Sustainable Use of Plant Nutrients in China

Fusuo Zhang
Jiqing Wang
Weifeng Zhang
MA Wenqi

China Agricultural University, Beijing

Outline

- Low nutrient use efficiency (NUE) in China
  - -Low PFP
  - -Low AE
  - -Low RE
- Integrated nutrient management in Winter wheat-summer maize cropping systems
- Conclusions and perspectives

Low PFP

Fertilizer application rate, grain yield, and partial factor productivity (PFP) in China，USA and France in 2000

	China	USA	France
Fertilizer application rate (kg/ha)	248	212	200
Yield (kg/ha)	4261	4745	13881
PFP (%)	17.2	22.4	69.2

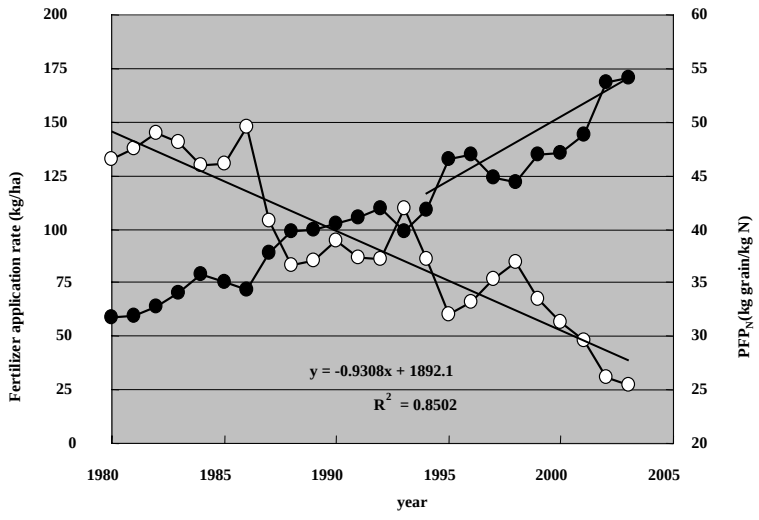
(Chinese data are from the farmer survey by Chinese Ministry of Agriculture in 2000;
The data of USA and France are from global survey of IFA in 1997-1999)

Partial factor productivity from applied nitrogen

PFP_N = kg harvest product per kg N applied:

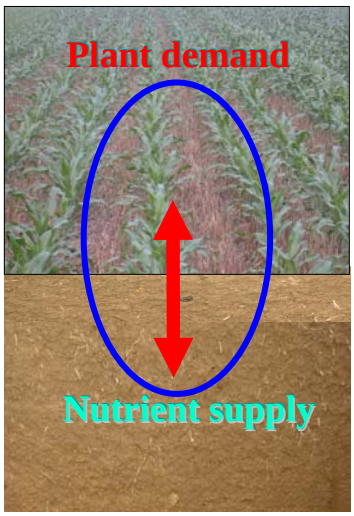
PFP_N (kg kg^{-1}) = Y_N/F_N $\quad$ $PFP_N = (Y_0/F_N) + AE_N$

Y_N= crop yield (kg ha^{-1}) $\quad$ F_N = amount of (fertilizer) N applied (kg ha^{-1})



Decreased PFP_N with increased rate of fertilizer application

Higher nutrient supply both from soil and environment



From environment

(e.g. Wet and dry N deposition)

North China Plain: 60-80 kg N ha^{-1} yr^{-1}

Sichuan Basin: 45-60 kg N ha^{-1} yr^{-1}

Indigenous nutrient supply from soil (e.g. N mineralization and residual N_{min})

North China Plain: 83-124 kg N ha^{-1} yr^{-1}

Sichuan Basin: 105-133 kg N ha^{-1} yr^{-1}

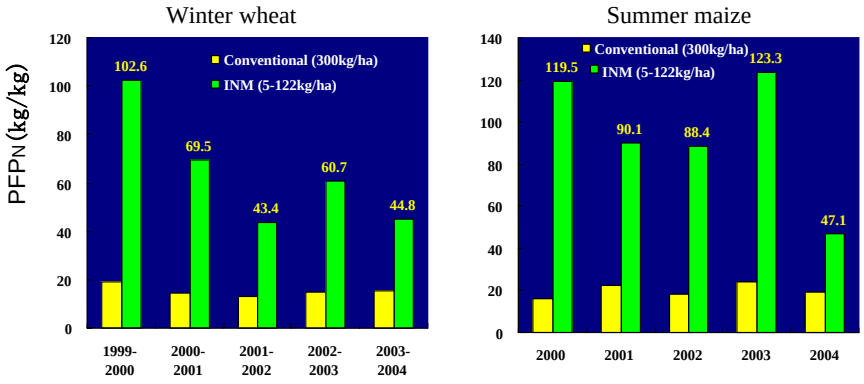
In the past, such nutrient supply was normally <40 kg N ha^{-1} yr^{-1} in China.

NO_3-N accumulation in soil profile are common in Guanzhong, Shaanxi

Land use type	NO_3-N（kg ha^{-1})			N rate (kg ha^{-1} yr^{-1})
	0-4m	0-2m	2-4m	
Apple orchard	3414	1602	1812	900
Vegetable field	1362	680	681	750
High yield farmland	537	323	214	500
Normal yield farmland	255	153	102	280

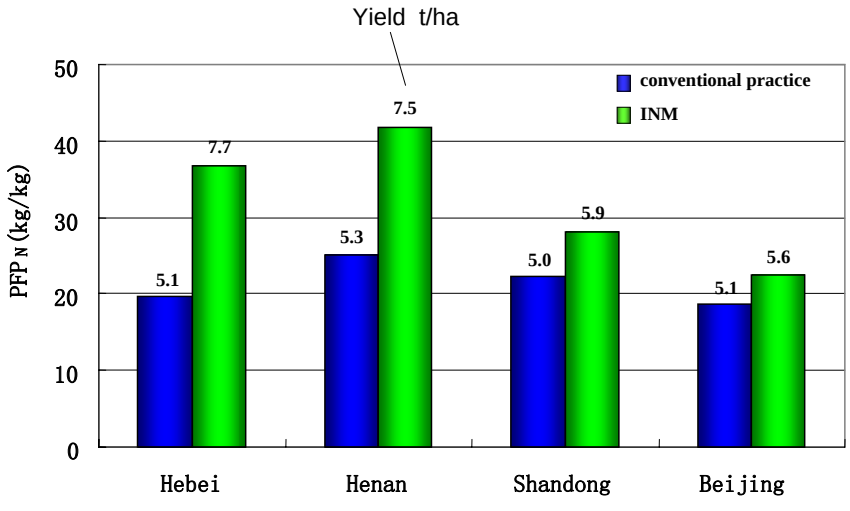
(Lu et al., 1998)

Increased N use efficiency (PFP_N) by INM compared with conventional practice in Beijing



(Data from the long-term experiment of Sino-German project in Dongbeiwang, Beijing)

Increased N use efficiency (PFP_N) and wheat yield through INM as compared with conventional practices in Hebei, Henan, Shandong and Beijing areas in 2005



Low AE

Change of N fertilizer efficiency (AE)

Grain	Year	Fertilizer application rate (kg/ha)	AE (kg/kg)
Wheat	1958-1962	45-60	10-15
	1981-1983	117.0 (1462)	10.0
	1997-2003	213.1 (148)	8.0
Maize	1958-1962	45-60	20-30
	1981-1983	124.5 (728)	13.4
	1997-2003	221.6 (89)	7.5
Rice	1958-1962	45-60	15-20
	1981-1983	126.0 (896)	9.1
	1997-2003	156.1 (99)	10.2

（AE=Agronomic Efficiency=$(Y_N-Y_0)/F_N$　　n：amount of experiments)

(Wang et al., unpub.)

Change of P_2O_5 fertilizer efficiency (AE)

Grain	Year	Fertilizer application rate (kg/ha)	AE (kg/kg)
Wheat	1958-1962	45-60	5-10
	1981-1983	81.0 (1851)	8.1
	1997-2003	157.5 (147)	7.7
Maize	1958-1962	45-60	5-10
	1981-1983	84.0 (1040)	9.7
	1997-2003	108.8 (34)	6.6
Rice	1958-1962	45-60	8-12
	1981-1983	58.5 (921)	4.7
	1997-2003	70.2 (63)	9.7

（AE=Agronomic Efficiency=$(Y_P-Y_0)/F_P$　　n：amount of experiments)

(Wang et al., unpub.)

Change of K_2O fertilizer efficiency (AE)

Grain	Year	Fertilizer application rate (kg/ha)	AE (kg/kg)
Wheat	1958-1962	45-60	0
	1981-1983	85.5 (687)	2.1
	1997-2003	116.9 (149)	6.8
Maize	1958-1962	45-60	2-4
	1981-1983	97.5 (314)	1.6
	1997-2003	125.9 (100)	6.5
Rice	1958-1962	45-60	2-4
	1981-1983	87.0 (875)	4.9
	1997-2003	86.5 (95)	6.9

（AE=Agronomic Efficiency=$(Y_K-Y_0)/F_K$　　n：amount of experiments)

(Wang et al., unpub.)

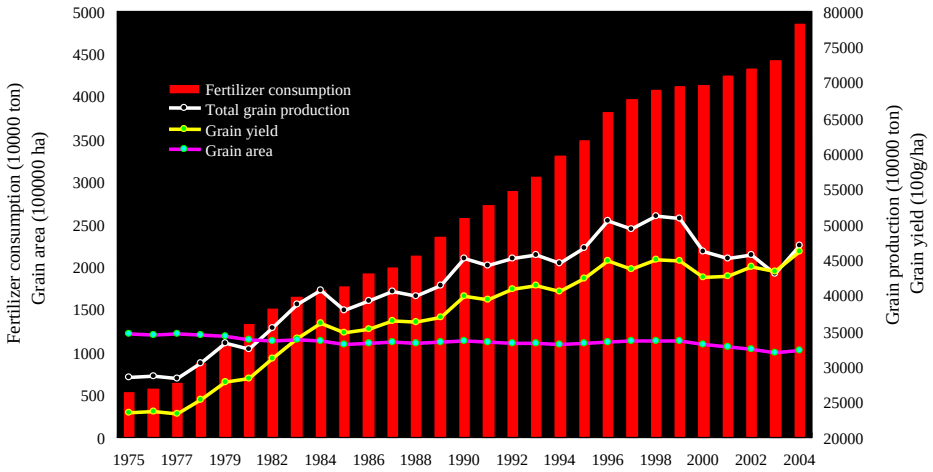
Low RE

Changes of recovery rates of chemical fertilizers in different years

Year	N	P2O5	K2O	source
1992	28% ~ 41%			Zhu
1998	30% ~ 35%	15% ~ 20%	35% ~ 50%	Zhu
1997-2003	25%	11%	30%	expt. data

(Wang et al., unpub.)

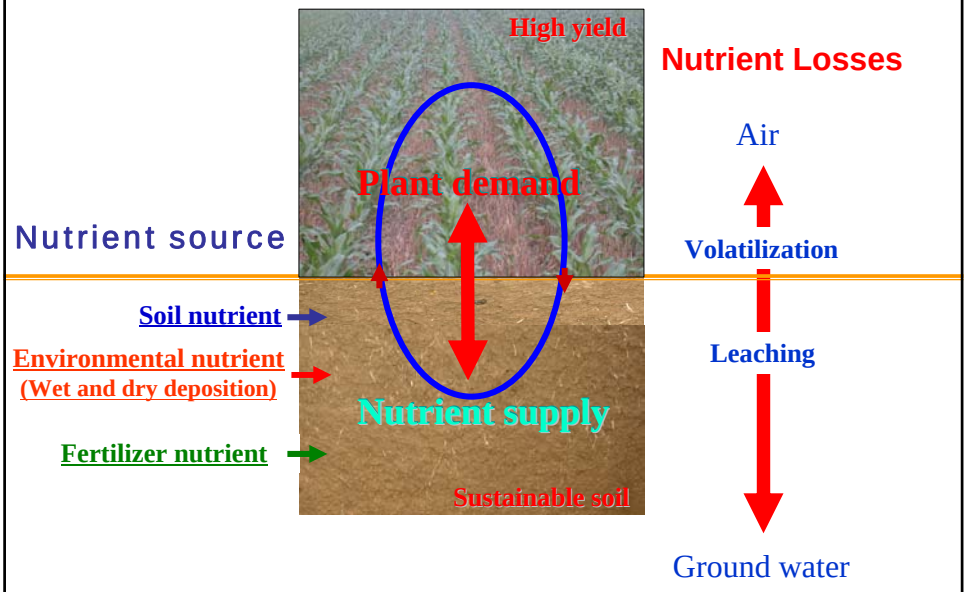
Trends of grain yield, production, grain area and fertilizer consumption (1975 – 2004)



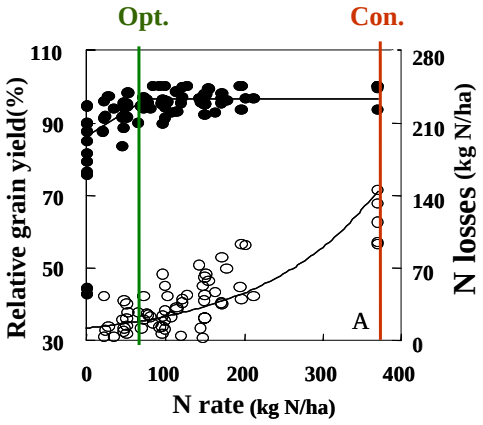
From 1984 to 1994, Fertilizer consumption increased by 90%,but the grain production increased by 9%; After 1996 no relationship can be demonstrated!

Integrated nutrient management in cropping systems

Integrated Nutrient Management (INM)



INM of winter wheat in the Northern China Plain(NCP)



(*n* = 9)

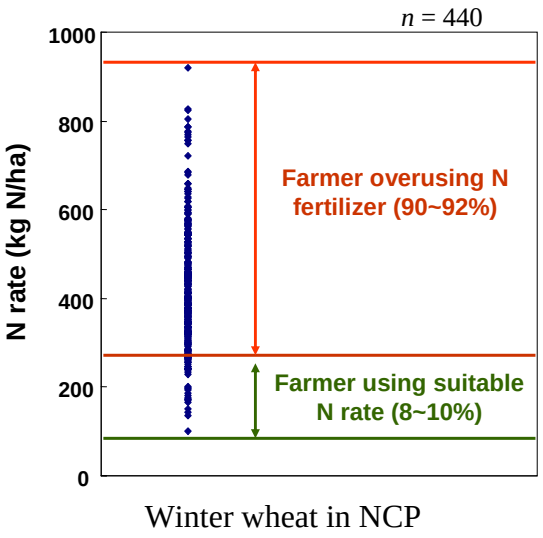
(unit, kg/ha)

Item	Opt.	Con.
N rate	70	369
N mineralization	26	26
Environmental N	11	11
N uptake	158	179
N losses	20	124
Soil N_{min}	-70	103
RE* (%)	50	14
AE** (kg/kg)	10	3

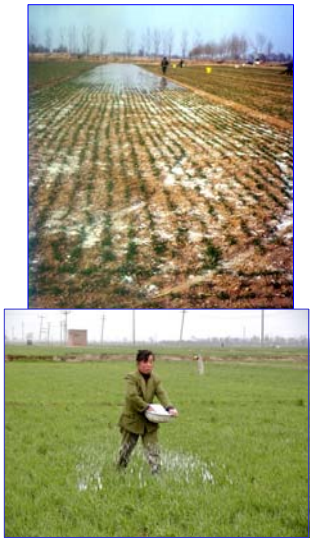
* Recovery efficiency of applied N

** Agronomic efficiency of applied N

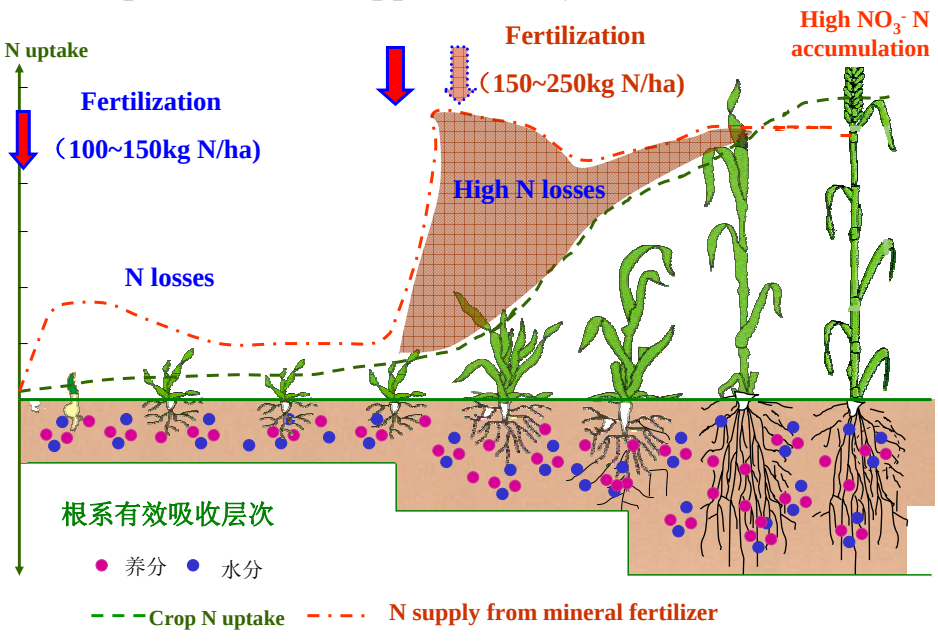
Farmers' practices of N fertilization in winter wheat in the NCP



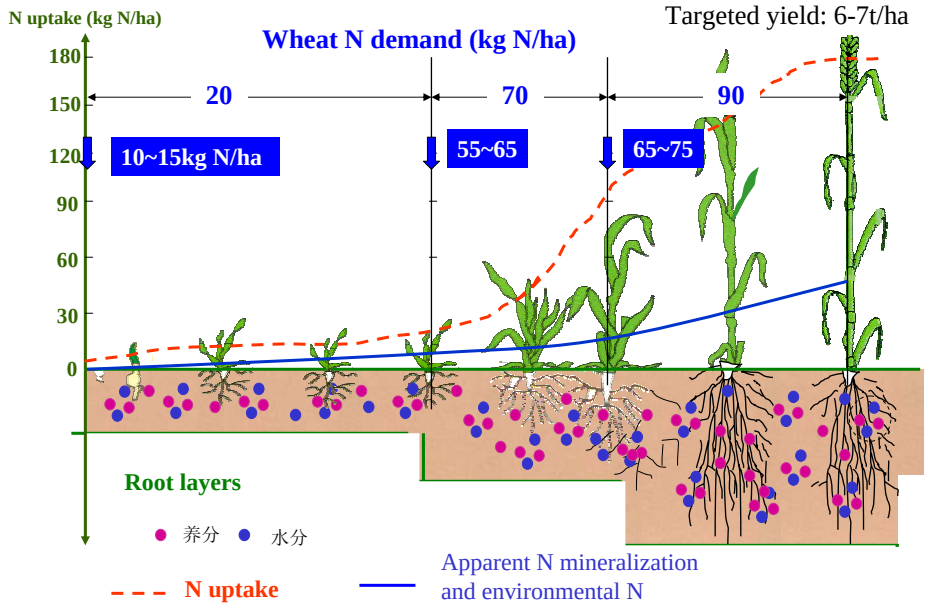
Winter wheat in NCP



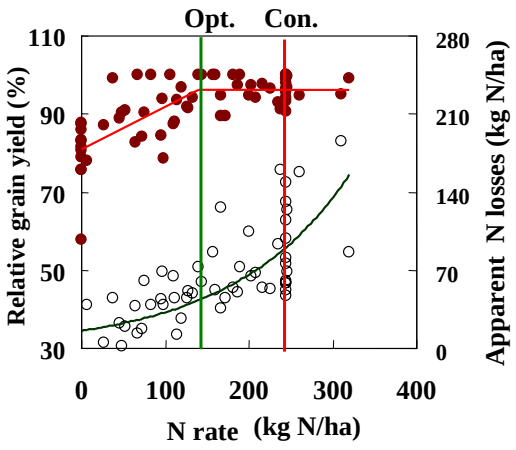
Main problem of N application by farmers in the NCP



INM of winter wheat in the NCP



INM of summer maize in the NCP



(n =11)

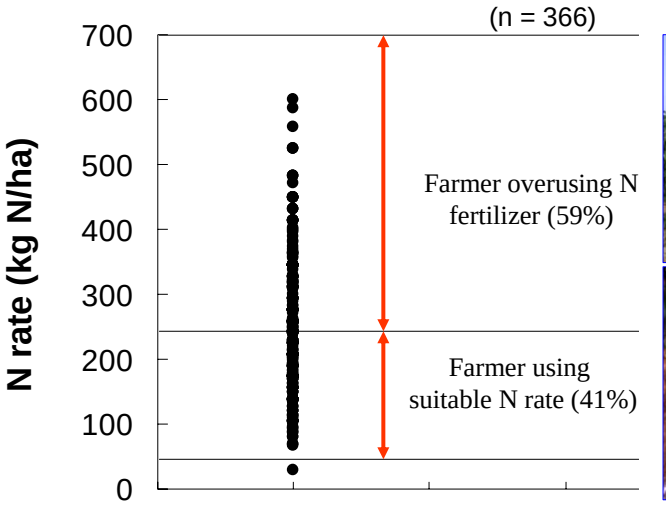
(unit, kg/ha)

Item	Opt.	Con.
N rate	142	244
N mineralization	86	86
Wet deposition N	14	14
N uptake	183	188
N losses	51	84
Soil N_{min}	4	75
RE* (%)	34	20
AE** (kg/kg)	13	5

* Recovery efficiency of applied N

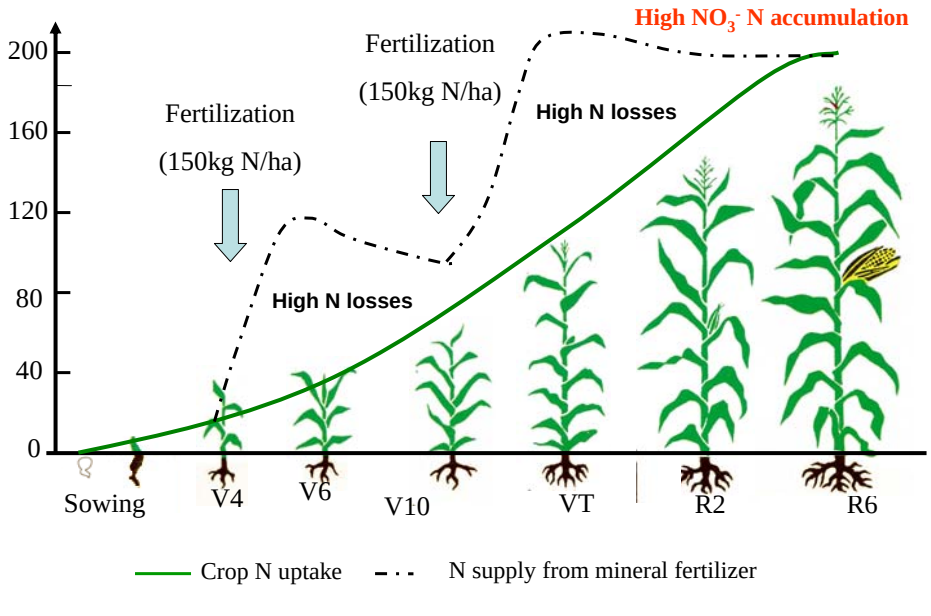
** Agronomic efficiency of applied N

Farmers' practices of N fertilization in summer maize in the NCP

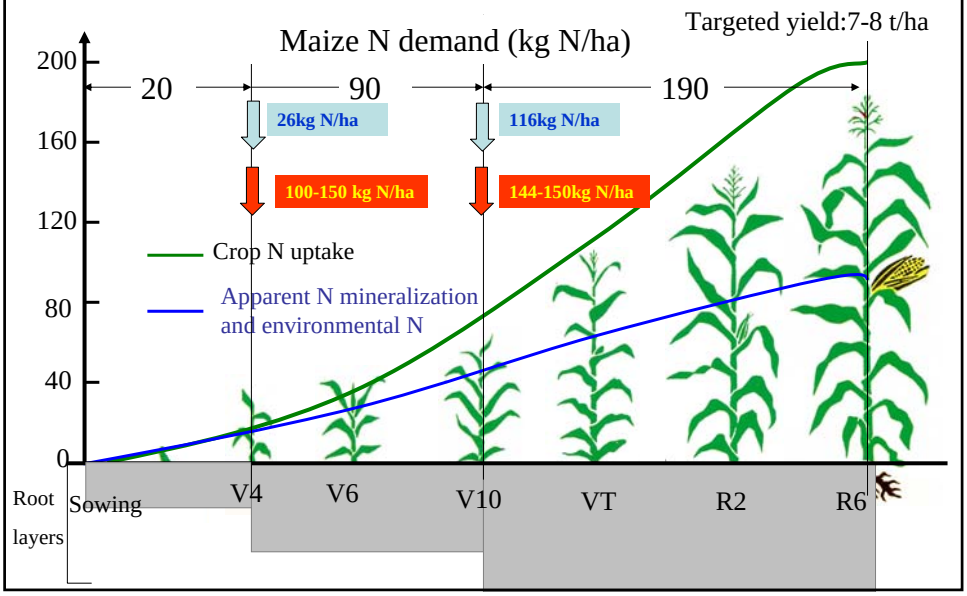


Fertilization techniques

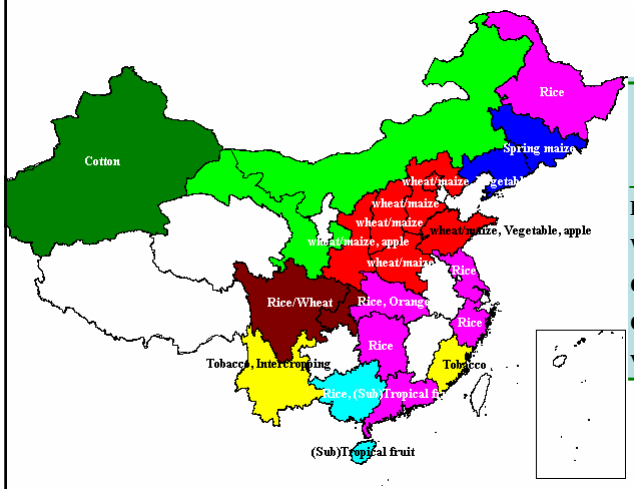
Main problem of N application by farmers in the NCP



INM of summer maize in the NCP



Potential of improved nutrient management in different cropping systems in China



Crop	Save nitrogen (kg/ha)	Increment of N recovery rate (%)
Rice	60~100	10~15
Wheat	80~120	15~18
Corn	60~80	12~15
Cotton	30~40	4~6
Vegetable	300~500	12~20

Outline

- Low nutrient use efficiency (NUE) in China
  - -Low PFP
  - -Low AE
  - -Low RE
- Improved nutrient management in main cropping systems
  - -Winter wheat- summer maize

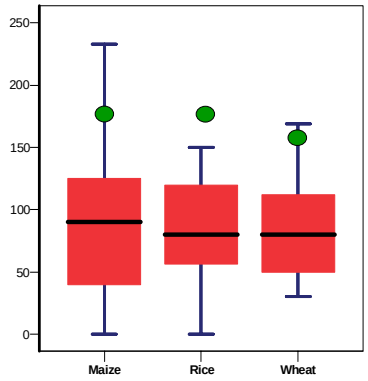
Conclusions and perspectives

-Can we increase crop yield and nutrient use efficiency at the same time?

-Can we improve farmers practices of fertilization?

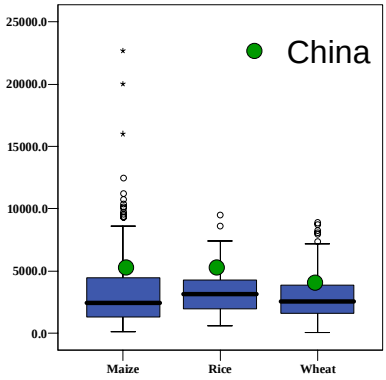
China has relatively higher fertilizer application rate , but low comparable grain yield

N application rate（kg/ha）

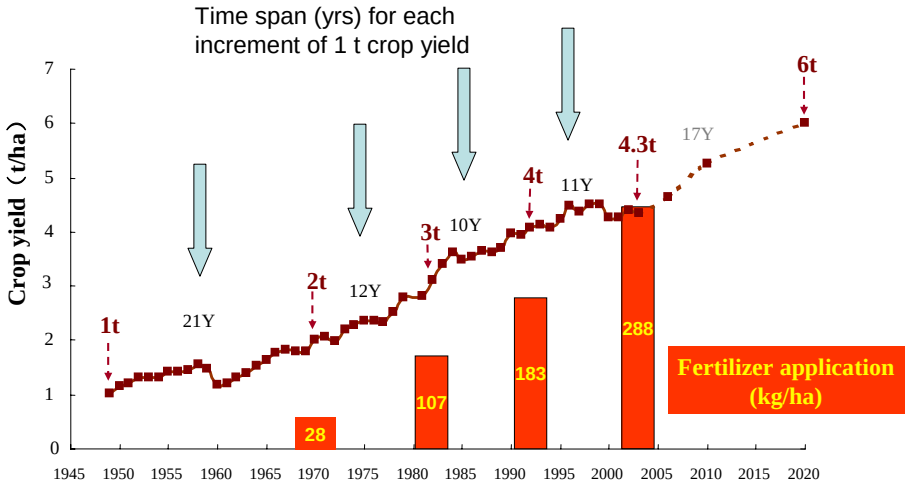


(Data from global survey of FAO, IFA and IFDC, Chinese data revised by farmer survey data in 2000)

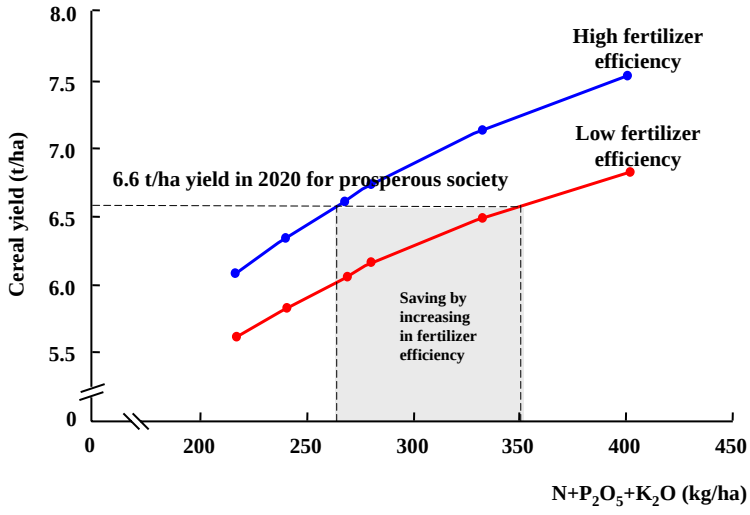
Grain yield (kg/ha）



Data from FAO database,2005



The challenge - Can we increase crop yield and nutrient use efficiency at the same time? How?

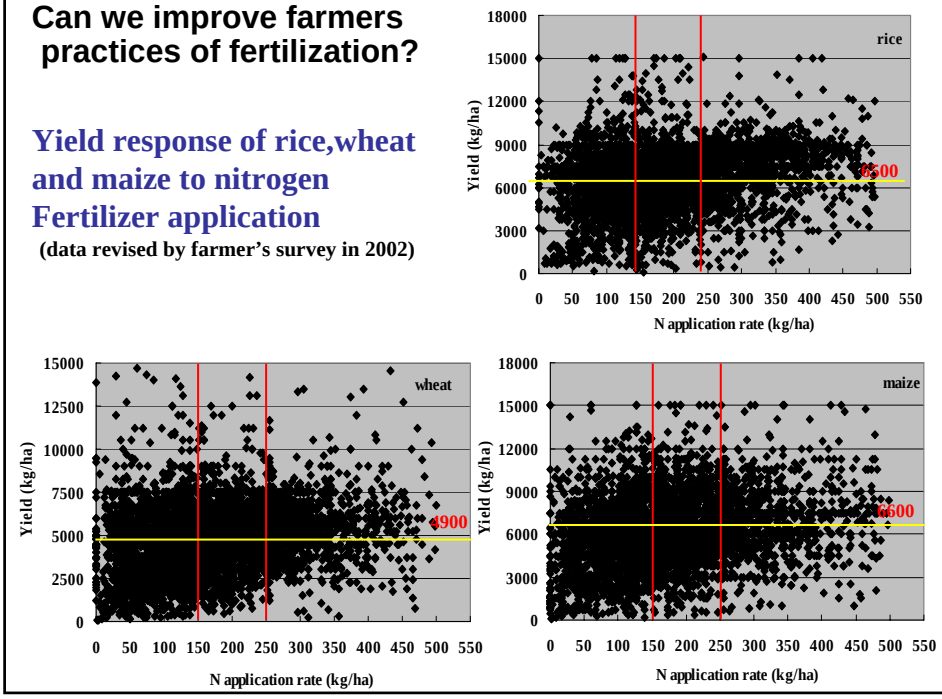


Potentials to increase both crop yield and fertilizer us efficiency in China

Can we improve farmers practices of fertilization?

Yield response of rice,wheat and maize to nitrogen Fertilizer application

(data revised by farmer's survey in 2002)



Only 1/3 of farmers applied proper fertilizer N rate

1/3 overuse, 1/3 lower use

Crop	N rate (kg N/ha)		
	<150	150-250	> 250
Rice	32.3	34.2	33.6
Wheat	34.5	39.1	26.4
Maize	34.9	34.3	30.8

(According to a survey from more than 10000 farmers in 22 provinces)

Set up integrated technique extension system with Chinese Ministry of Agriculture

National Program for Fertilizer Recommendations Based on Soil Testing

200 Million RMB￥covers 200 counties in 2005,
More than 500 counties will be covered in 2006

Soil Testing

Fertilizer prescription

Fertilizer production

Fertilizer application

Fertilizer distribution

Field experiment

Aims:

Area: 40 million ha/ year; Increase fertilizer use efficiency: 3-5%
Increase manure recycling rate: 40-50%; Grain yield increase: 5%
Increase income:18 billion Yuan

Conclusions and perspectives

- Low nutrient use efficiency
  large soil pool
  high environmental input
  over-fertilization in some areas

- Increase NUE by INM

- Increase both crop yield and nutrient use efficiency simultaneously

- Change farmers practices