

**75<sup>th</sup> IFA ANNUAL CONFERENCE**  
**Istanbul, Turkey, 21-23 May 2007**

**CHALLENGES AND OPPORTUNITIES TO IMPROVE  
FERTILIZER MANAGEMENT IN CHINA**

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**“Challenges and opportunities to improve fertilizer management in China”**

F. Zhang, W. Zhang and M. Fan

**1. Fertilizer plays an important role in food production in China**

China has a long tradition over thousands of years of using organic manure to maintain crop production and prevent soil fertility from declining. Before 1949 almost no chemical fertilizer was used in agriculture and the food production was kept at lower level. For example wheat yield had been less than 800 kg/ha before 1950s. In the period of traditional organic farming, protein production per unit land was only 200kg/ha, which can feed 6~8 vegetarians. But the situation has been changed greatly with the application of chemical fertilizers. In 2005, the consumption of chemical fertilizer in China reached 47.7 million tons, which was 35% of global total consumption (Heffer and Prud'homme, 2006). With the increased input of chemical fertilizer, food production was increased significantly. It was estimated that total grain production has increased by 220% and grain yield increased by 320% from 1949 to 2005. The protein production per unit land was now 600~800kg/ha, which can feed 20~30 vegetarians. Long-term experiments proved that fertilizer use accounted for about 50% of increased grain production (Lin and Li, 1989), 75% of nitrogen used in agriculture came from fertilizer (Roy and Hammond, 2005), and 54% of protein consumed by people came from fertilizer. Therefore, fertilizer use is one of the important reasons for China to be able to feed 22% of the global population with only 9% of the world's arable land successfully.

**2. Challenges of fertilizer production and consumption in China**

**2.1. Increased pressure in environmental protection and resource utilization**

Although fertilizer plays an important role in food production of China, irrational utilization of fertilizers has led to environmental pollution. For example, the losses of N and P from various nutrient sources including fertilizer through leaching and run-off have led to drinking-water pollution, which affects 30% of the population, and resulted in eutrophication in 61% of lakes in the country. The amount of nitrogen oxide emissions from agricultural production accounted for about 30% of total agricultural emissions in the world (Norse et al., 2004, Zhang, 2005a).

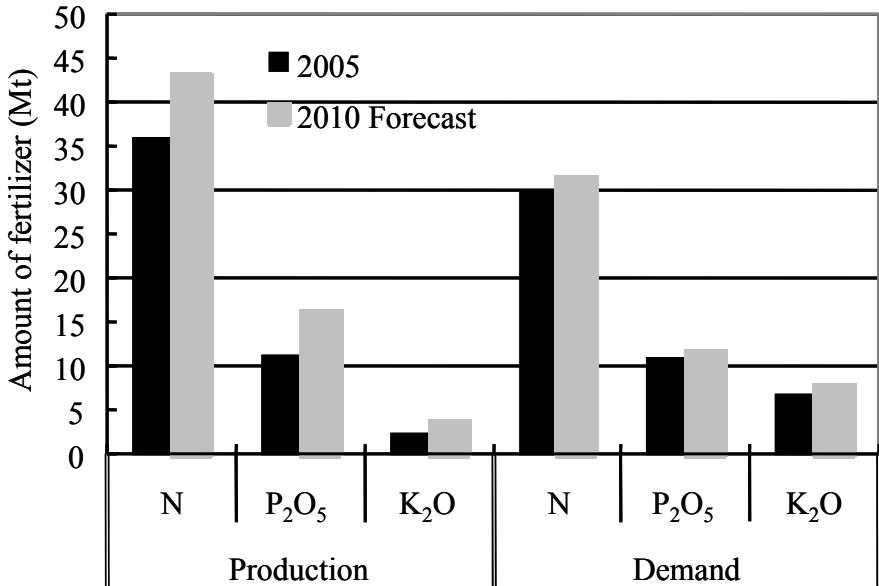
On the other side, the huge demand for chemical fertilizer has induced the booming of domestic fertilizer industry. The total production of fertilizers in China exceeded 50 million tons. This should ascribe mainly to governmental support. For instance, Chinese government adopted several supporting policies on the fertilizer industry, such as subsidies including cheaper material supply (coal, natural gas and electricity), cheaper and preferential transportation by train, and favorable tax rate for production and trade. It is estimated that total financial support from government was 40.3 billion Yuan in 2005 (Zhang et al, 2007a; Wang, 2006). However, China is faced with low fertilizer manufacturing efficiency and shortage in raw material for fertilizer production such as materials including coal, natural gas

and electricity, and P and K mines. In the case of P, current P resource use efficiency was merely 39%, i.e. from every 10 kg P in rock material only 4 kg of P fertilizer were produced (Zhang et al, 2007b). It was forecasted that most of natural resources used for fertilizer production would be exhausted in this first half century. But the duration of high grade P rock would be less than 10 years.

2.2. Increased pressure in food security

In spite of the fact that grain production in China has been fluctuating between 460 to 480 million tones in recent years, China has to produce at least 31% more food to feed an increasing population, which is predicted to reach 1.36 billion in 2010, 1.45 billion in 2020 and a plateau of 1.6 billion before 2050. According to the prediction, food production has to be increased by 150~200 Mt, and crop yield to be increased at an annual rate of 1.4% within the next 30 years. The improving living standards will also drive demand for high-value food products. The consumption of meat, eggs and milk per capita of China in 2005 reached 59.22kg, 22.02 kg and 21.91 kg, which were 3.74, 6.45 and 14.07 times higher than that in 1980, respectively. According to the increasing demand for animal food, grain production was forecasted to be 750 million tones in 2030. This would lead to increase production and demand for fertilizer. For instance, according to forecast by the fertilizer industry association of China and our research, compared with those in 2005, the production and demand of fertilizer would be increased by 20% and 3.6~7.5% for N, 42% and 2.4~14.1% for P<sub>2</sub>O<sub>5</sub>, and 51% and 6.5~38.7% for K<sub>2</sub>O in 2010 (Figure 1).

Figure 1. The production and demand of chemical fertilizer in 2005 and projection in 2010.



2.3. Lower fertilizer use efficiency

Chinese farmers are using more than 35% of the world’s total fertilizers on only 9% of the world’s total arable land. In terms of N, one third of farmers apply more than 250kg/ha for wheat, rice and maize and more than 50% farmers overuse several folds of fertilizers for vegetable, fruits and sugar cane. More than 30% of farmers apply more than 150kg/ha P<sub>2</sub>O<sub>5</sub> for wheat, tea, oilseeds, sugar cane, vegetable and fruits. The average application rates of N

and P<sub>2</sub>O<sub>5</sub> for most of crops in China are higher than those counterparts in other main production countries. Irrational fertilizer utilization led to low fertilizer use efficiency. For instance, the partial factor productivity of fertilizer in maize cropping systems was 17 kg/kg in China, which was lower than that in USA (27kg/kg) and Argentina (70 kg/kg). The fertilizer recovery rate are 30~35% for N, 15~20% for P<sub>2</sub>O<sub>5</sub> and 35~50% for K<sub>2</sub>O (Zhu and Chen, 2002). The lower use efficiency accompanied by the growing population, growing economy and improving living standard was considered to bring more demand for fertilizer. Thus, it is urgent to place large emphasis on understanding and improving nutrient use efficiency and reducing nutrient losses in both production and consumption systems.

### 3. Opportunities to improve fertilizer management in China

The Chinese government regards agriculture as the primary field of development of the national economy in the 21st century. For China, the critical limitation for sustainable agricultural development is to improve resource use efficiency and protect the environment while guaranteeing food supply. The integrated measures of resource exploitation, industry management and fertilizer use in crop land were proposed and conducted to improve fertilizer management in China.

The FBMP (Fertilizer Best Management Practices) was proposed to be the best measure to improve fertilizer management in China. With the support of the Chinese Ministry of Agriculture and the National Natural Science Foundation of China, a large scale project has been carried out since 2002 which features integrated nutrient management systems for 12 cropping systems at more than 127 sites across the country.

Current result indicates that FBMP offers benefits to farmers. As shown in Table 1 that the FBMP techniques have realized multiple objectives of fertilizer saving, grain yield and quality improvement, resource use efficiency increase as well as environmental pollution reduction. Compared with farmer's traditional treatments, FBMP treatments on average save N by 20-40%, increase yield 2-12%, increase N recovery rate 10-15%, and decrease N loss by 10-50% over 9 cropping systems across the country.

Table 1. The potential of saving N fertilizer, increase in crop yield, N recovery rate and decrease in N loss from FBMP compared with farmers' practices in different cropping systems in China.

Cropping system	N save (%)	Yield increase (%)	N recovery increase (%)	N loss decrease (%)
Wheat/Maize	41-59	5-10	12-15	43-69
Rice	22-32	8-12	10-15	40-50
Vegetable	30-50	2-10	5-15	40-65
Cotton	20-30	5-8	10-15	10-30
Oilseed rape	10-30	5-30	8-15	-
Rice/wheat	30-50	8-20	8-30	30-50
Intercropping	20-50	0-10	8-13	20-45
Tobacco	10-30	0-10	7-20	40-50
Apple	10-50	5-15	2-12	-

Many experimental bases or stations have played a remarkable role in not only development of FBMP techniques, but also dissemination. For instance, the farmers were organized in the form of special associations in Jianyang base, Sichuan province. By joining the farmers' special association, farmers would participate in the development of FBMP techniques, receive training and share experience and information with each other, while the local government will give certain subsidy to those farmers who use FBMP techniques in the first year. This has greatly facilitated the promotion of development and dissemination of FBMP in Jianyang base, Sichuan province.

Effective cooperation with fertilizer industries substantially facilitated the dissemination of FBMP. For instance, cooperating with Sinochem, a "R&D center of Sinochem and CAU" was established in 2003, which focuses on new fertilizer development, fertilizer market investigation, on-farm survey of fertilizer application, and training staffs in both fertilizer industries and official extension service system. The main measures adopted in FBMP extension included: (1) organizing workshops using interactive educational methods that focus on problem solving in the field and tailored nutrient management case studies for local audiences; (2) releasing technique notebooks and publications as resource materials of FBMP training to farmers and/or technicians; (3) establishing Web site ([www.fertrdc.cau.edu.cn/cnm](http://www.fertrdc.cau.edu.cn/cnm)) designed for nutrient management planners; and (4) producing special compound-fertilizers targeting at crops in typical ecological regions of China.

The action to extend the technology of fertilizer recommendation based on soil testing was reported to get great achievement in China since the government invested 1.60 billions Yuan in 600 counties in 2006. Roughly estimated from the Ministry of Agriculture that the grain yield increased 8-15%, and fertilizer use efficiency increased 5% by using this technology in some regions. About 2.3 million tones of fertilizer was saved in whole China in 2006. It was reported by the Ministry of Agriculture of China that a total of 1200 counties have joined the project in 2007. The quick extension of this project is assessed to increase fertilizer use efficiency (recovery rate) by 5% in 2010.

In conclusion, it appears that FBMP is a feasible solution to tackle or alleviate the problem within next 20-50 years. But there is still a long way from research in plot to wide technology adoption by farmers. Despite its N fertilizer save, current FBMP did not lead to significant higher yield than Farmer' practices. This will discourage farmers' enthusiasm to adapt FBMP. Thus, efforts are needed to attain higher nutrient use efficiency with higher yield and environmental protection. Additionally, the interactions among farmers, researches, extension services and non-governmental sector involved in research and distribution of integrated nutrient and soil management should be further strengthened.

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# **Fertilizer Management in China: Challenges and Opportunities**

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## **Outline**

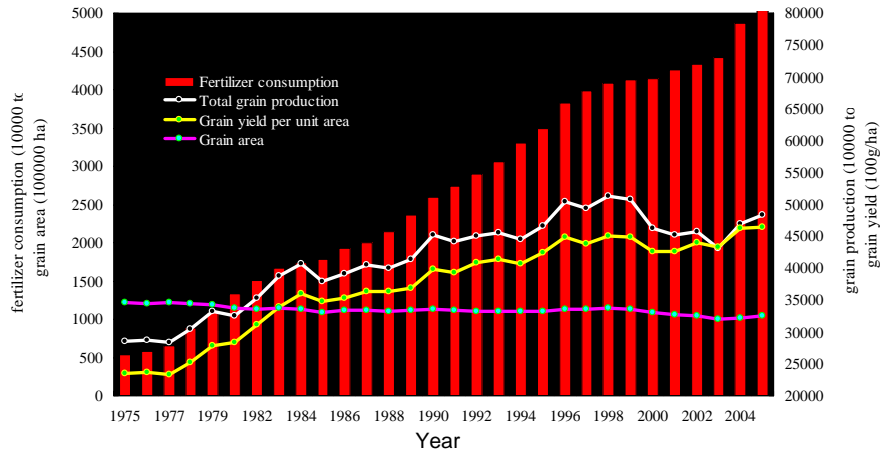
- **Importance of fertilizer in food production in China**
- **Challenges of fertilizer production and consumption**
- **Opportunities to improve fertilizer management in China**



# China

9% of world arable land  
 21% of world population  
 30% of world fertilizer consumption

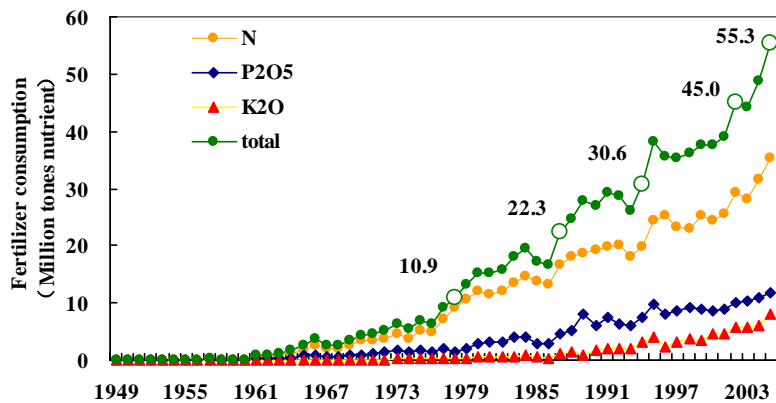
> 50% of grain production came from fertilizer in 1980s!



Trends of grain yield, production, grain area and fertilizer consumption (1975 – 2005)

## China consumed more than 55 million tones of NPK as chemical fertilizers in 2005

Consumption= production+ import-export



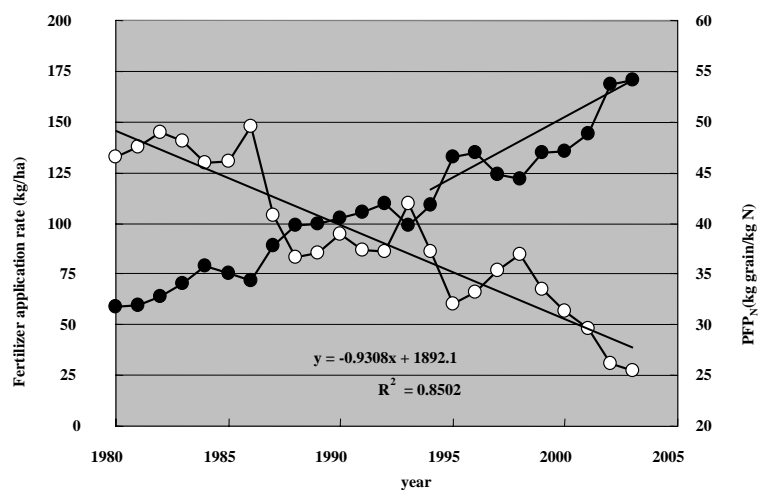
The trends of fertilizer consumption in China from 1949 to 2005

## Outline

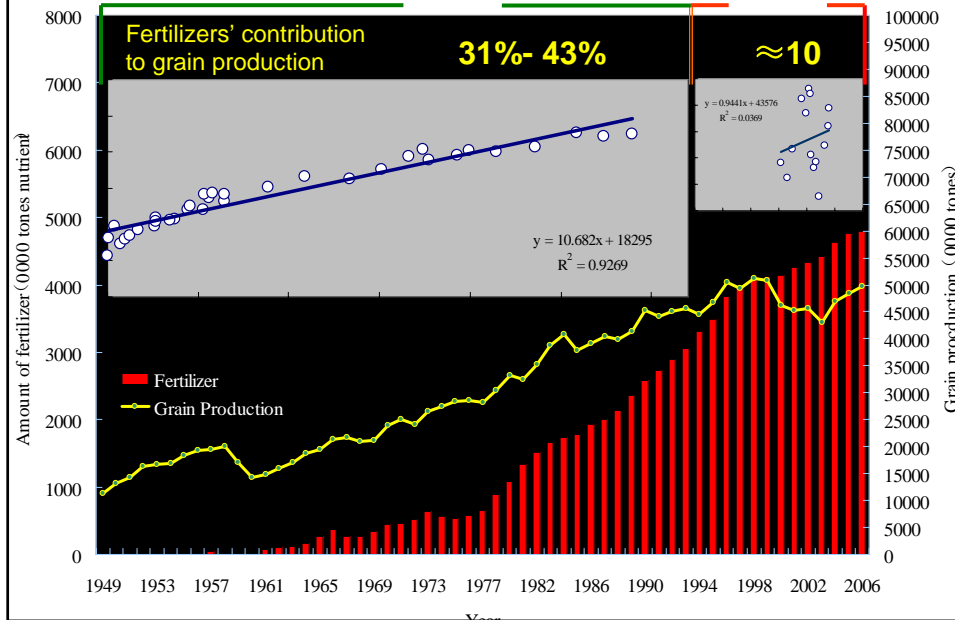
- Fertilizer feeds China
- Challenges of fertilizer production and consumption
- Opportunities to improve fertilizer management in China

### Substantial decrease in fertilizer use efficiency ---Low PFP

Partial factor productivity:  $PFP_N = \text{kg harvest product per kg N applied}$



## Decreased contribution to grain production

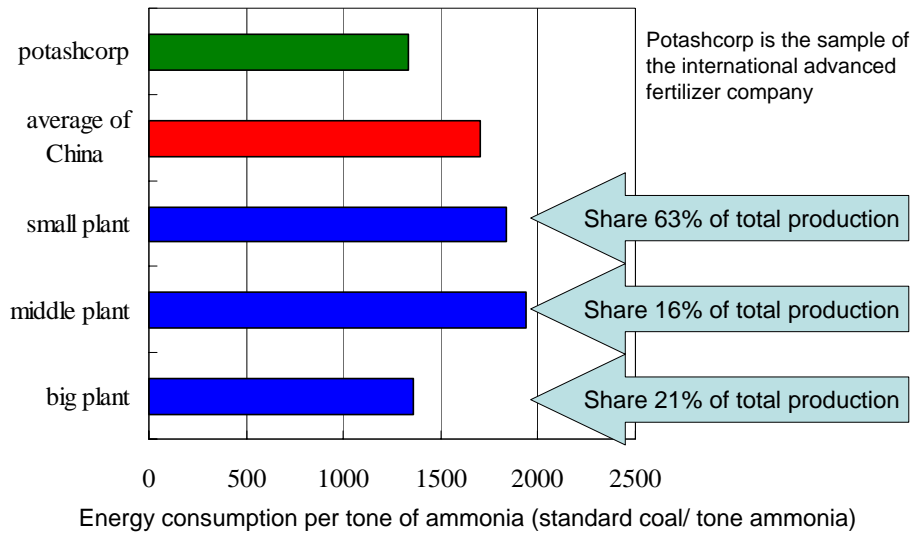


## Grain yield and N rate of rice crop

Country	Grain yield* (t ha <sup>-1</sup> )	N rate (kg ha <sup>-1</sup> )
China	6.26	~200
Japan	6.42	70
South Korea	6.79	110

\*FAO, 2004

## Sky-high energy consumption



Cao, unpub

## 10% of economic efficiency in fertilizer industry of China compared with U.S.

Process of production and marketing	Mining		Fertilizer manufacture	
	China	United States	China	United States
Number of Employees per plant	119	1818	189	5200
Production per employee (ton P <sub>2</sub> O <sub>5</sub> )	168	537	40	533
Net sale per employee (USD <sup>1</sup> )	10854	47300	25366	421269
Gross margin per employee <sup>2</sup> (USD)	2927	98516	13659	34846

Note:

1 Exchange rate between USD and Yuan was 8.2:1;

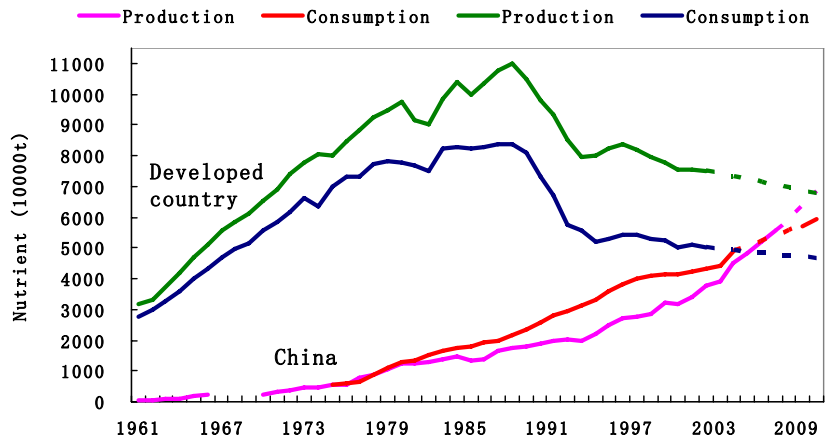
2 Gross margin = Net sale - Cost;

3 Data from the statistics of CPFIA (2004);

4 Data from the USGS (2004);

5 Data from IMC (2003);

The government's subsidy policy stimulated a rapid expansion of the fertilizer enterprise



(Forecast based on the increase rate of recent five years  
Data from FAO website and Chinese statistics )

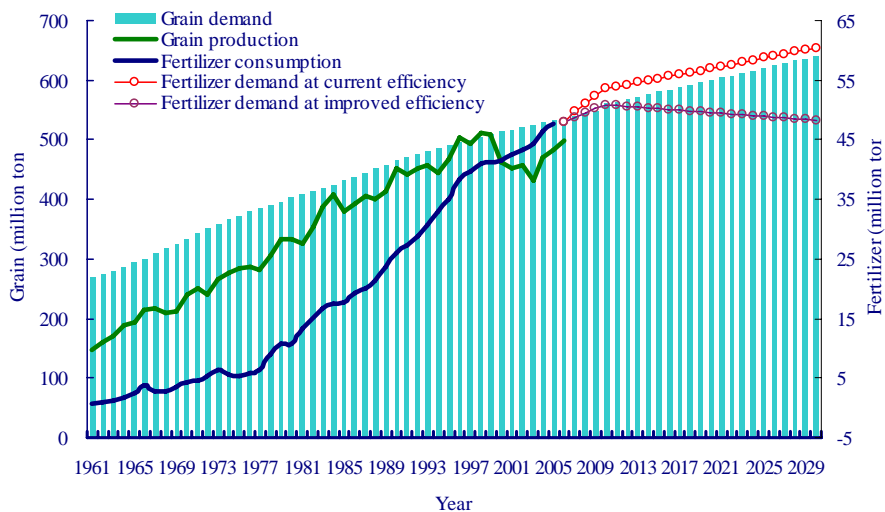
Financial support to fertilizer industry by Chinese government (Billion RMB), 2005

Item	Financial	Remarks
Natural gas	39.6	746 ¥ /000m <sup>3</sup> for fertilizer production but 1100 ¥ /000m <sup>3</sup> for other products
Electricity	115.5	0.3 ¥ /kwh for fertilizer production but 0.5 ¥ /kwh for other products
Added value	160	8% for fertilizer production but 13% for other products
Transportation	88	Include railroad fee of raw material and products
Sum	403.1	
Percentage of production value	17%	Total production value in current exchange rate

## Outline

- Fertilizer feeds China
- Challenges of fertilizer production and consumption
- Opportunities to improve fertilizer management in China

## Food security via fertilizer consumption



## Target of fertilizer management in 2010

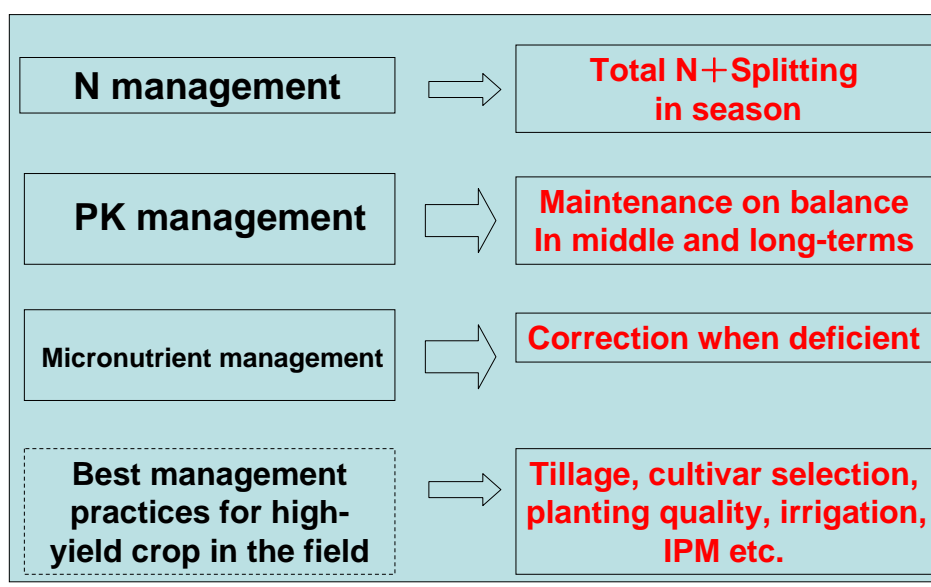
### Target

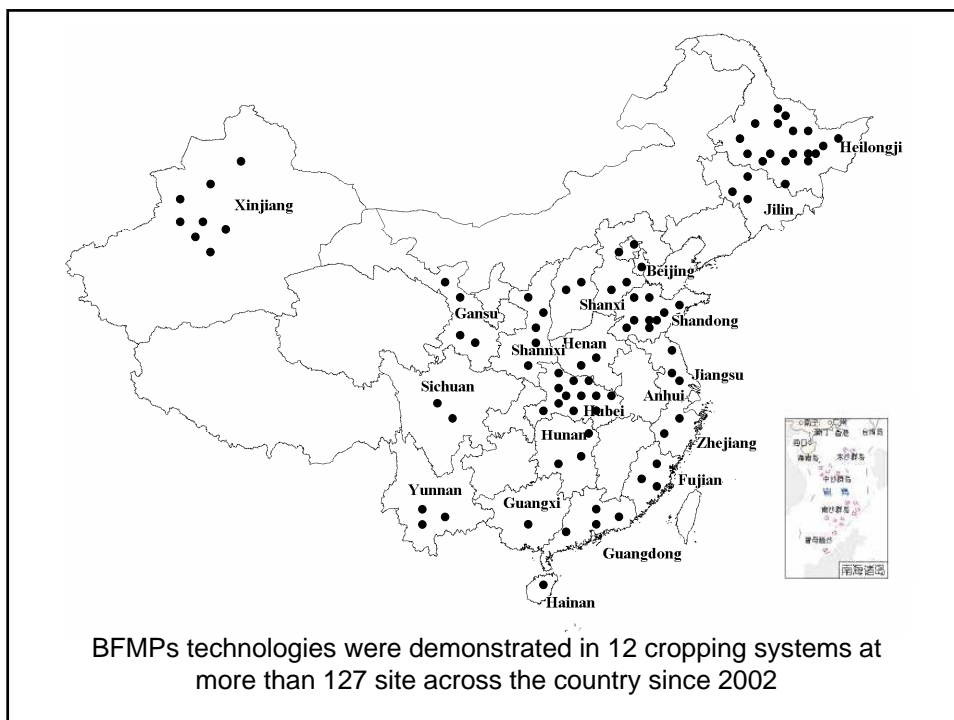
- **Agriculture:**
  - Grain production: increase 2%
  - Fertilizer use efficiency: increase 5%
  - Farmer's income: increase 27%
- **Fertilizer industry:**
  - Energy: save 20%,
  - Waste: decrease 20%,

### Measures

- Keep the cultivated land
  - Set up a reasonable technology extension system
  - Stop the subsidy to fertilizer industry and increase subsidy for farmers
  - Keep fertilizer price at optimal level
- 
- 70% production comes from 20 big competitive companies
  - 70% production comes from the resources regions
  - 70% production comes from the high analysis products

## Principal and technology of best fertilizer management practice (BFMPs)





### Result of on-farm wheat and maize demonstrations

Treatment	N rate (kg/ha)	Yield (t/ha)	N recovery rate (%)	PFP <sub>N</sub> (kg/kg)
Control	0	5.9	-	-
FP	356	6.8	20	20
FBMPs	111	6.8	36	72

Wheat (n=87)

Treatment	N rate (kg/ha)	Yield (t/ha)	N recovery rate (%)	PFP <sub>N</sub> (kg/kg)
Control	0	8.1	-	-
FP	242	9.2	18	40
FBMPs	180	9.8	25	58

Maize (n=189)



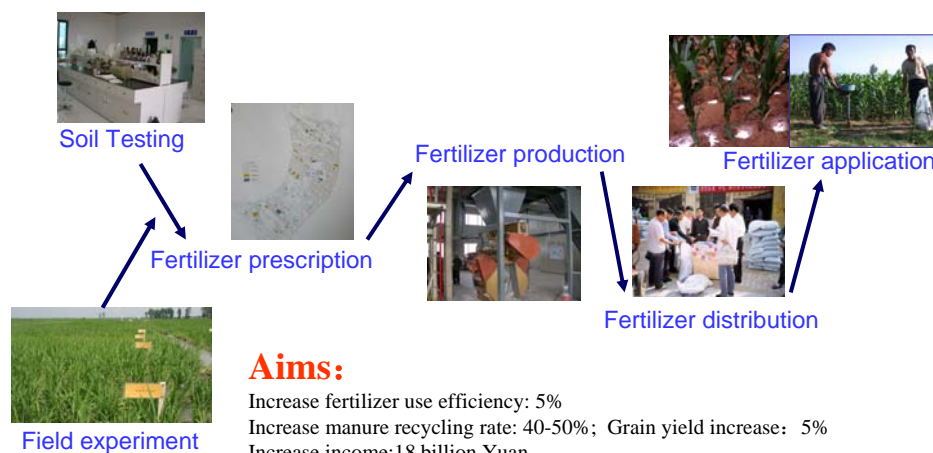
The potential of N saving, yield increase, N recovery rate increase, and N loss decrease in FBMPs compared with farmers' traditional treatment in different cropping system in China

Cropping system	N saved (%)	Yield increase (%)	N recovery increase (%)	N loss decrease (%)
Wheat/Maize	41-59	5-10	12-15	43-69
Rice	22-32	8-12	10-15	40-50
Vegetable	30-50	2-10	5-15	40-65
Cotton	20-30	5-8	10-15	10-30
Oilseed rape	10-30	5-30	8-15	-
Rice/wheat	30-50	8-20	8-30	30-50
Intercropping	20-50	0-10	8-13	20-45
Tobacco	10-30	0-10	7-20	40-50
Apple	10-50	5-15	2-12	-

### Set up integrated technique extension system with Chinese Ministry of Agriculture

National Program for Fertilizer Recommendations Based on Soil Testing

1.6 billion RMB ¥ covered 1200 counties from 2005 to 2007!



## Perspectives

Change policies both in agriculture and fertilizer industry

- Develop and extend fertilizer saving technologies
- Train farmers
- Reform current public agricultural extension system
- Encourage the development of fertilizer-sensitive and resource/energy efficient technologies in fertilizer industry.

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*Thanks*

**for your attention !**

