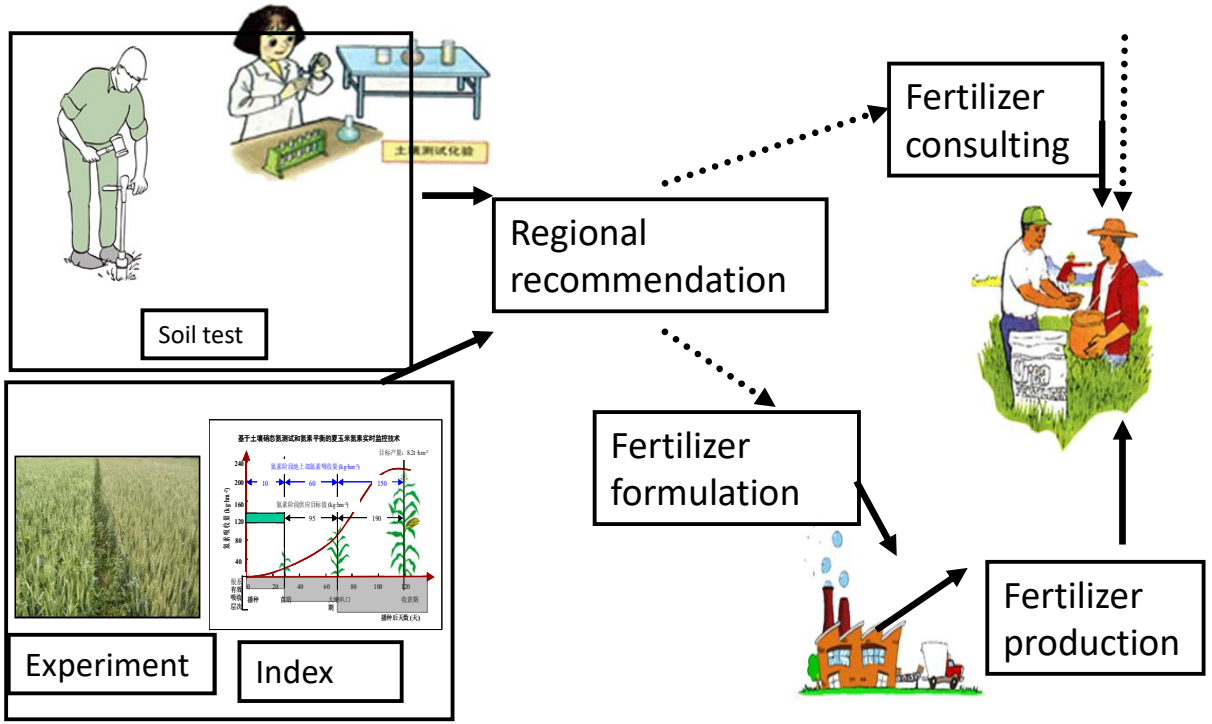
(c) To what extent can K fertilizer regulate yield change in China?

(d) What is optimal K management of cereal crops in China?

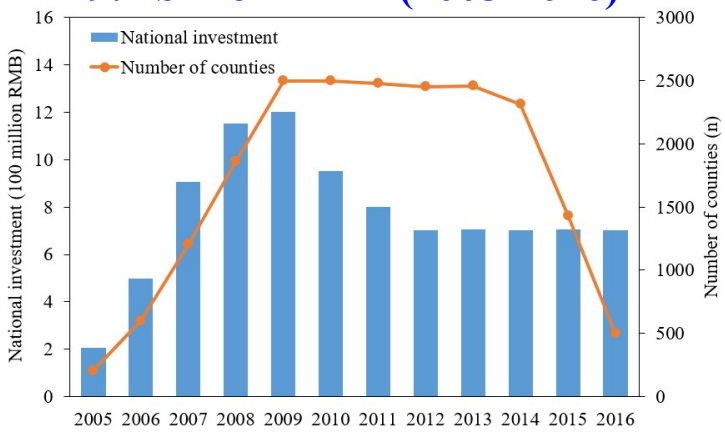
Data Source

National Soil Testing and Fertilizer Recommendation Project

Since 2005



9.2 billion RMB (2005-2016)

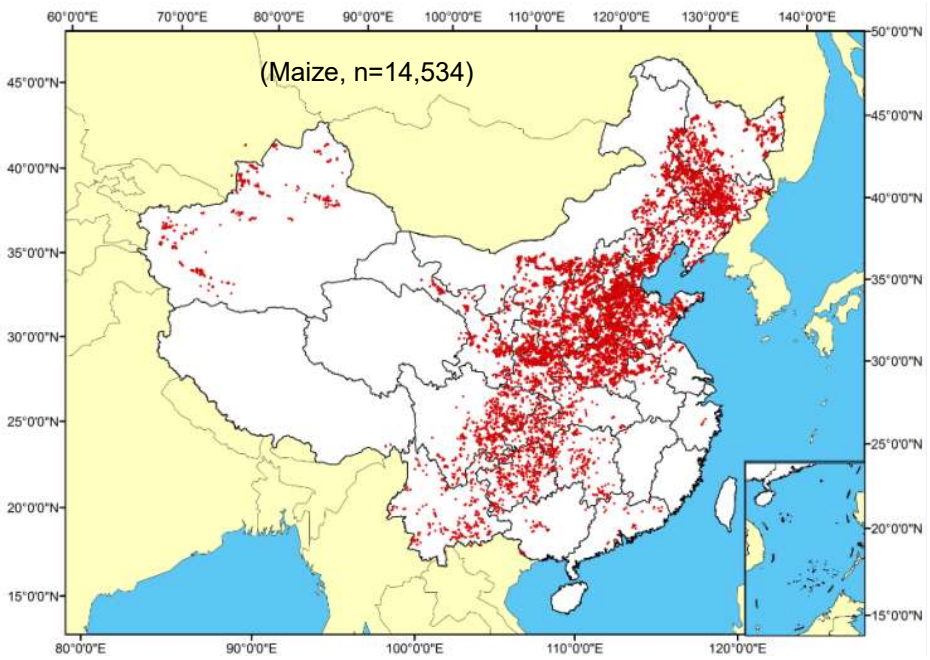


Items	Unit	10 years
Soil samples	Million	**19.35**
Plant samples	Million	**1.69**
Soil nutrient testing	Million	**128.77**
Plant nutrient testing	Million	**9.36**

Main content:

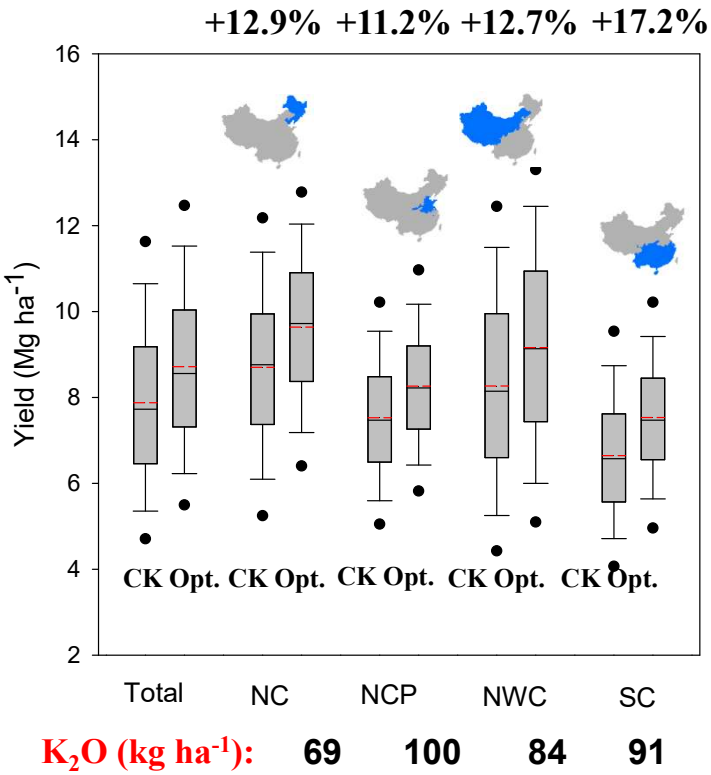
- Background and current K management
- **Yield response to K application and K use efficiency**
- K fertilization limit standards of cereal crops in China

1. Field experiments to investigate yield response to K application (Maize as the example)



Experimental sites

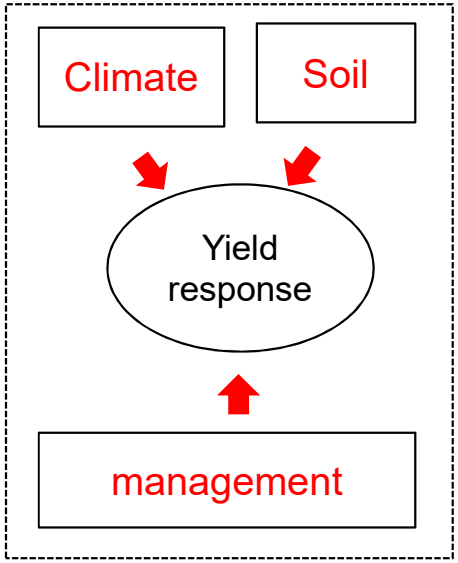
+12.5%

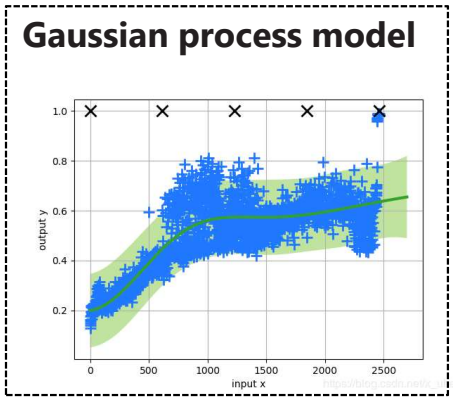


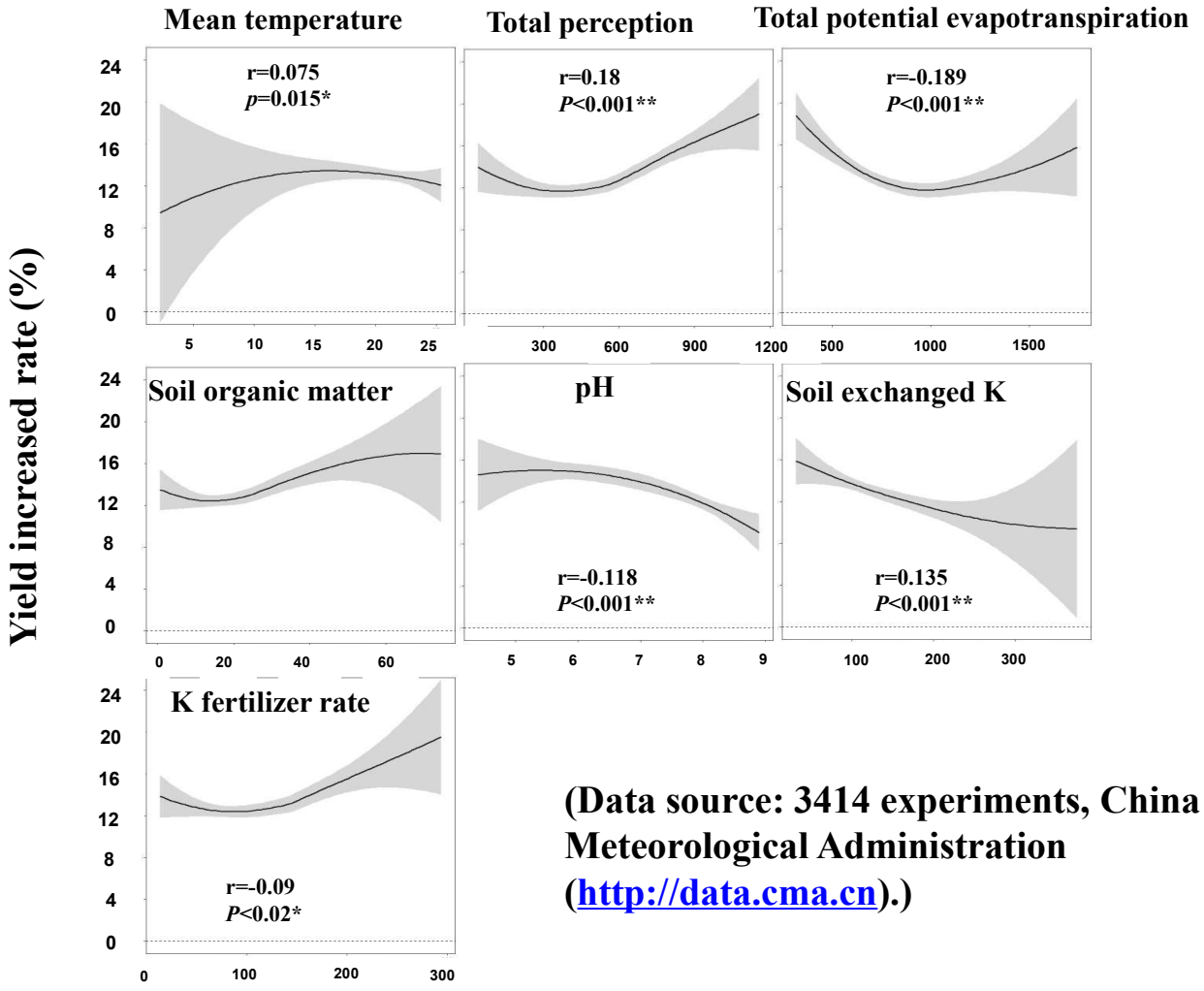
K_2O (kg ha^{-1}): 69 100 84 91

(Data source: 3414 experiments)

Climate, soil and management influences yield response to K application



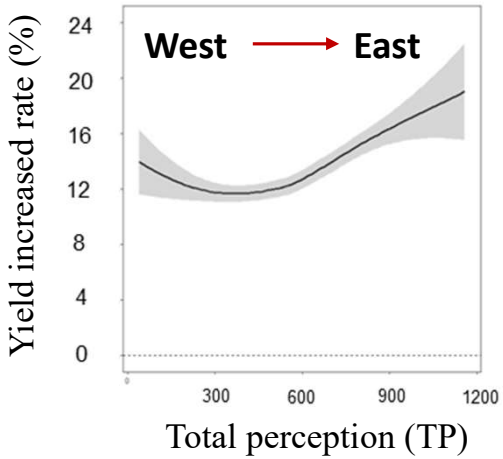


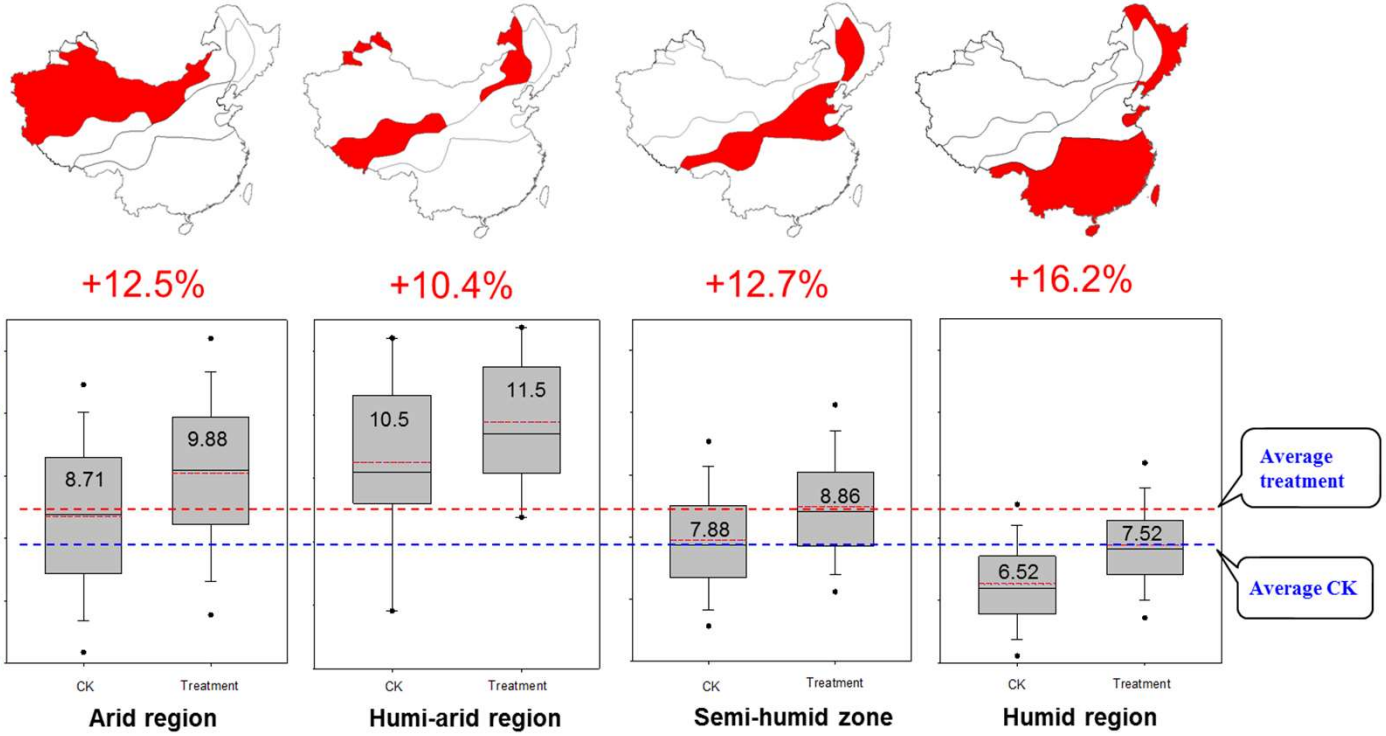


(Data source: 3414 experiments, China Meteorological Administration (http://data.cma.cn).)

Change of yield response to K application for wet-dry zone

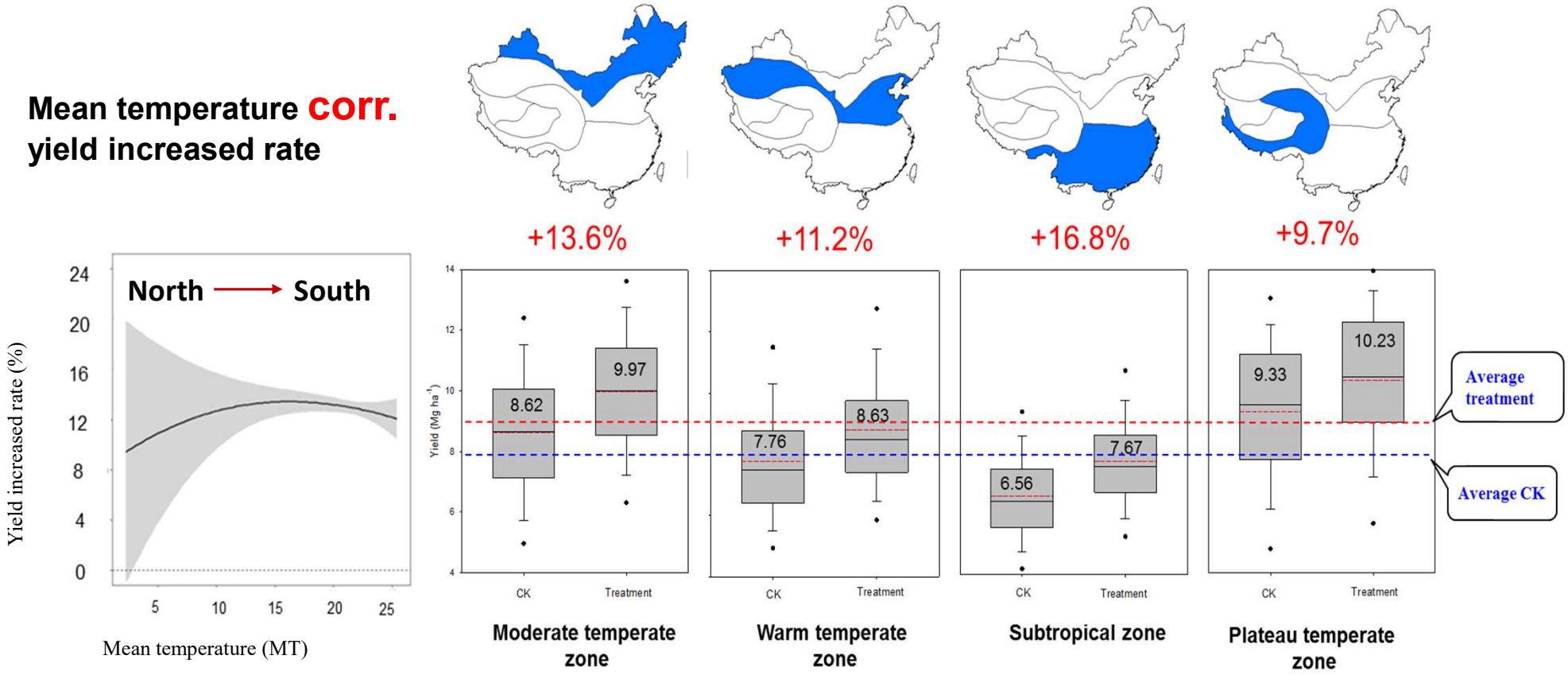
Total perception corr.
yield increased rate



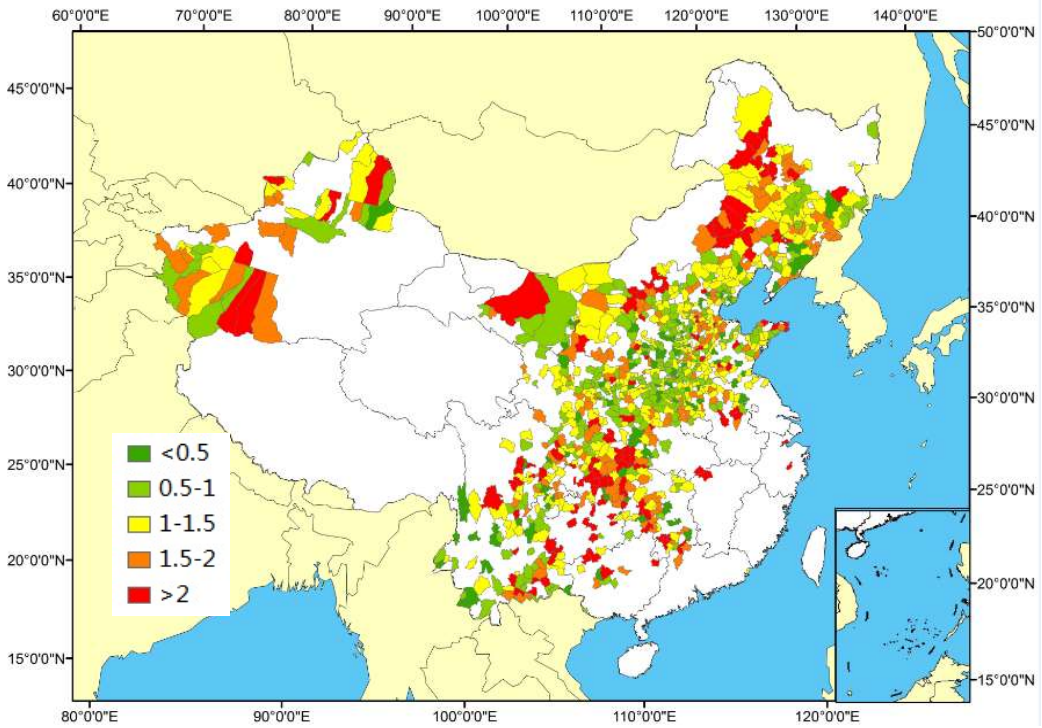


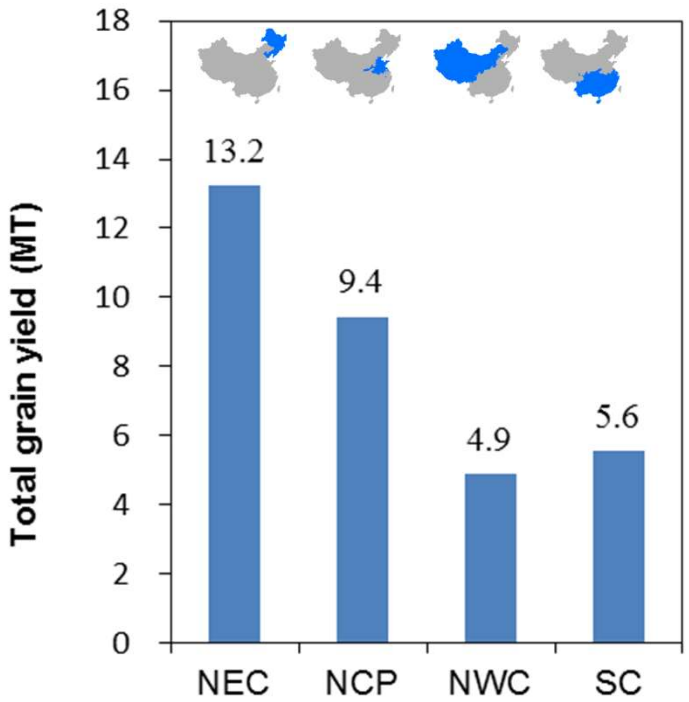
Change of Yield response to K fertilizer for temperature zone

Mean temperature corr. yield increased rate



K application contributed to maize production in China





Yield increased:

0.8 Mg ha^{-1} (-1.3-4.6 Mg ha^{-1})

Total production increased:

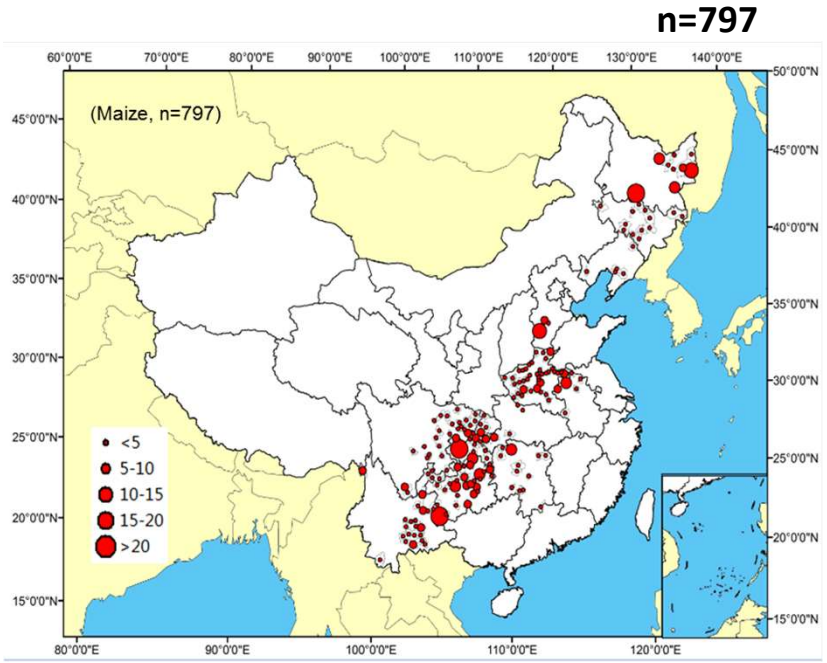
33.1 Mt

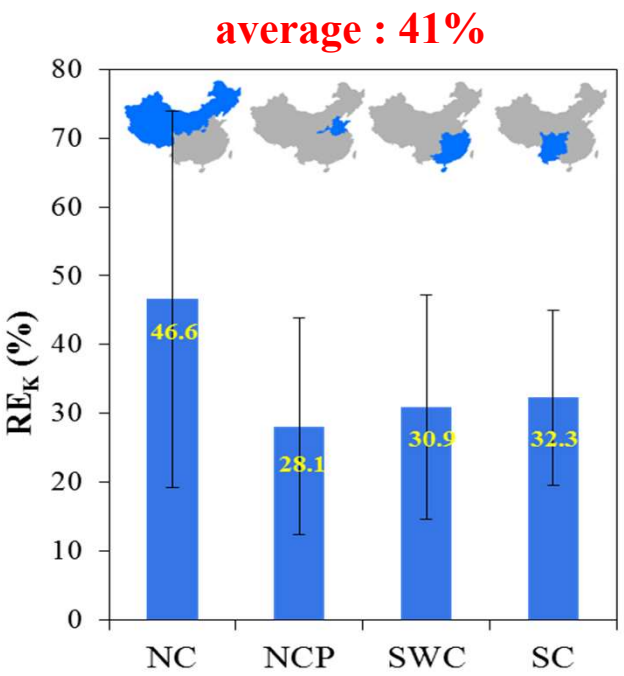
Yield response of K application for rice and wheat production

Crops	regions	Increased yield	Increased rate	Total increase production	Influence factors
		Mg ha^{-1}	%	MT	
Rice	NC	0.6±0.9	8.5±13.3	2.4	TP>MT>pH> TPE>SK> K fer.>SOM
	YRB	0.8±0.6	10.9±10.7	12.3	
	SWC	0.8±0.7	10.2±10.5	2.0	
	SC	0.9±0.8	15.0±15	7.9	
	China	**0.8±0.7**	**11.6±10.7**	**24.1**	
Wheat	NC	0.5±0.3	13.1±9.3	2.2	MT>TPE>TP> pH>SK> SOM >K fer.
	NCP	0.6±0.7	13.3±13.3	9.3	
	SWC	0.8±0.6	15.4±13.2	2.0	
	YRB	0.7±0.7	12.2±12.2	2.8	
	China	**0.7±0.7**	**12.5±12.5**	**16.5**	

2. Field experiments to investigate K recovery use efficiency

(Maize as the example)





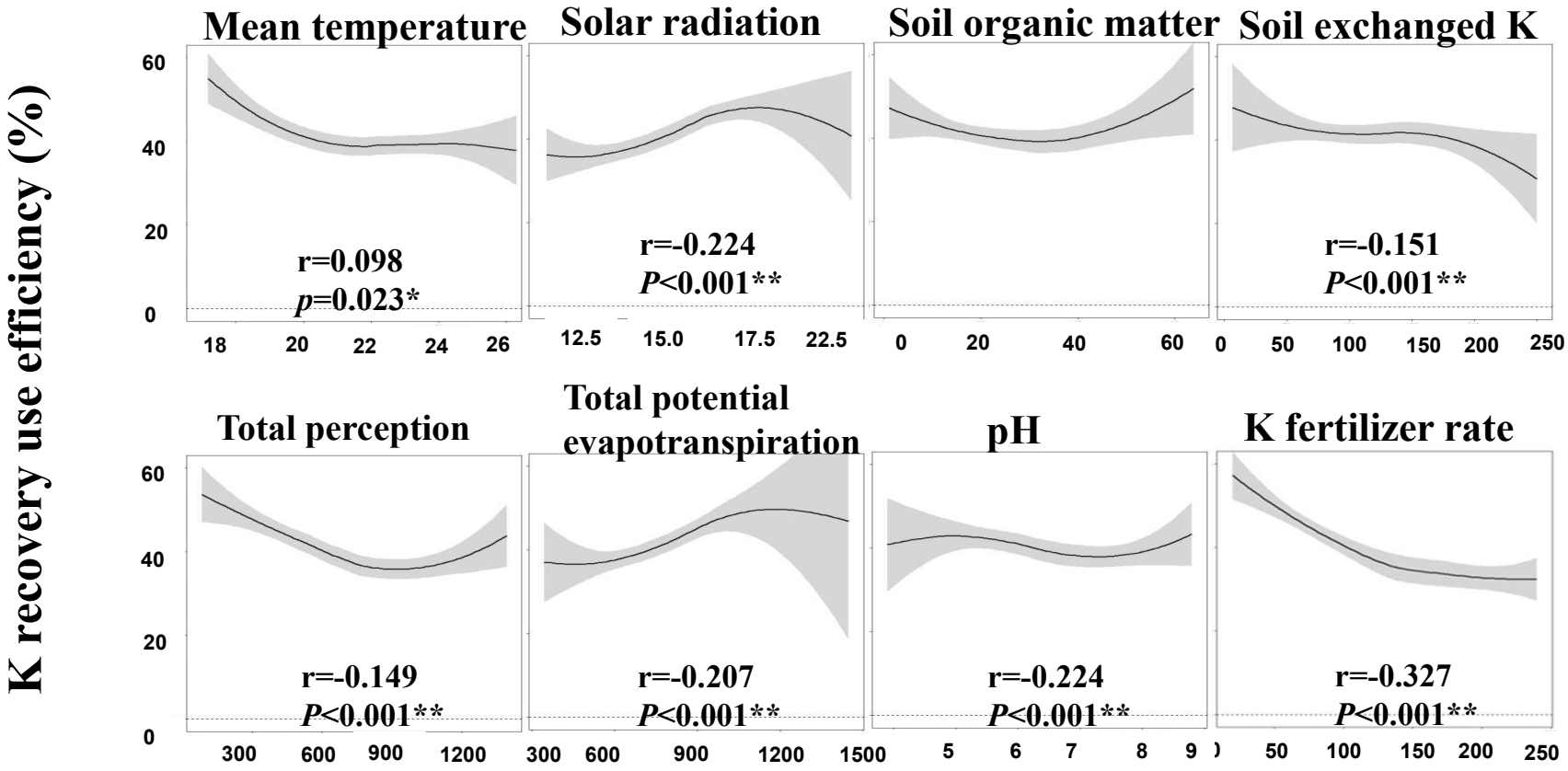
Nutrient recovery efficiency (RE) = (U-U0)/F

U — total nutrient uptake in aboveground biomass at maturity in a plot that received fertilizer (kg ha^{-1})

U_0 — total nutrient uptake in aboveground biomass at maturity in a plot that received no fertilizer (kg ha^{-1})

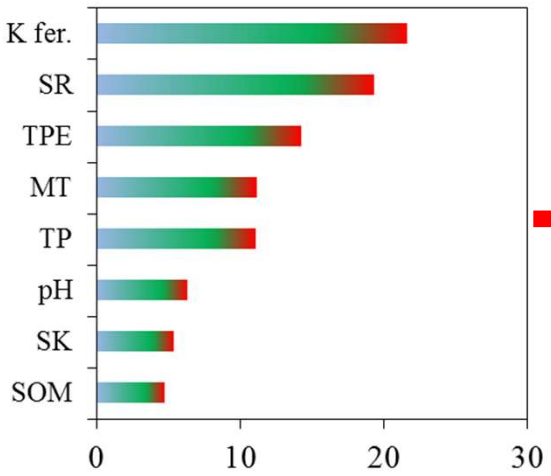
F — amount of nutrient applied (kg ha^{-1})

Climate, soil and management influences K recovery use efficiency

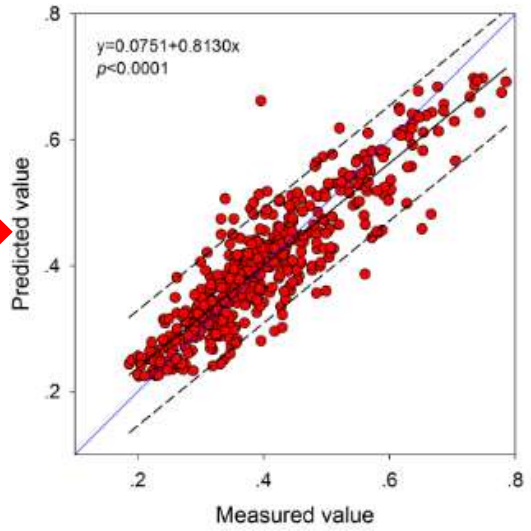


County-level K recovery use efficiency

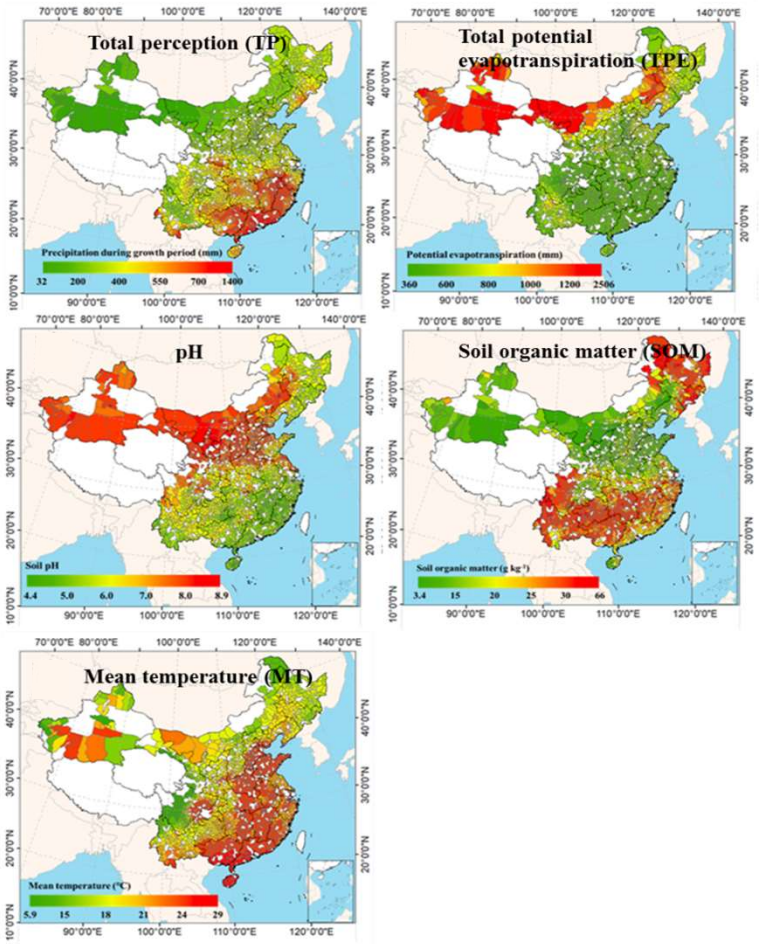
Importance



Models

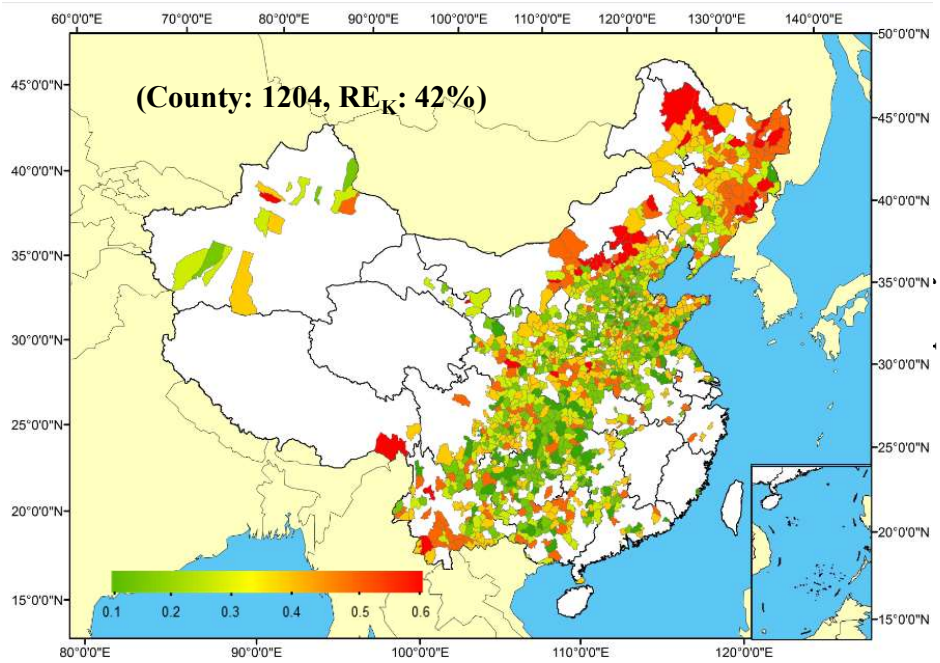


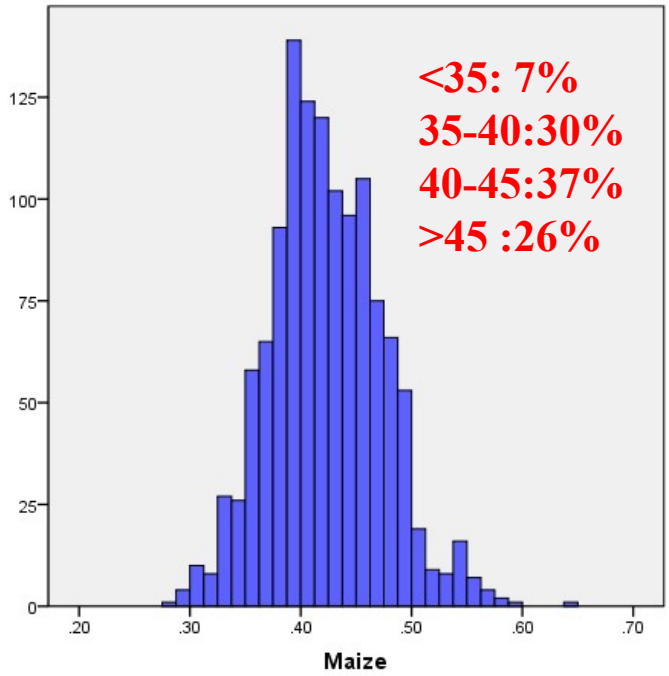
County-level cropland basic information in China



County-level K recovery use efficiency

Maize:

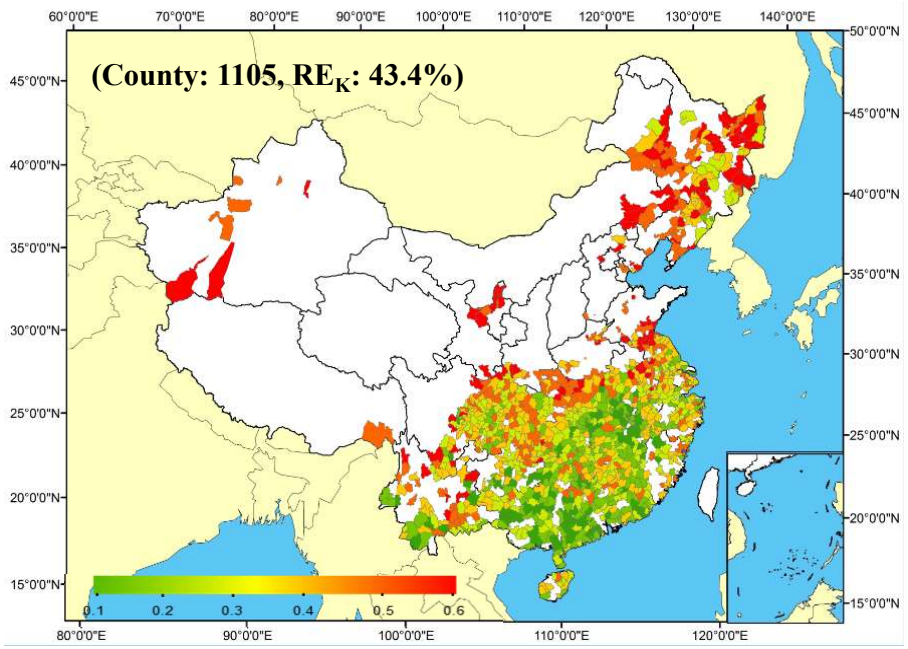




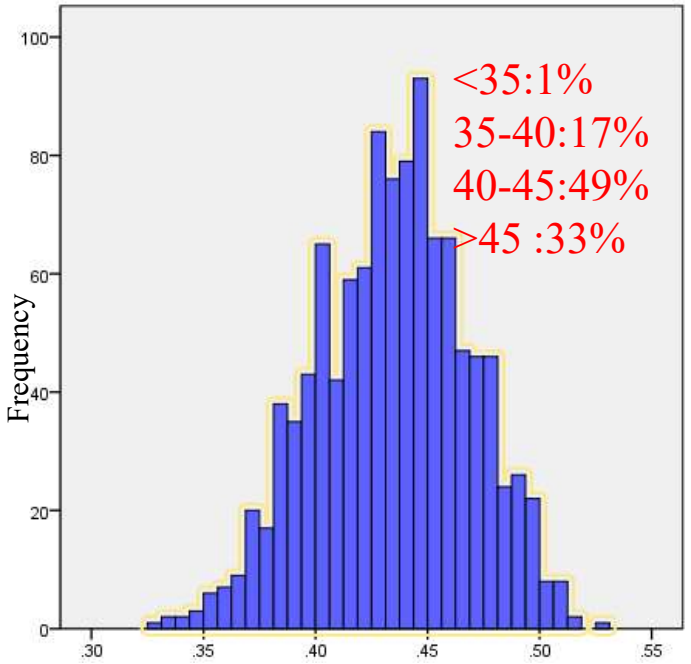
Regions

RE_K (%)	45.0	39.7	43.1	39.3

County-level K recovery use efficiency



Rice:

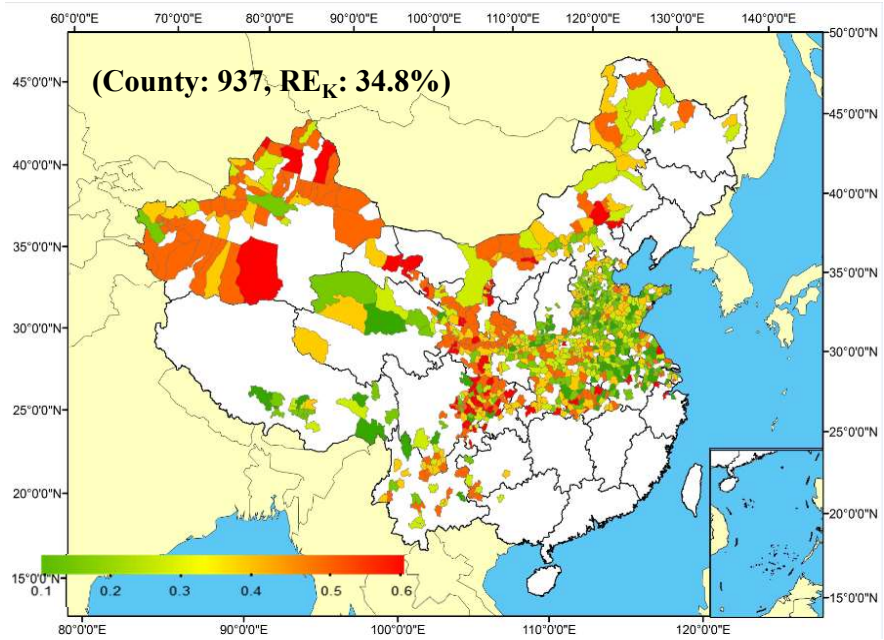


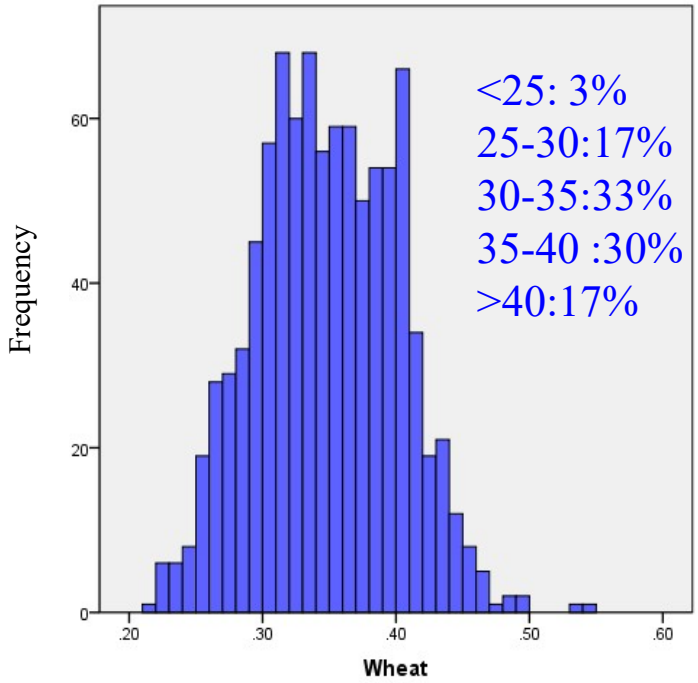
Regions

RE_K (%)	46.9	43.3	42.6	41.8

County-level K recovery use efficiency

Wheat:





Regions				
RE_K (%)	37.6	31.0	37.0	32.9

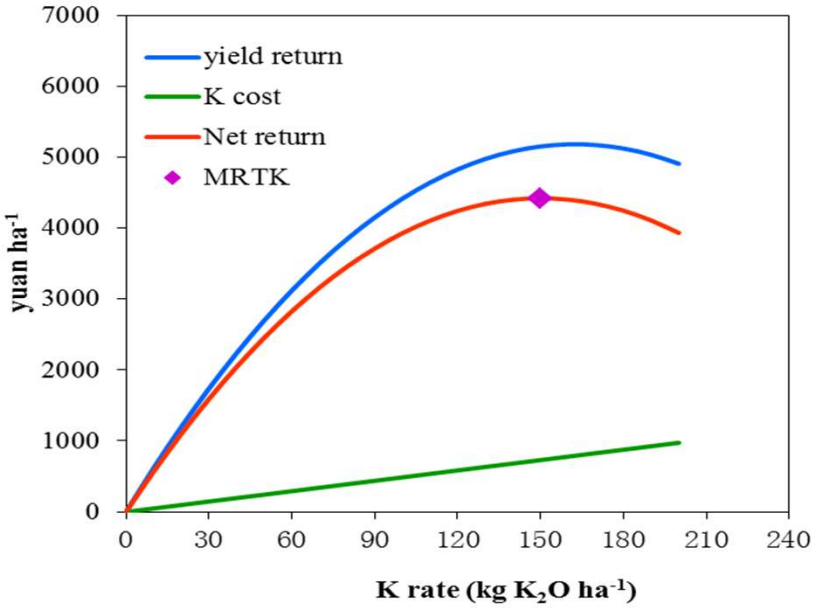
Potassium recovery efficiency over time

Crop systems	Eras and regions	n	K_2O rate kg ha^{-1}	Basal yield t ha^{-1}	Yield t ha^{-1}	REK(%)
Rice	1990s	43	106	5.0	5.8	**44(7-83)**
	2000s	35	121	7.2	8.0	**42(2-80)**
	North rice	13	90	6.0	7.5	**44(9-50)**
	South rice	80	125	6.7	7.5	**43(22-70)**
	Current	1105 county				**43.4 (37-57)**
Wheat	1990s	40	112	4.9	5.7	**36(3-82)**
	2000s	77	131	5.7	6.2	**33(3-92)**
	North winter wheat	75	123	6.0	6.6	**37(2-89)**
	South winter wheat	50	123	5.5	6.2	**33(7-92)**
	Current	937 county				**34.8 (21-55)**
Maize	1990s	58	152	6.5	7.2	**31(3-71)**
	2000s	37	185	7.0	8.1	**27(1-54)**
	Summer maize	62	159	6.1	7.0	**28(1-71)**
	Spring maize	33	176	7.7	8.7	**31(1-70)**
	Current	1204 county				**42(28-64)**

Main content:

- Background and current K management
- Yield response to K application and K use efficiency
- **K fertilization limit standards of cereal crops in China**

1. Maximum return to K application



Crops	Price of grain	Price of K_2O
	(Yuan kg^{-1})	(Yuan kg^{-1})
Maize	2.0	5.65
Rice	2.7	5.65
Wheat	2.3	5.65

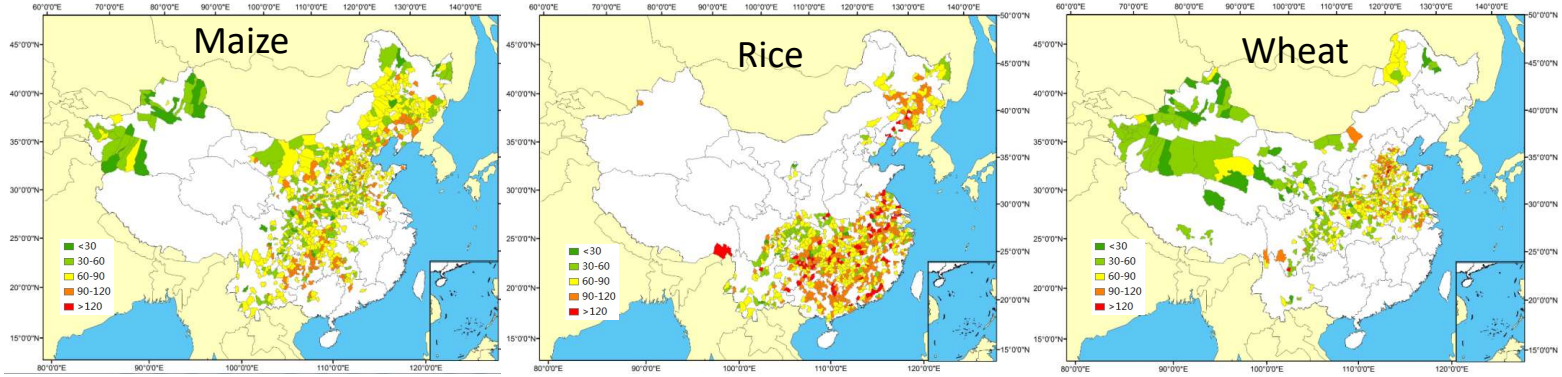
MRTK (Maximum return to K):

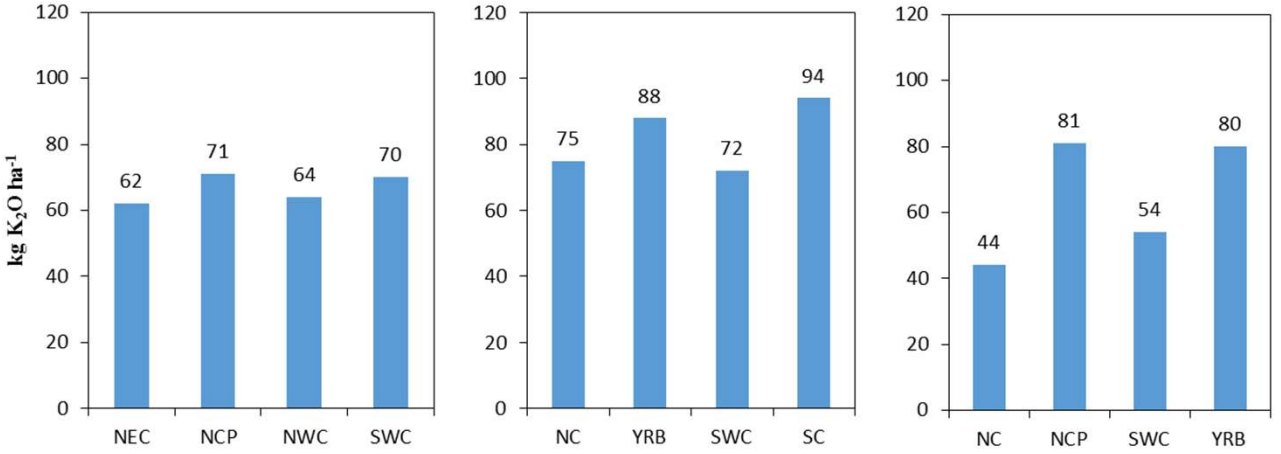
$B = Y_{increase} * P_y - F * P_f = \beta * K_2O + \alpha * (K_2O)^2$

where B is the net return (Yuan ha^{-1}), $Y_{increase}$ is the increased yield, Py and Pf are the price of crop grain and K fertilizer, F is the K fertilizer rate, α is the quadratic regression coefficient, and β is the primary regression coefficient.

Optimal K fertilizer rate for cereals

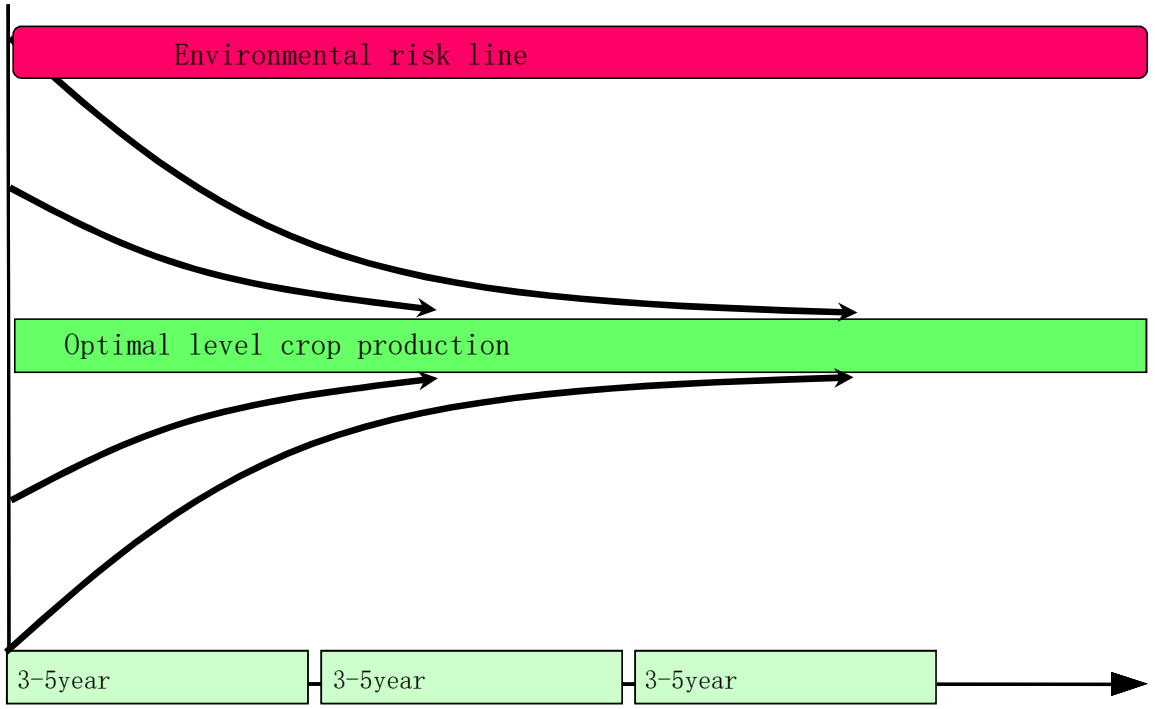
68 kg ha^{-1} K_2O **86 kg ha^{-1} K_2O** **67 kg ha^{-1} K_2O**





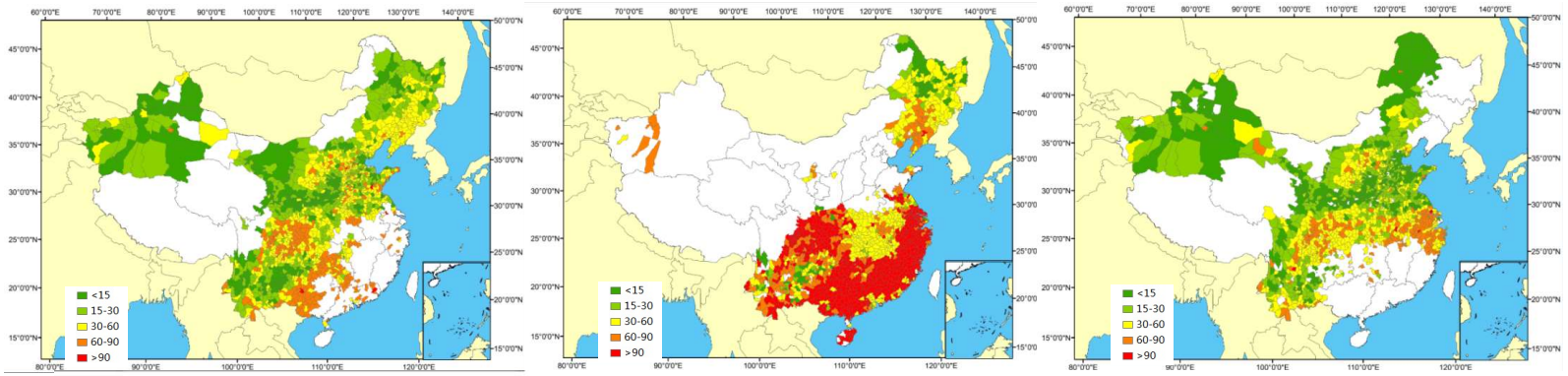
2. Principle of K fertilizer recommendation

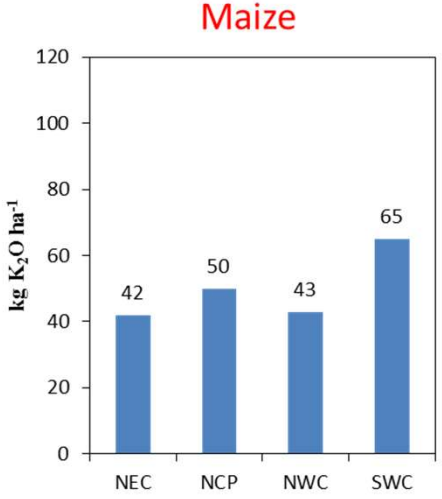
Approach	K recommendation	Soil K
Control	No fertilizer	Very high
	Input＞＞Output (K_2O rate = Crop remove 50 -70%)	High
Maintenance	Input＞＞Output (K_2O rate = Crop remove 100%)	Medium
	Input＞＞Output (K_2O rate = Crop remove 130 -170%)	Low
Building up	Input＞＞Output (K_2O rate = Crop remove 200%)	Very low

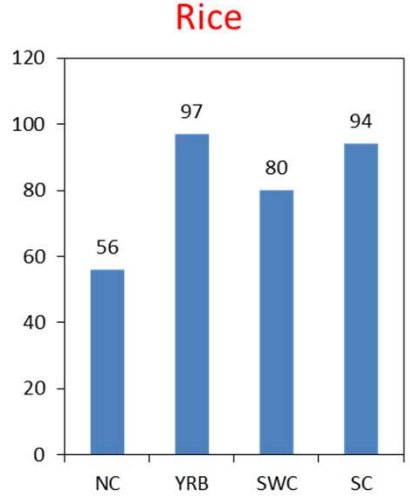


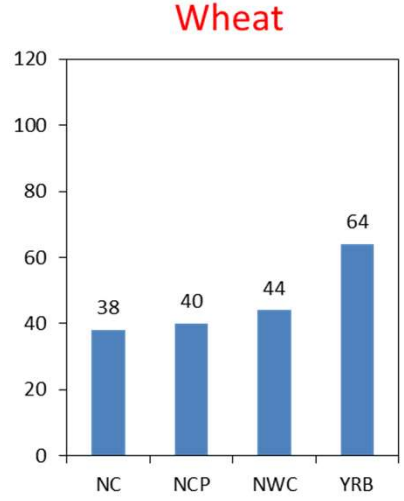
Optimal K fertilizer rate for cereals

54 kg ha^{-1} K_2O | **84kg ha^{-1} K_2O** | **53 kg ha^{-1} K_2O**









Summary

- **Optimized K management is important technology for Chinese food security, especially cereal crop production;**
- **Yield responses of K application and K use efficiency are location-specific, depend on climates, soil and management, and mechanism need more future research from modeling and experiments ;**
- **Current K application rate is a litter lower than estimated optimal K rate, but future optimized K application have to consider regional variation.**

Thanks for your attention

谢谢！