IPNI
INTERNATIONAL
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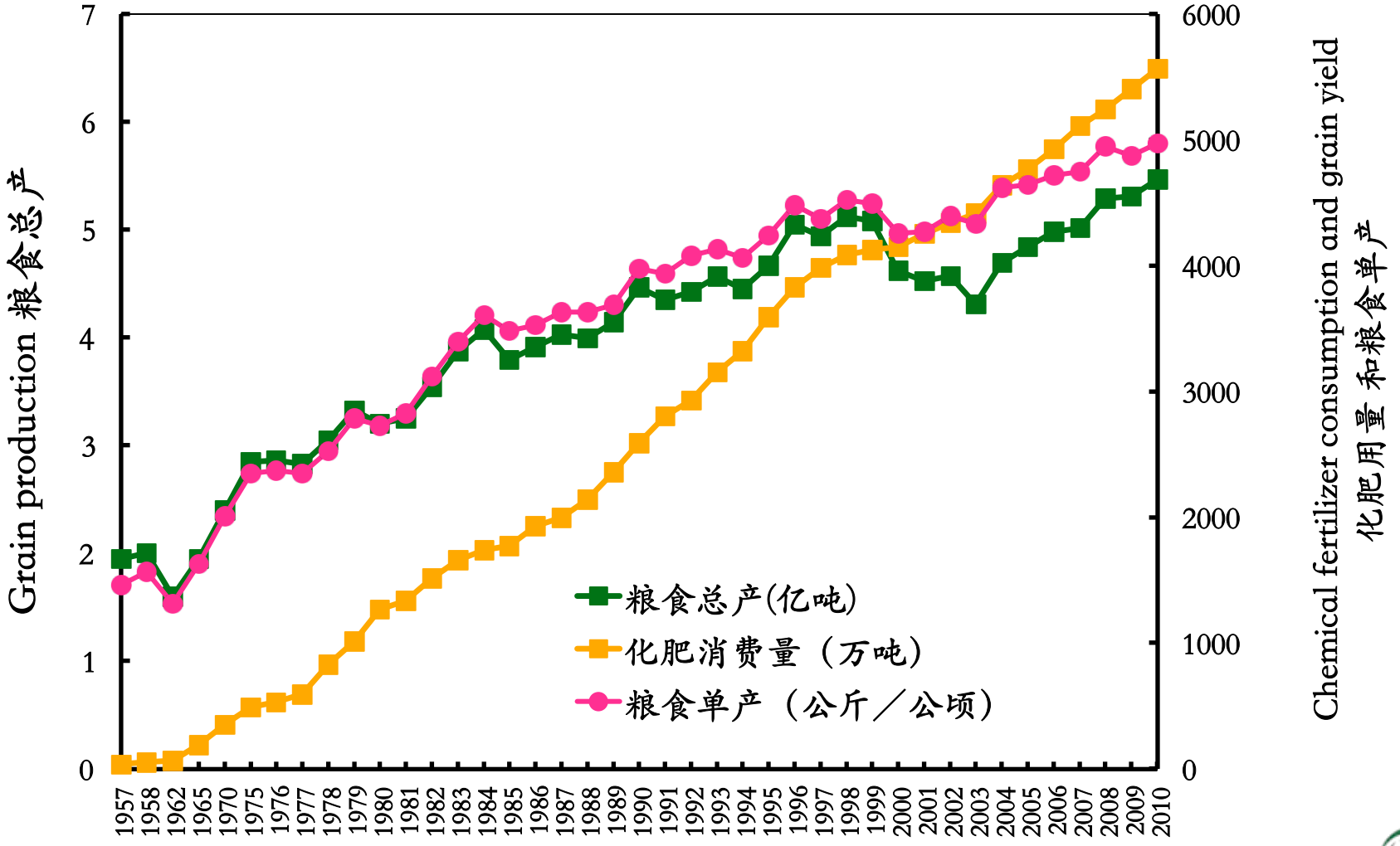
Nutrient Expert based fertilizer recommendation

Ping He

IPNI China Program

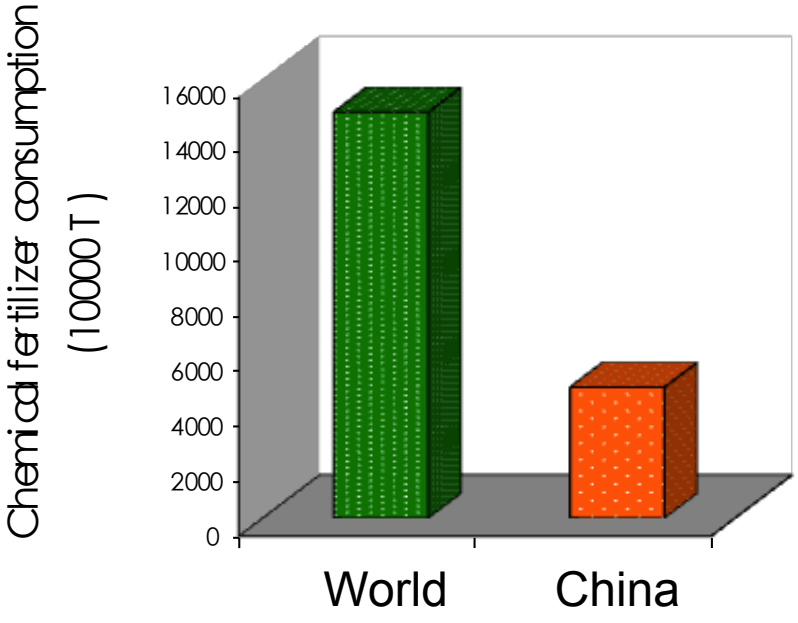
IPNI annual meeting Beihai, Feb 11, 2015

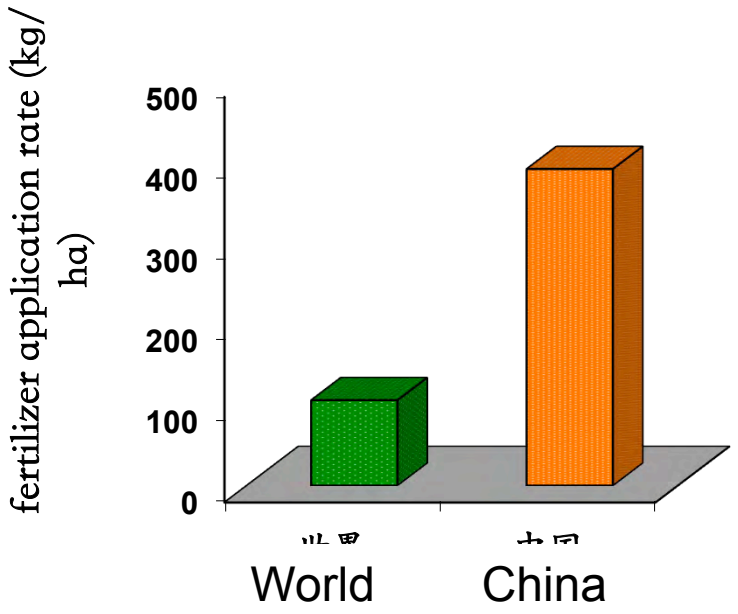
Chemical Fertilizer is the most important guarantee for food security



China is the first fertilizer consumption country

With 9% of world arable land, China consumes about 1/3 of world fertilizer, resulting in high fertilizer application rate (3.7 times of world average level) and low nutrient use efficiency





Low N fertilizer use efficiency

Country	Crops	RE (%)	AE (kg/kg)
China[1]	**Wheat**	**38**	**10**
China[2]	**Maize**	**32**	**10**
China[2]	**Rice**	**27**	**12**
US[3]	**Cereals**	**52**	**20**
World average[3]	**Cereals**	**55**	**21**

1 Liu et al., Agron. J.103: 1452-1463 (2011)
2 IPNI unpublished
3 Ladha et al., 2005, Advances in Agronomy, 87:85–156 (2005)

- Dobermann et al (2007) indicated that AE_N and RE_N was10-30 and 30-50% in developing countries, and could be reached to >25 and 50-80% under well management condition.

Over fertilization has brought about environmental problems

news feature

Nature, 2003, 425: 894-895

Fertilized to death

Vast quantities of nitrogen being poured onto farmers' fields are wreaking havoc with our forests. Nicola Nosengo investigates.

Dotted throughout forests around the world, yellowed leaves and thinning crowns suggest that some trees are dying an early death. But the culprit may come as something of a surprise. It isn't just pollution spewed from car fumes, or damage from insects proliferating thanks to global warming. Our forests are facing a quieter villain. They're being plagued by the very stuff that has provided people with food for the past hundred years — fertilizer.

The use of fertilizer changed dramatically in the twentieth century. In the late 1890s, people struggled to get enough fertilizer for their fields — the main sources were bird

Nature, 2004, 427:99

correspondence

Cooperation needed to increase fertilizer efficiency

Better use of nitrogen could provide more food and reduce the environmental impact.

Sir — Your News Feature "Fertilized to death" (*Nature* **425**, 894–895; 2003) deals with an extremely important issue: reactive nitrogen and the need to increase the efficiency of nitrogen fertilizers. James Galloway's work, as well as that of the IVL Swedish Environmental Research Institute, has pointed to significant environmental problems with excess reactive nitrogen.

Although environmental concerns about excess nitrogen are worth highlighting, the need to produce more food, more efficiently, in many parts of the world is even more urgent. Energy expert Vaclav Smil estimates that approximately 40% of the world's dietary protein supply in the mid-1990s originated from fertilizer nitrogen (V. Smil *Enriching the Earth* 156–161, MIT Press; 2001). Agronomists and soil scientists throughout the world are working to make nitrogen use in farming more efficient for both food production and environmental reasons.

Although cutting back on fertilizer use might be a method to reduce the total load of reactive nitrogen in developed countries with excess food production capacity, it is not an acceptable solution in countries with malnourished people. The effect of increased food costs on people with low incomes in developed countries must also be considered. Efficiency improvements can help reduce nitrogen-fertilizer consumption if populations stabilize, and reduce its impact on the environment.

Ecologists, agronomists, environmental groups and industry must join to increase nitrogen-fertilizer efficiency for the benefit of everyone. Publications such as *Nature* should lead the way in building interdisciplinary support for this worthy goal.

M. M. Alley
Crop and Soil Environmental Sciences Department, Virginia Tech, Blacksburg, Virginia 24061-0403, USA

Nutrient management strategies

- SOIL BASED:
  - Rely mainly on soil testing, traditional, destructive, and more static

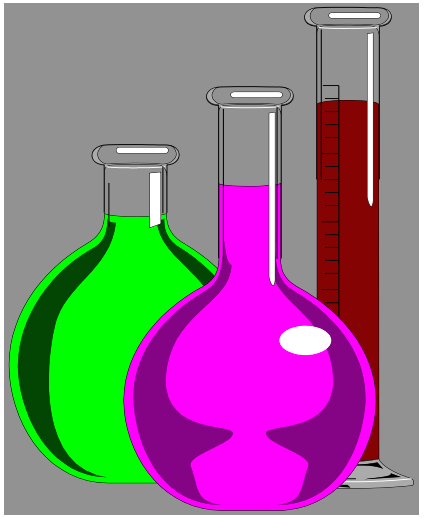
- PLANT BASED:
  - Rely mainly on plants as indicators, new, non-destructive, and more dynamic

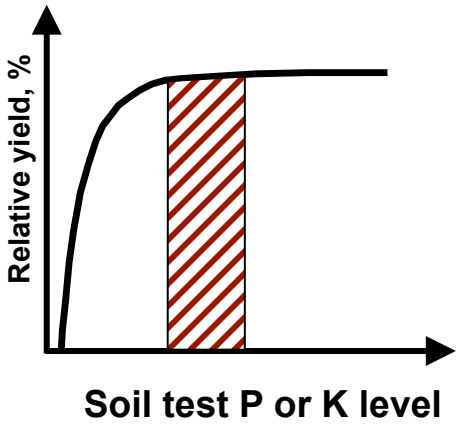
Soil testing process

- Soil sampling
- Extraction and chemical analysis
- Correlation and calibration
- Fertilizer recommendation philosophy

15-20 samples per area tested, clean equipment and containers, proper sample handling, delivery to the lab.

Do the chemical methods used by soil testing labs best suit their local soils?





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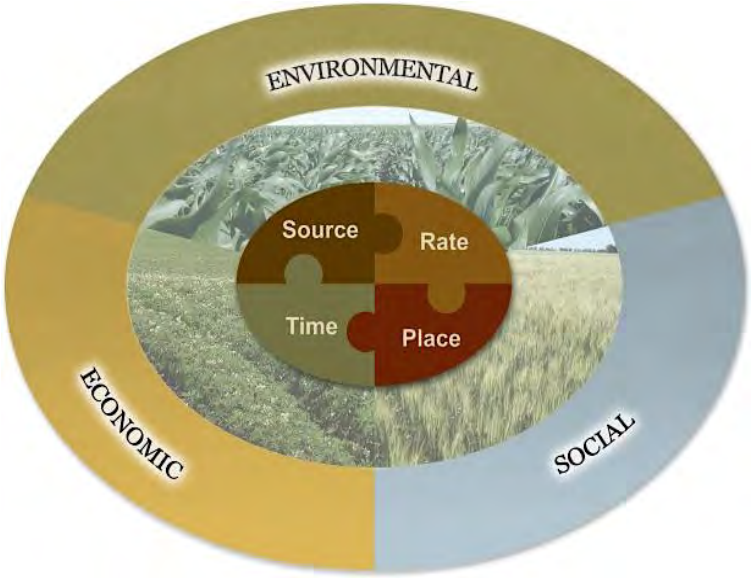
Great challenge - soil testing

- One recommendation for large domain neglecting farmer to farmer variation (大配方小调整).
- Difficult to reach one to one farmers
- Not timely for double or triple cropping system
- Costly, 6.4 billion RMB input since 2005 (2013年农业部报告：2005年以来财政补贴测土配方64亿，覆盖1457个县14亿亩耕地)
- Low correlation between soil test N and crop yield response

Plant based nutrient management -Nutrient Expert®

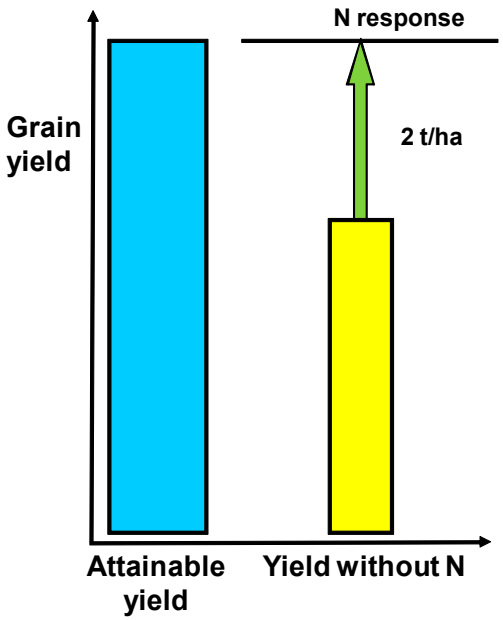
- An approach for “feeding” crops with nutrients as and when needed. It advocates:
- Optimal use of existing indigenous nutrient sources (e.g. crop residue, manure)
- Consider cropping system
- Manage nutrient with 4R strategy
  - Apply fertilizer with the right source at the right rate, right time and right place

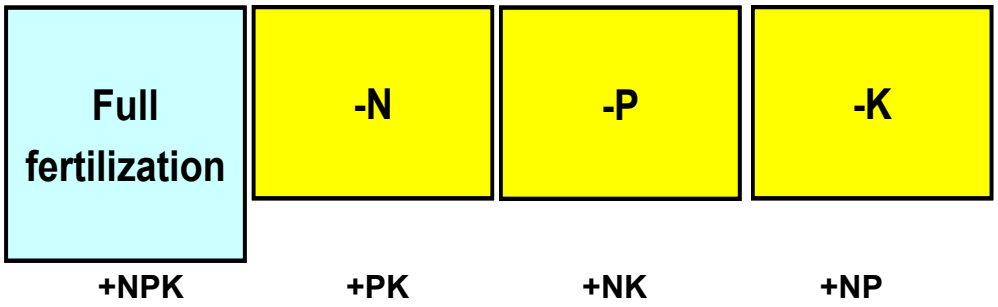


Nutrient Expert uses soil indigenous nutrient supply

For fertilizer recommendation:

- Identify a yield target (i.e. attainable yield)
  - Yield achieved with best management practices where nutrients were not limiting
- Estimate indigenous nutrient supply
  - Can be determined through use of nutrient omission plots
- Estimate amount of nutrient to be supplied as fertilizer





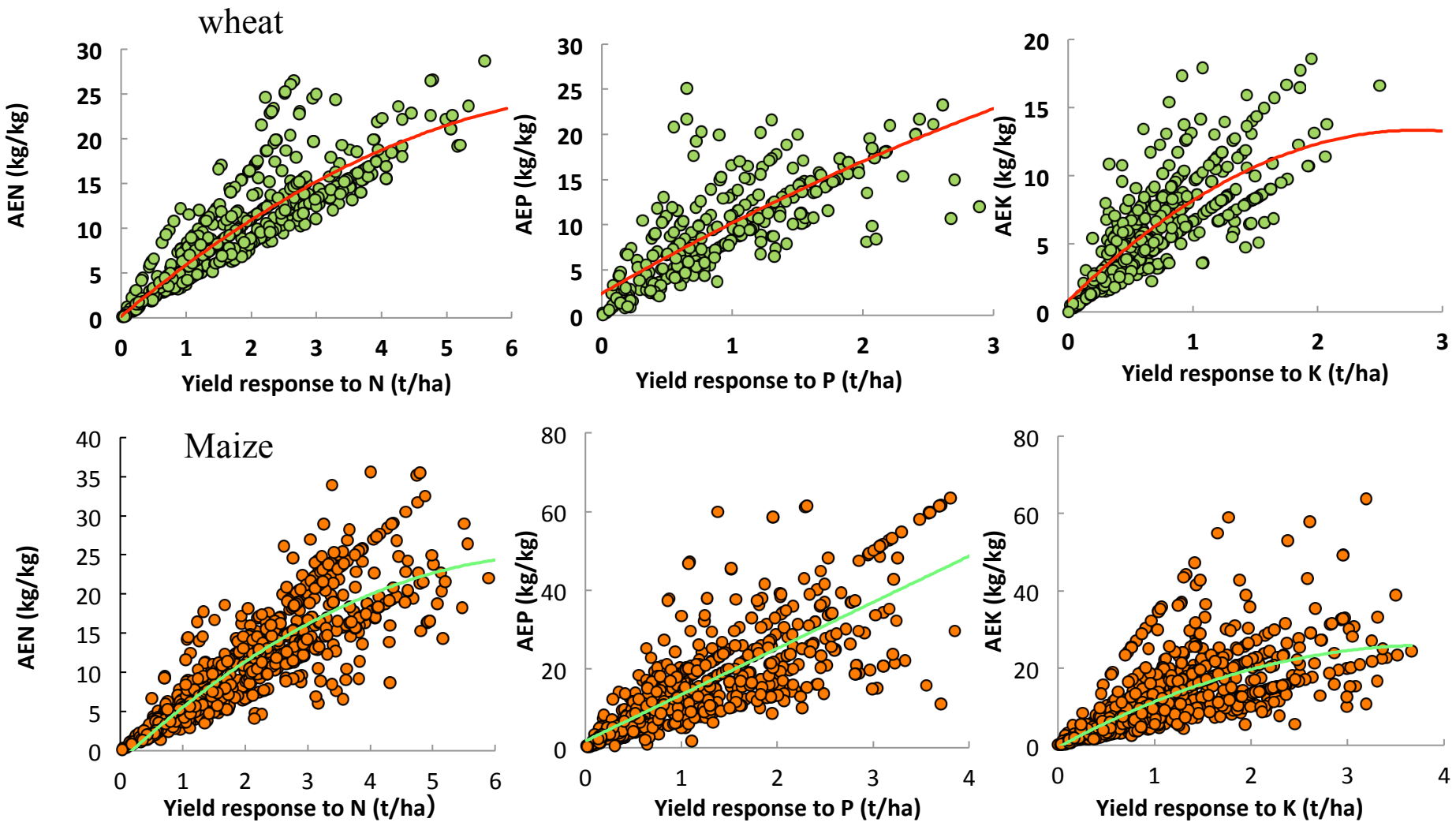
Fertilizer recommendation principles for Nutrient Expert®

- Fertilizer recommendation method in *Nutrient Expert* is based on **yield response and agronomic efficiency** (AE)

- Fertilizer N requirements: to use a target agronomic efficiency and an estimation of yield response to applied N (YR/AE)

- Fertilizer P and K requirements: yield response + nutrient removal (QUEFTS based)

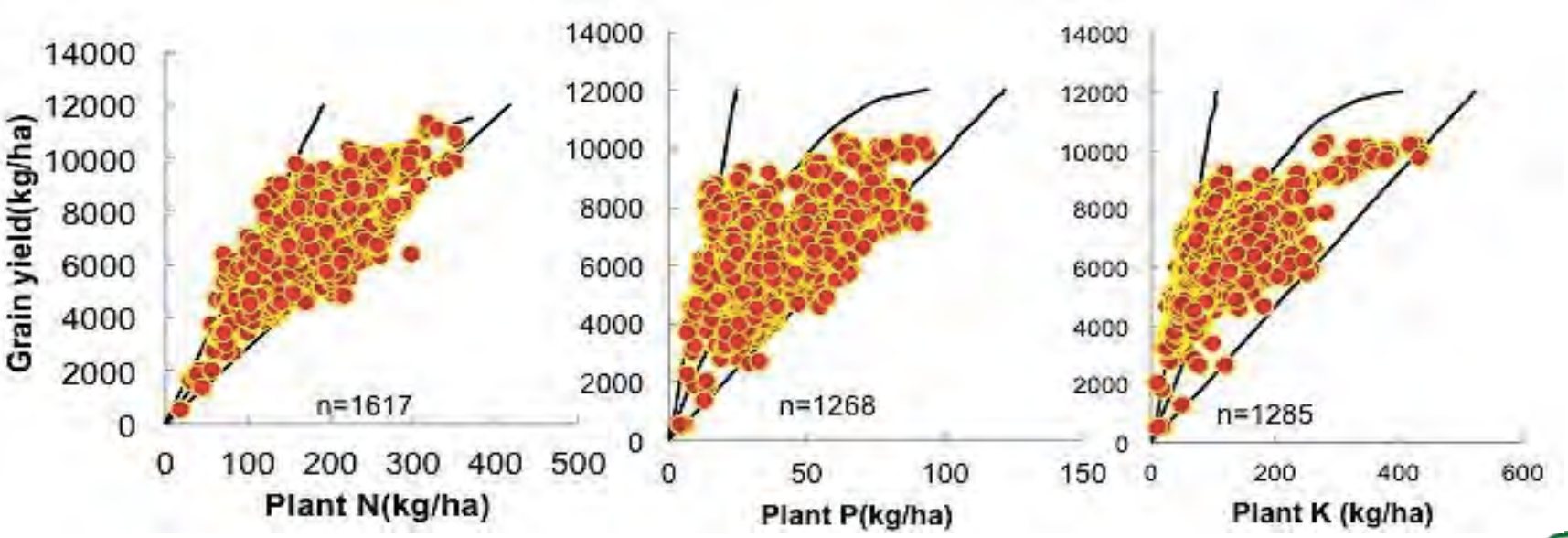
Relationship between AE and yield response



Chuan et al. Field Crops Research, 2013, 140:1-8

Estimating nutrient requirements
The QUEFTS model

- The Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS) model to use to determine more generic relationship between grain yield and crop nutrient requirements
- The QUEFTS model can simulate optimal nutrient requirement to avoid imbalanced fertilization (example below-wheat)



Chuan et al. Field Crops Research, 2013, 146:196-104

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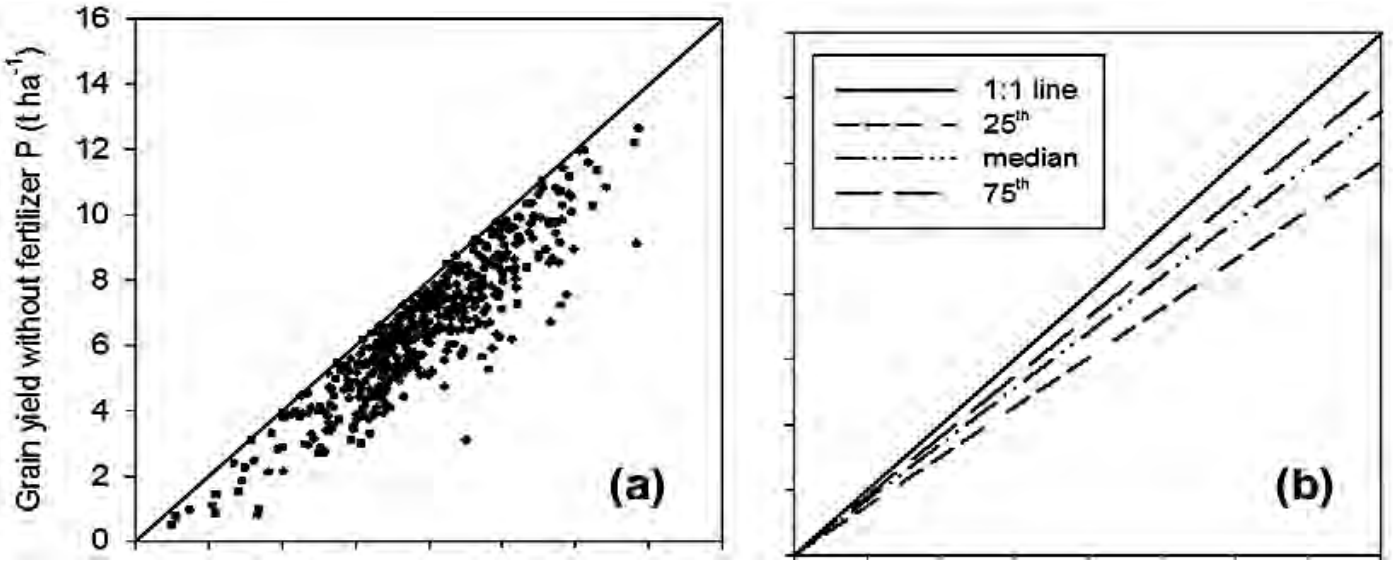
Nutrient uptake requirements for cereal crops as predicted using QUEFTS – China data

Crop	Reciprocal internal efficiency (kg nutrient/1000 kg grain)		
	N	P	K
Rice [1]	17.7	3.9	17.8
Summer maize [2]	22.5	4.4	15.9
Spring maize [2]	16.9	3.5	15.3
Wheat [3]	22.8	4.4	19.0

[1] IPNI China. Unpublished data
[2] Xu et al. 2013. Field Crops Research
[3] Chuan et al. 2013. Field Crops Research

If no omission plots, how to evaluate yield response?

- Soil indigenous supply determines the nutrient limited yield
- Here we use 25th, 50th and 75th percentile to estimate the nutrient limited yield for a given attainable yield and soil fertility class of low, median and high fertility



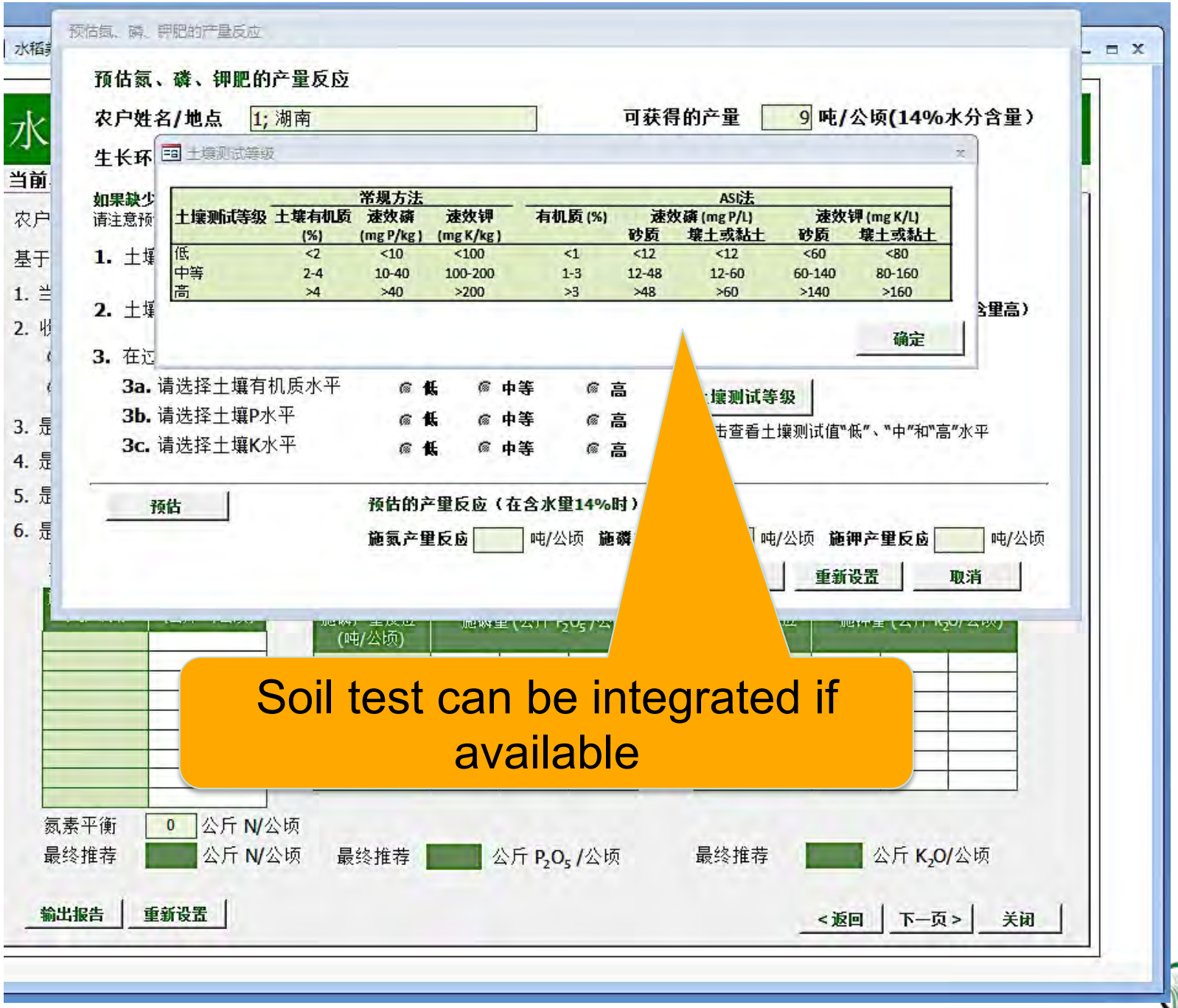
Soil indigenous nutrient supply – to evaluate yield response if omission plots not available 产量反应系数

(n = 1637)	GY0N/GYa	dYN/GYa	INS class
25th	0.60	0.40	L
median	0.77	0.23	M
75th	0.88	0.12	H

(n = 295)	GY0P/GYa	dYP/GYa	IPS class
25th	0.79	0.21	L
median	0.87	0.13	M
75th	0.93	0.07	H

(n = 384)	GY0K/GYa	dYK/GYa	IKS class
25th	0.84	0.16	L
median	0.90	0.10	M
75th	0.94	0.06	H

- Yield Response = Attainable yield × dYN/GYa


预估氮、磷、钾肥的产量反应
预估氮、磷、钾肥的产量反应
农户姓名/地点
1; 湖南
可获得的产量
9
吨/公顷(14%水分含量)
土壤测试等级
常规方法
ASI法
土壤测试等级
土壤有机质 (%)
速效磷 (mg P/kg)
速效钾 (mg K/kg)
有机质 (%)
速效磷 (mg P/L) 砂质
速效磷 (mg P/L) 壤土或黏土
速效钾 (mg K/L) 砂质
速效钾 (mg K/L) 壤土或黏土
低 <2 <10 <100 <1 <12 <12 <60 <80
中等 2-4 10-40 100-200 1-3 12-48 12-60 60-140 80-160
高 >4 >40 >200 >3 >48 >60 >140 >160
确定
3a. 请选择土壤有机质水平
3b. 请选择土壤P水平
3c. 请选择土壤K水平
低
中等
高
预估
预估的产量反应（在含水量14%时）
施氮产量反应
吨/公顷
施钾产量反应
吨/公顷
重新设置
取消
Soil test can be integrated if available
氮素平衡
0
公斤 N/公顷
最终推荐
公斤 N/公顷
最终推荐
公斤 P_2O_5 /公顷
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重新设置
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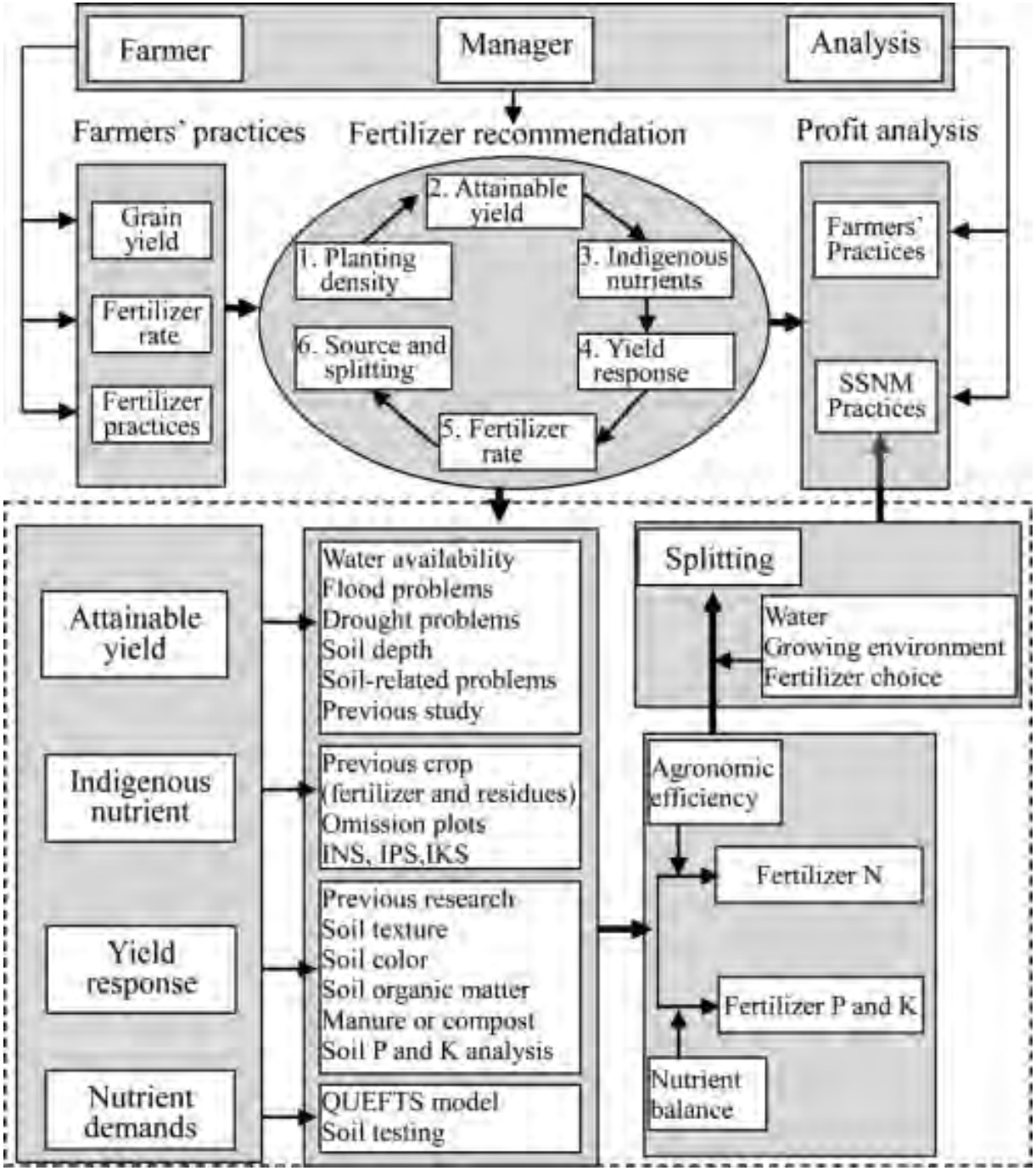
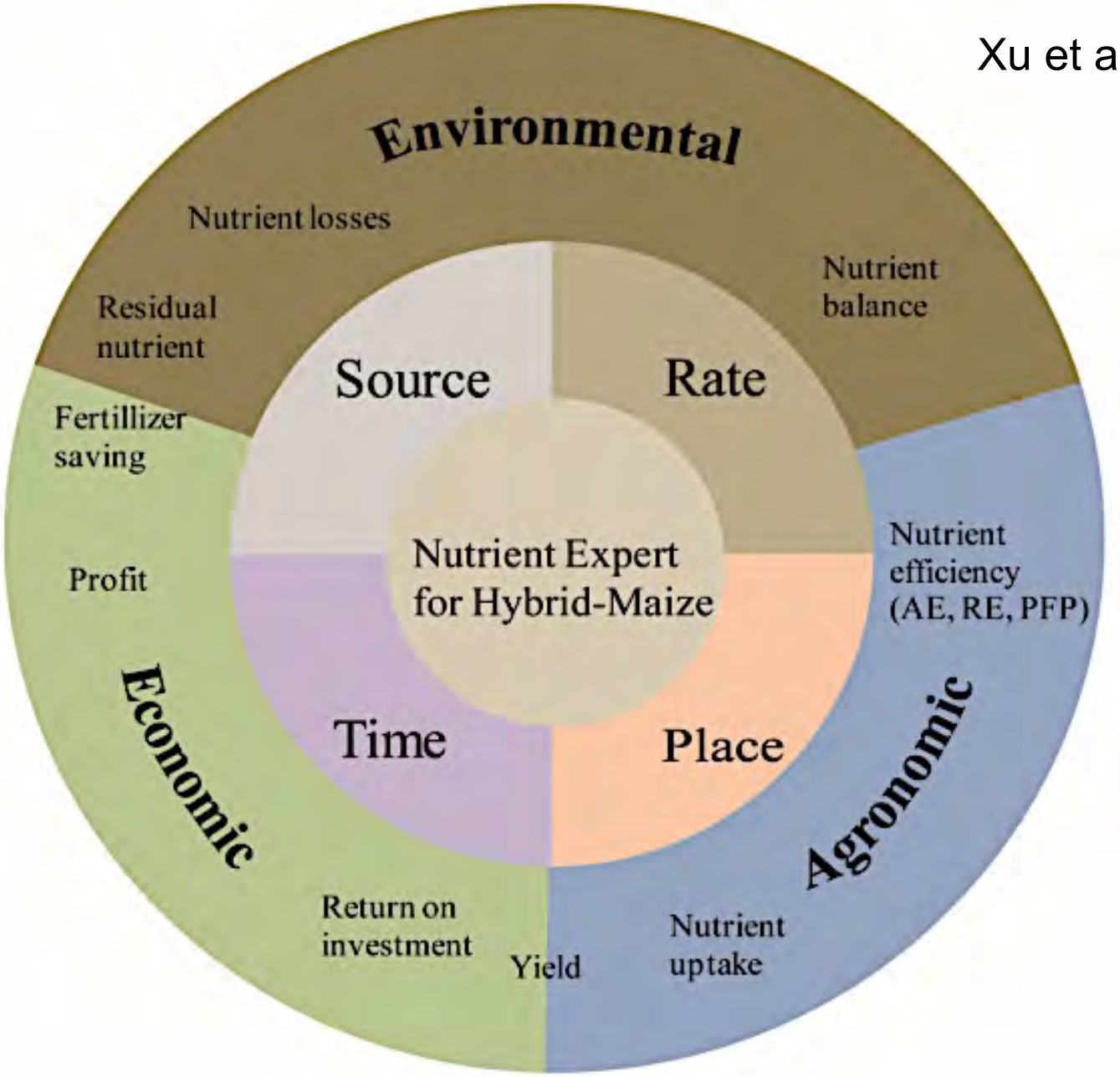


Flow chart of Nutrient Expert

Xu et al. 2014. FCR

Xu et al. 2014. FCR

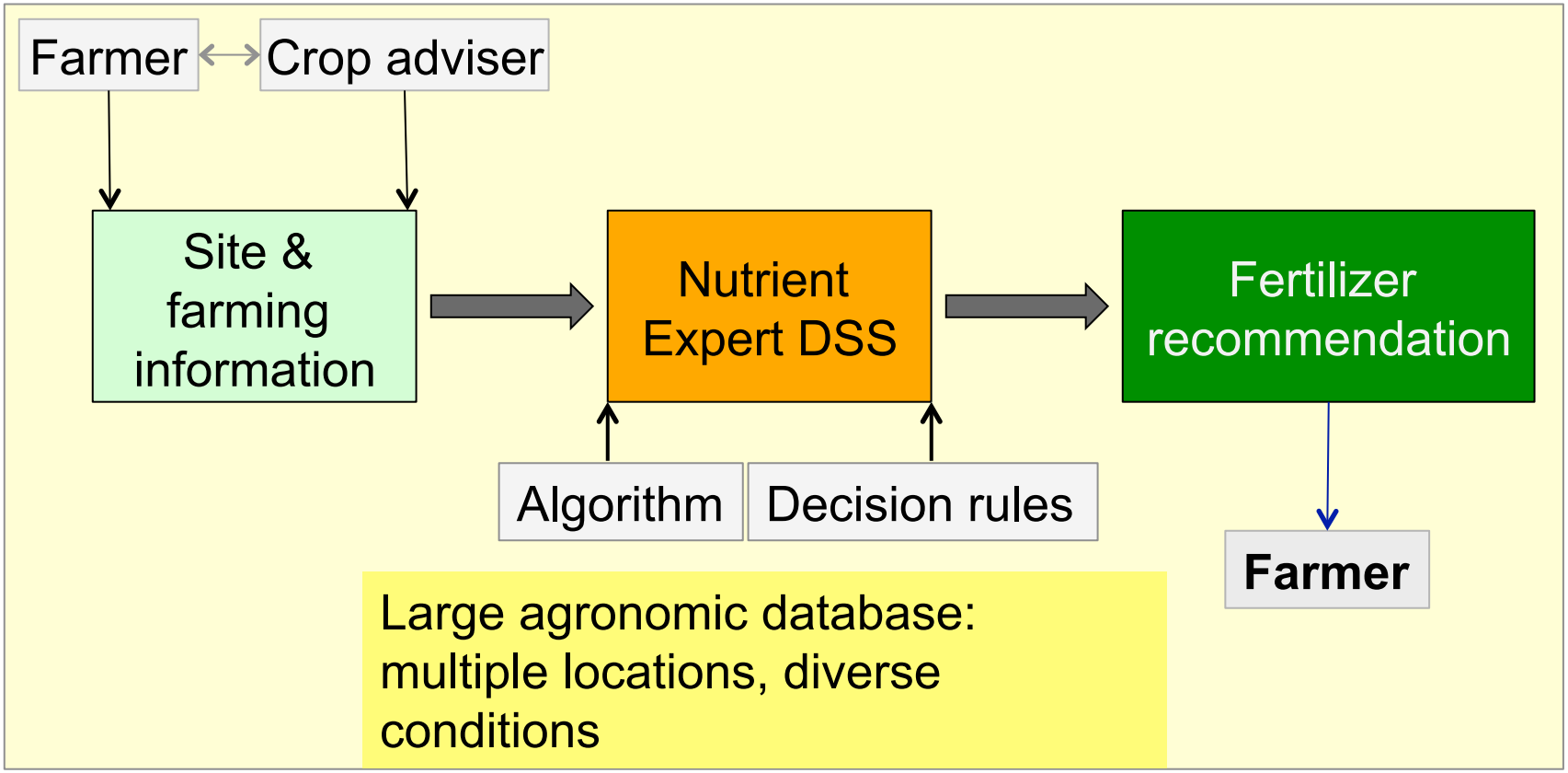


Complexity of fertilizer decision support in small-holder system

Nutrient Expert® for maize in China

Nutrient Expert® for wheat in China

Nutrient Expert: Simplifying implementation of SSNM



Nutrient Expert: science based, but simple and user friendly

- Large agronomic database
- Strong correlation between soil indigenous supply and yield response
- Uses only site information that can be easily provided by a farmer or local extension worker
- Can be used with or without soil testing data
- Gives fertilizer recommendation for secondary and micro-nutrients
- Considers cropping system and nutrients from other sources

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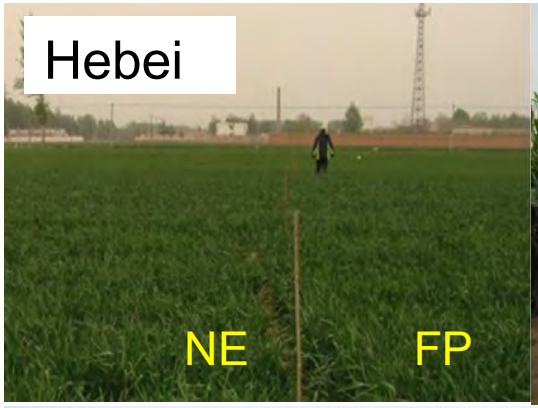
Field validation effect of Nutrient Expert



From 2010-2012, 461 maize and 187 wheat field validation has been successfully conducted. From 2013, the technology has been transferred to large scale and southern China

Field validation indicated that NE increased crop yield, NUE and profitability through better NM (2010-2013)

Crop	Treat-ment	Yield	Fertilizer rate (kg/ha)			Cost	Profit	VCR	REN	AEN
		t/ha	N	P_2O_5	K_2O	RMB/ha	RMB/ha		%	Kg/kg
Wheat	FP	7.9	271	118	50	2248	14378	6.4	17.5	6.4
(N=290)	NE	**8.0**	**162**	**82**	**74**	**1683**	**15230**	**9.0**	**30.2**	**9.0**
	Soil test	8.3	237	105	73	2166	15491	7.2	22.5	7.2
	NE-FP	0.1	-109	-36	24	-565	852	2.6	12.7	2.6
	NE-FP (%)	**1.3**	**-40.2**	**-30.5**	**48.0**	**-25.1**	**5.9**	**28.9**	**42.1**	40.6
Maize	FP	9.9	230	62	47	1711	18285	10.7	18.5	10.7
(N=541)	NE	**10.2**	**158**	**56**	**68**	**1472**	**19095**	**13.0**	**29.1**	**13.0**
	Soil test	10.3	202	57	75	1725	18936	11.0	23.0	11.0
	NE-FP	0.3	-72	-6	21	-239	810	2.1	10.6	2.3
	NE-FP (%)	**3.0**	**-31.3**	**-9.7**	**44.7**	**-14.0**	**4.4**	**19.6**	**57.3**	**21.5**

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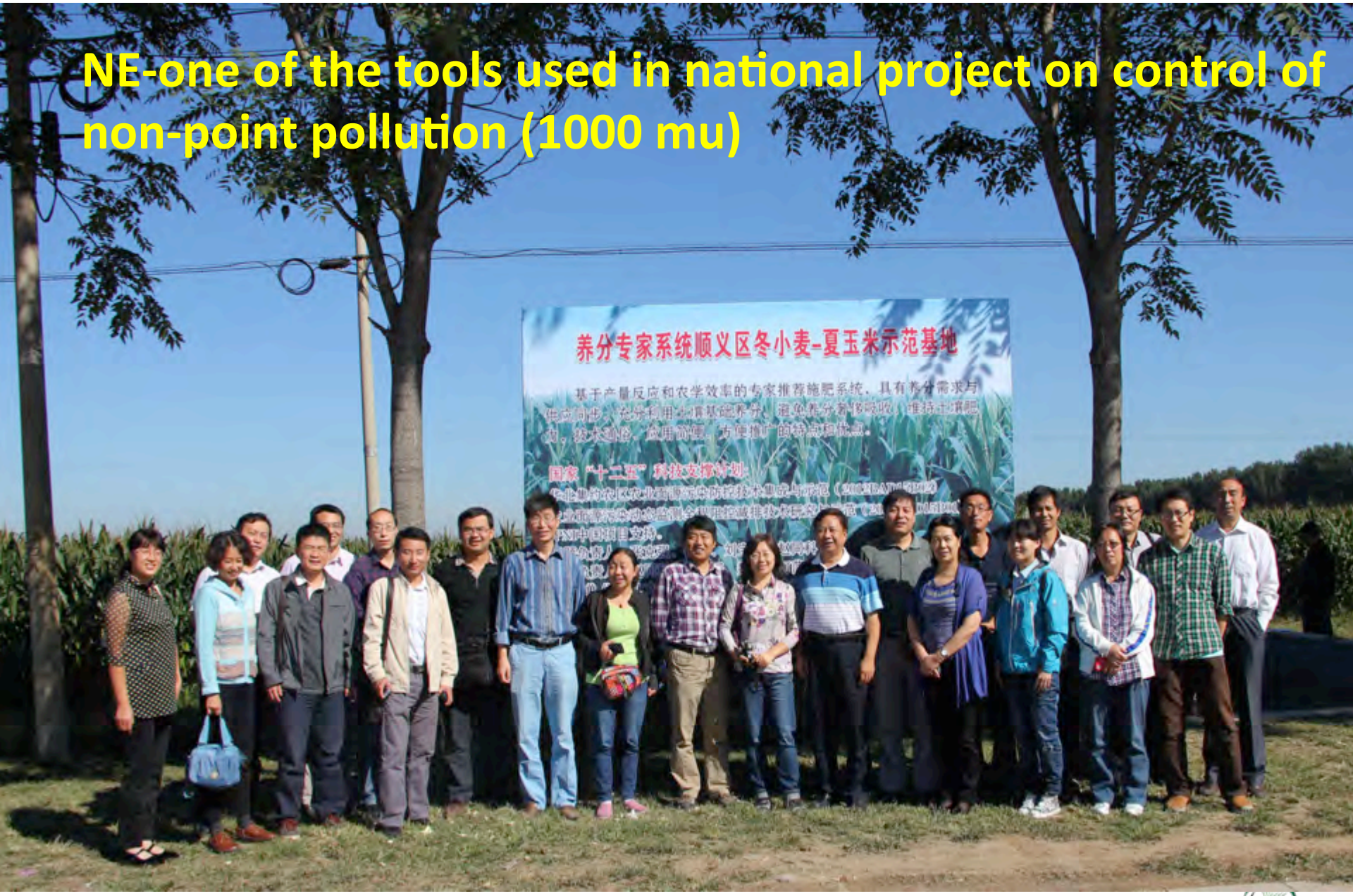
NE implementation

- Governmental supports from 973 project, NSFC, 948 and IPNI
- Used as fertilizer recommendation method by members companies
- Welcome by large farmers and local technicians

玉米、小麦NE专家系统光盘

IPNI

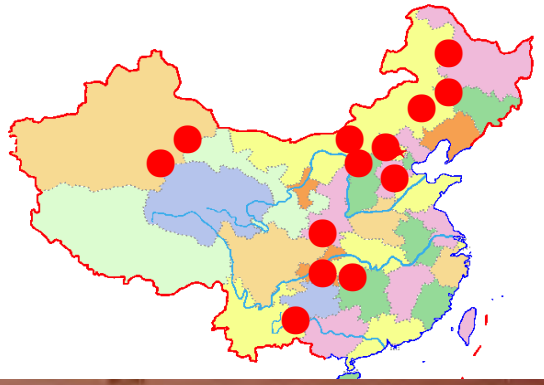
NE-one of the tools used in national project on control of non-point pollution (1000 mu)




IPNI项目黑龙江Nutrient Expert

Nutrient Expert养分专家系统培训讨论会
（2013年7月9日·北京）

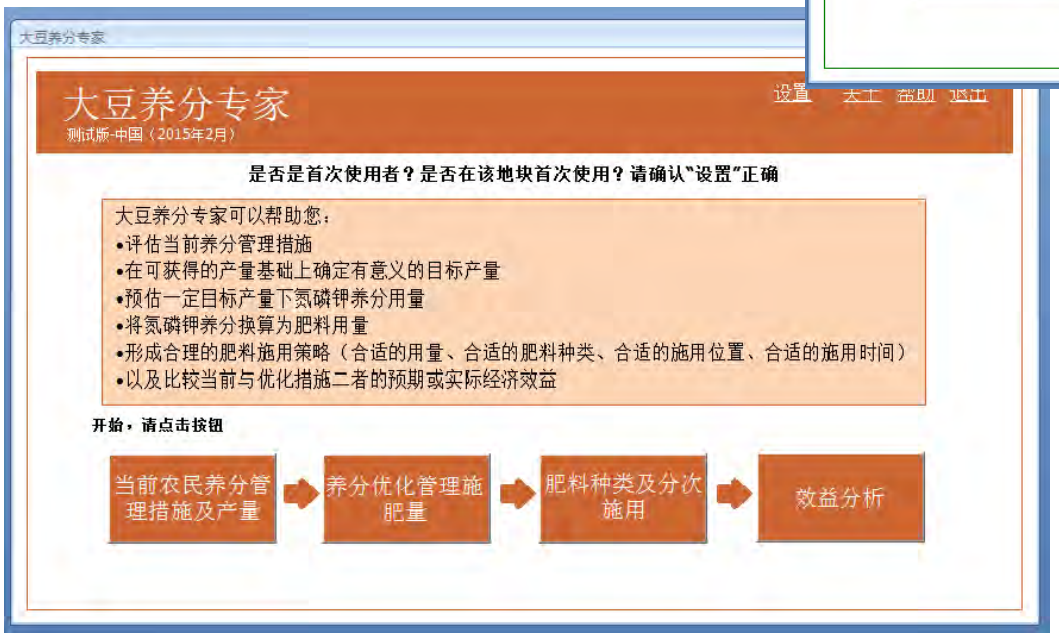
Nutrient Expert:



- NE Wheat and Maize released in Xiamen meeting in 2013
- Adopted in 11 wheat and maize production provinces

NE development in other crops in China

- NE Rice Cropping System
  - Single season
  - Early/late
  - Middle rice



- NE Soybean with national project – Wei Dan

NE in other countries

- South Asia
- Africa
- Southeast Asia

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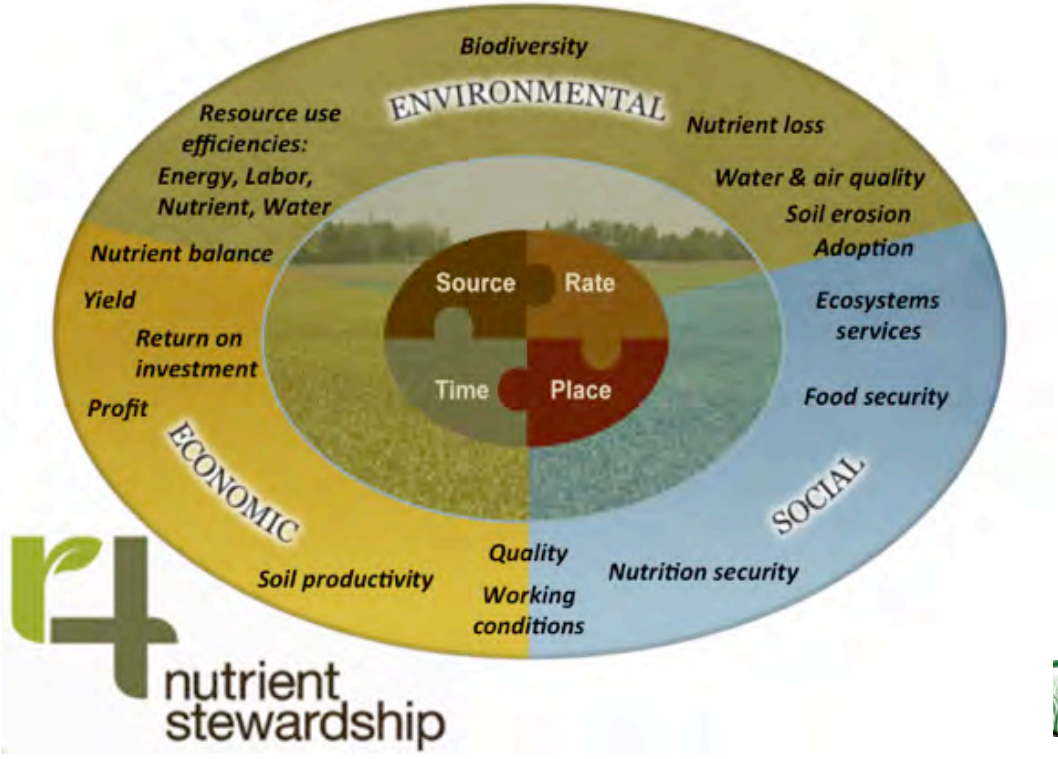
Further improvement and cooperation

- Fertilization practice needs to work together with water management, tillage, cultivation practices, mechanization, and all other agronomic practices
- Farmers need BMPs and set/package services
- Need governmental support



Nutrient Expert related publications

1) Estimating a new approach of fertilizer recommendation across small-holder farms in China. Field Crops Research, 2014, 163:10-17
2) Fertilizer recommendation for maize in China based on yield response and agronomic efficiency. Field Crops Research, 2014, 157: 27-34
3) Estimating nutrient uptake requirements for wheat in China. Field Crop Research, 2013, 146: 96-104
4) Establishing a scientific basis for fertilizer recommendations for wheat in China: Yield response and agronomic efficiency. Field Crop Research, 2013, 140:1-8
5) Nutrient requirements for maize in China based on QUEFTS analysis. Field Crop Research, 2013, 150:115-125
6) Yield gaps, indigenous nutrient supply, and nutrient use efficiency of wheat in China. Agronomy Journal, 2011, 103: 1452-1463
7) Fertilizer recommendation based on yield response and agronomic efficiency. Plant Nutrition and Fertilizer Science, 2012, 18(2): 499-505

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PhD students involved in Nutrient Expert Project

- Dr Chuan Limin: graduated in 2013 with PhD thesis entitled "Nutrient Expert based fertilizer recommendation for wheat". Her thesis awarded as **one of the ten excellent thesis among 250 PhD graduates**. Two papers related to Nutrient Expert has been published in ***Field Crops Research***.

- Mr. Xu Xinpeng: His thesis entitled "Nutrient Expert based fertilizer recommendation for maize and rice" has been selected to be involved in **the Excellent Thesis Incubation Plan**. Three papers published in ***Field Crops Research*** and two under review.

NE was reported in farmer's daily in Nov 2013

农民日报

农资周刊

[导读]

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昌宁县秋冬种 农家肥当家

Summary

- Over fertilization is one of the main reasons for low nutrient use efficiency in China
- Nutrient Expert can improve both grain yield and nutrient efficiency for wheat and maize
- Nutrient Expert based fertilizer recommendation is a promising method in small holder farmers when soil testing is not available or not timely
- Nutrient use efficiency can be improved further with integrated with other agronomic practices

Thank you!

Questions and comments ?

Acknowledgement: IPNI, MOST, MOA, NSFC

www.ipni.net/ china.ipni.net
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If no omission plot information, attainable yield can be evaluated by:

- Growing environment: water condition – rainfed, irrigation, flooding, drought
- Soil fertility factors: soil texture, OM, soil test, organic application, problem soils
- Crop rotation system
- Crop residue management