Agricultural Outlook Forum Presented: February 17, 2006

CHINA'S GMO AND ADOPTION OF NEW TECHNOLOGY

Scott Rozelle
Professor of Agricultural Economics
U.C. Davis

Plant Biotechnology in China: Investment and Impacts

Scott Rozelle, UC Davis

Jikun Huang, CCAP

Plus Co-authors

Questions

- **Should China continue to promote biotech and commercialize its GM food, particular the food crops such as rice?**
- **How much benefit China can gain from agricultural biotech development?**
- **How important are trade restrictions on GM products by other countries**
- **Are the gains sustainable (or how can they be made so)?**

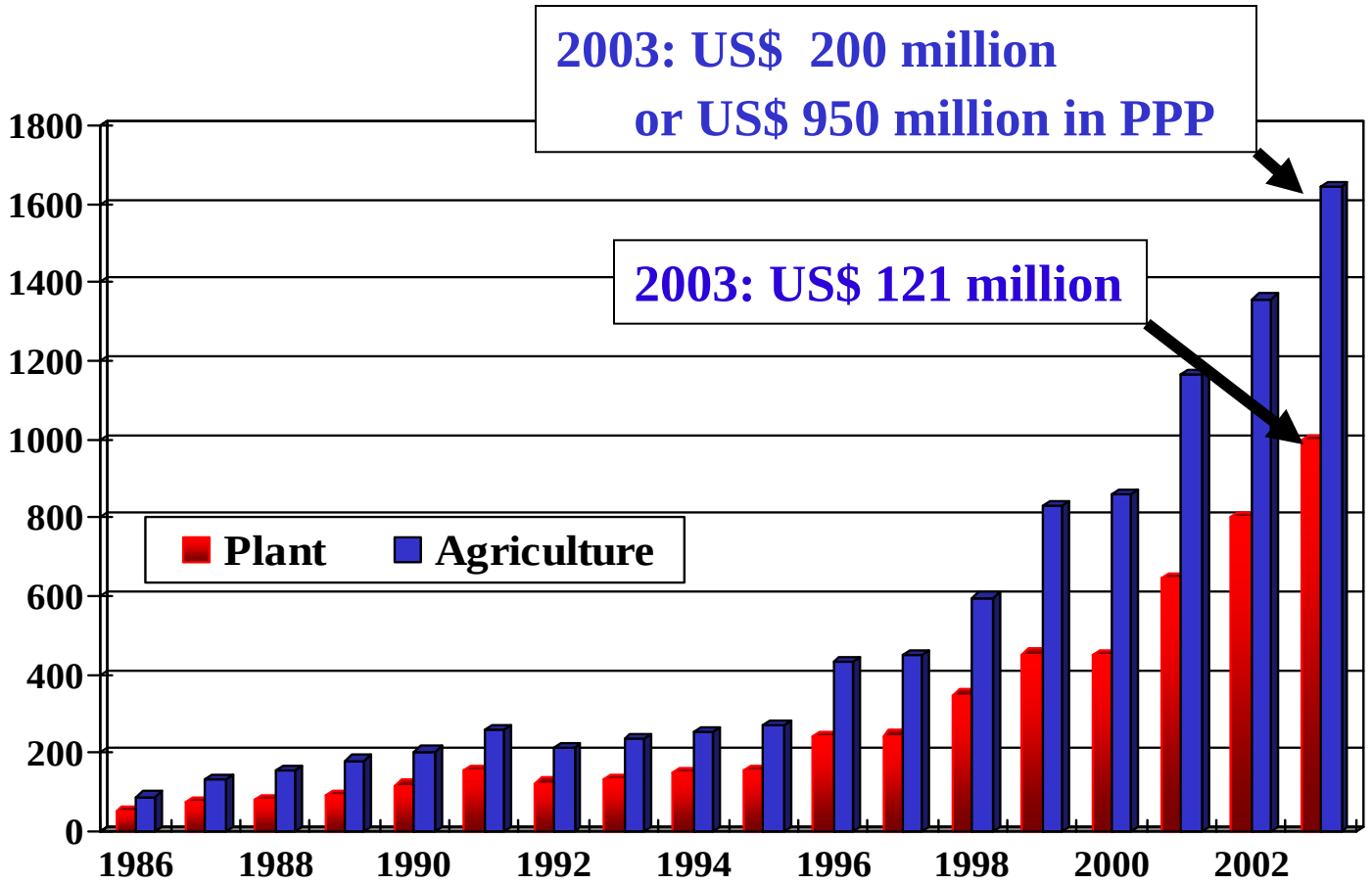
Overall goal:

To provide an economy-wide assessment of plant biotechnology development in China

Outline of presentation

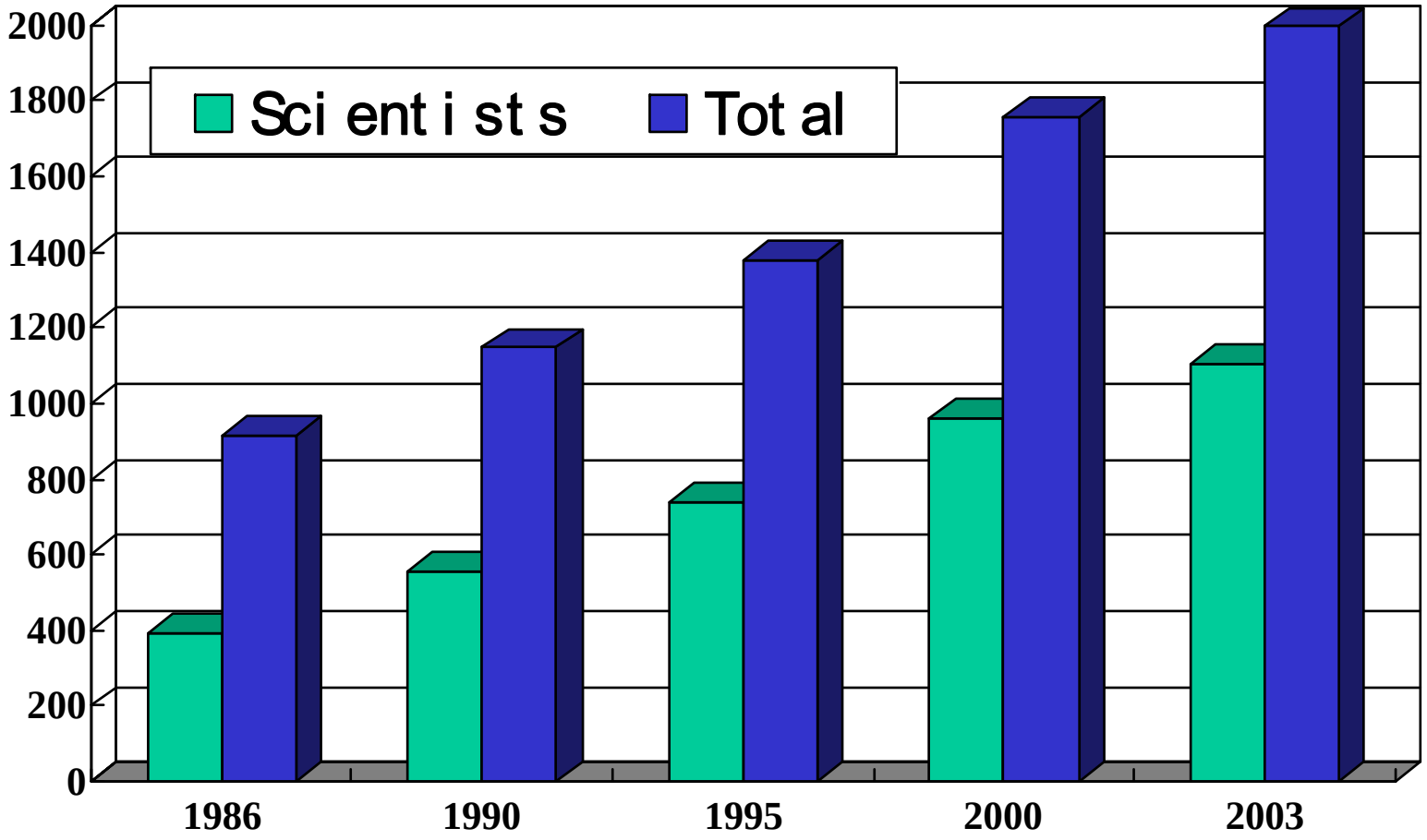
- Overview of China's plant biotechnology research investment
- Bt cotton and GM rice: farm level impacts
- Bt cotton and GM rice: economy-wide impacts
- Biosafety management—successes and not
- Concluding remarks

Agricultural plant biotechnology research expenditure in China, 1986-2003 (million yuan in 2003 prices)

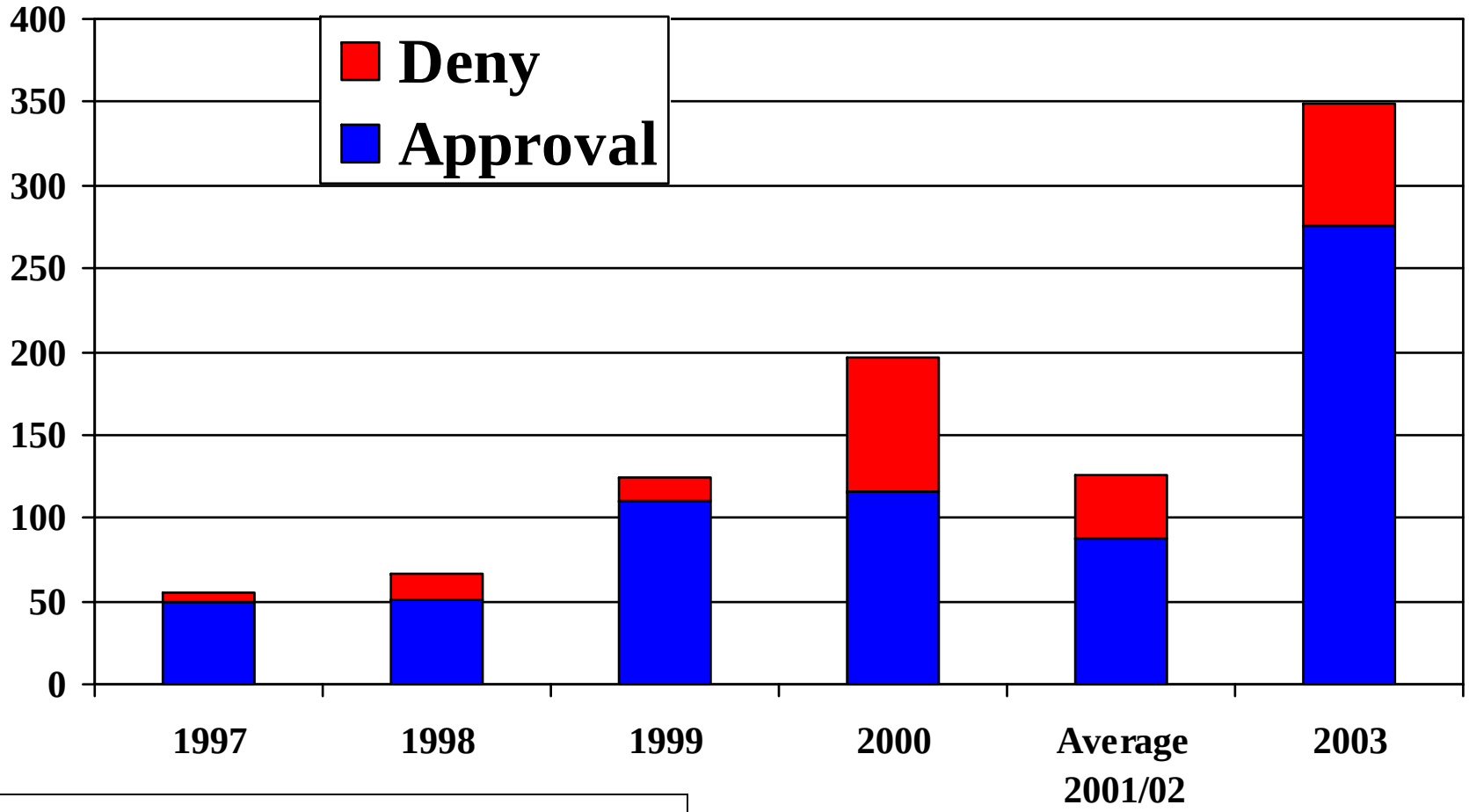


Based on CCAP's survey, 2003

Plant biotechnology researchers, 1986-2003

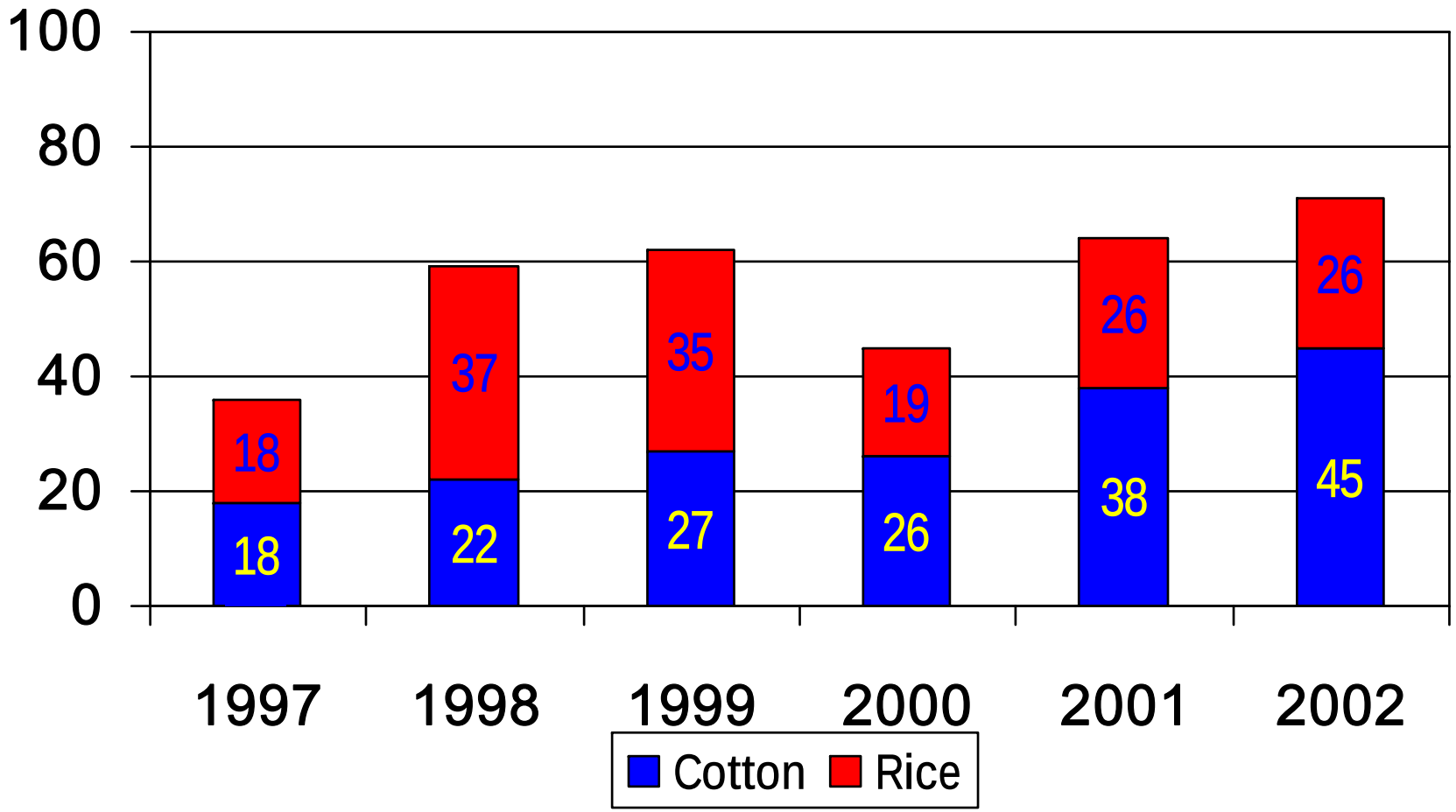


Increasing action for Biosafety Committee

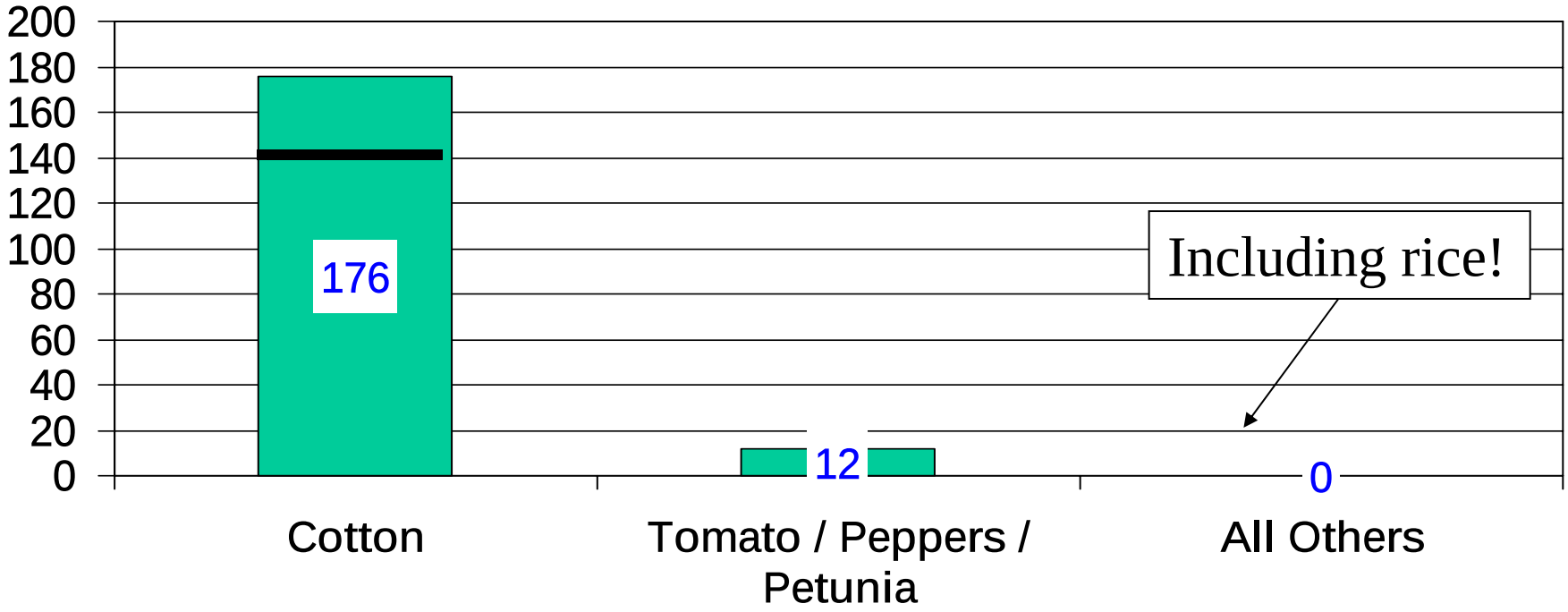


1044 cases with 777 approved

Domination of Cotton and Rice in China's GM Program



Cases approved for commercialization by 2004: 188 cases (rice case: Zero)



But, 4 cases were approved for pre-production trails since 2001 – in pre-production trials, farmers are given seed and cultivate the crop with no supervision.

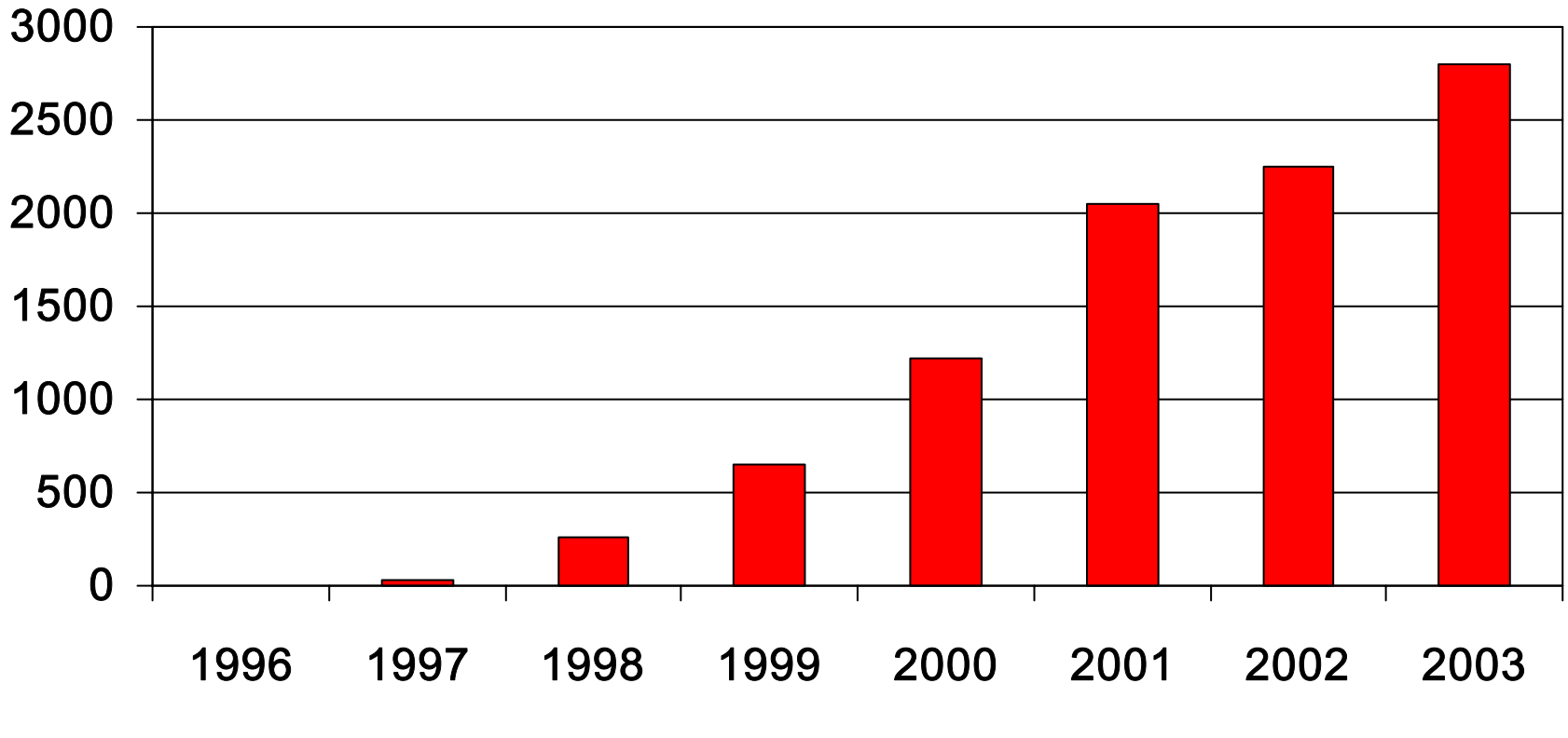
Case 1: Cotton

Non-Bt cotton

Bt cotton

Source: CAAS

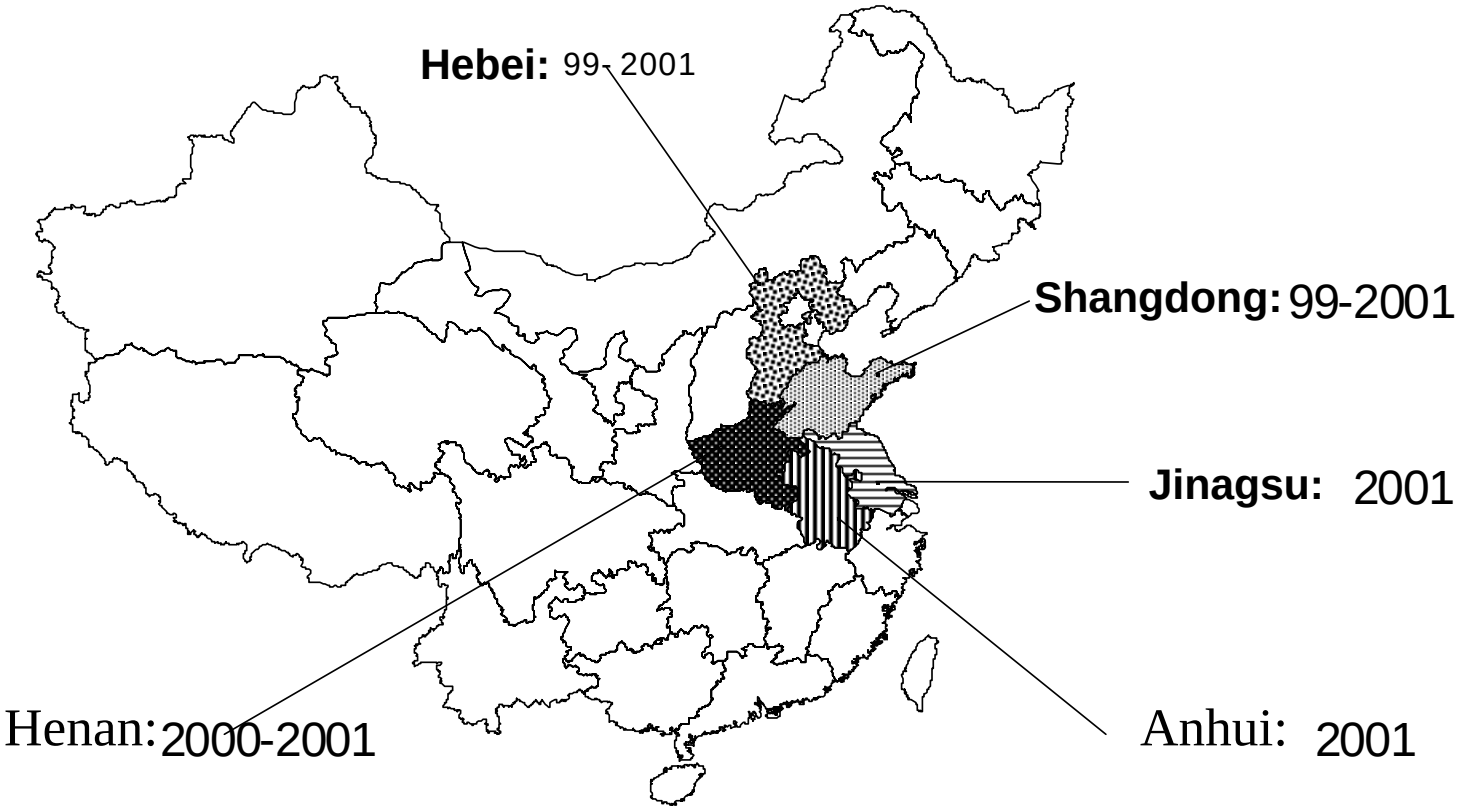
Bt cotton areas in China, 1996-2003 (thousand hectares)



More than 5 million farmers adopted Bt cotton in 2003

Case study: Bt vs Non-Bt

Samples' locations (1999-2001)



1999-2001:Sample Households: 1056

Productivity Effects of Bt Cotton
Bt vs Non-Bt Cotton
Inputs levels:

No significant different in:

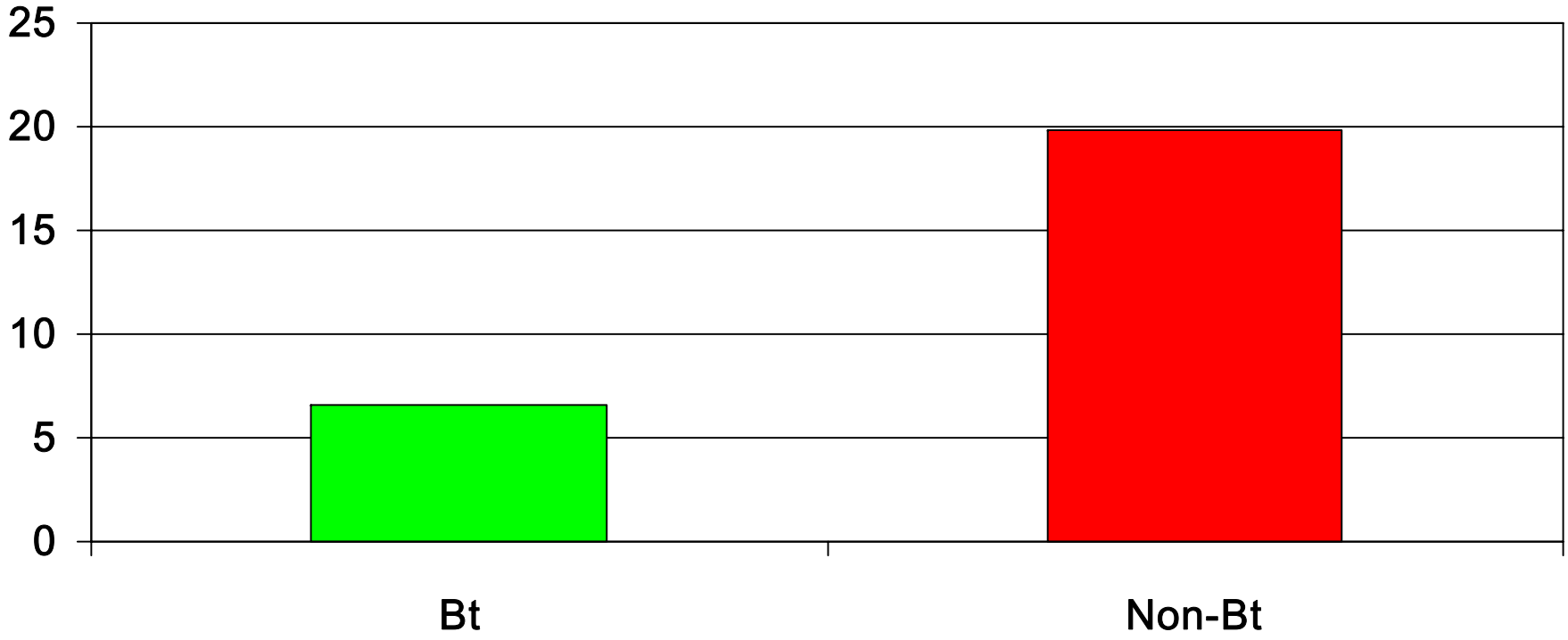
- **Fertilizer use**
- **Irrigation**
- **Machinery**
- **Harvest cost**

Significantly different in

- **Pesticide use**
- **Labor use**
- **Seed price**

Numbers of pesticide applications in Bt and non-Bt cotton in Hebei and Shandong in 1999

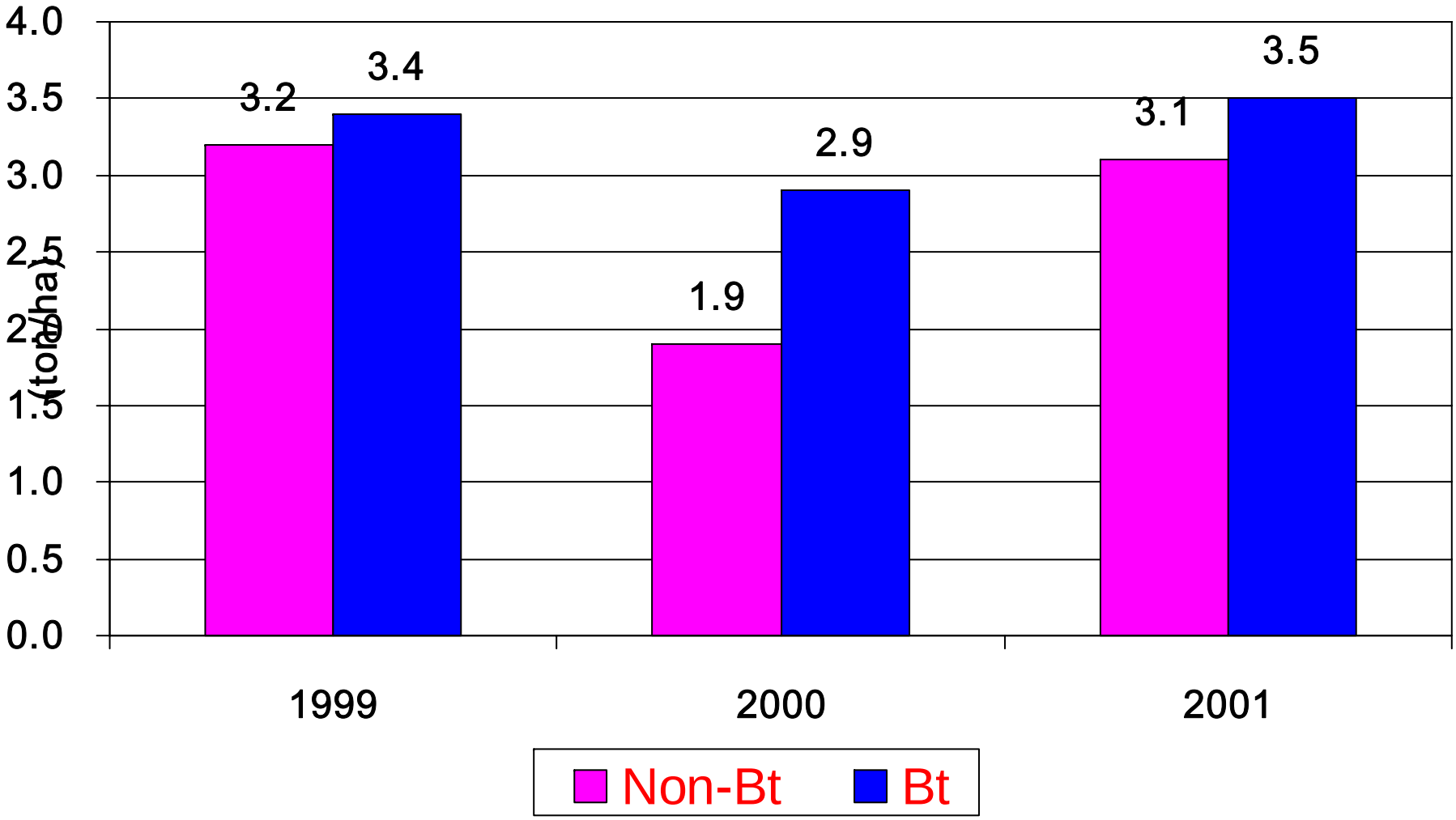
-- reduced by 13 applications



In 2000: by 12 applications

In 2001: by 14 applications

Cotton yield (ton/ha): Bt vs non-Bt cotton



Methodologies

Yield Model

(1) $Y = f(X)\, G(Z)$,

Y : yield

X: conventional inputs, farm-specific factors and others

$G(Z)$: a damage abatement function

Z: the pesticides and Bt cotton variety

(2) $Y = a\, \Pi_i^n X_i^{ki} [\, 1 - exp(- c\, Z)]$,

(3) $a = a_0 + a_1\, Bt$

(4) $c = c_0 + c_1\, Bt$

Pesticide Use Model

(5) *Pesticide use*= f (*Yield loss, Price, Farm size, Age, Education, Village leader dummy, Training dummy, Seed dummies, Bt cotton dummy, others)*

Major findings on Bt cotton impacts in 1999-2001 (per hectare)

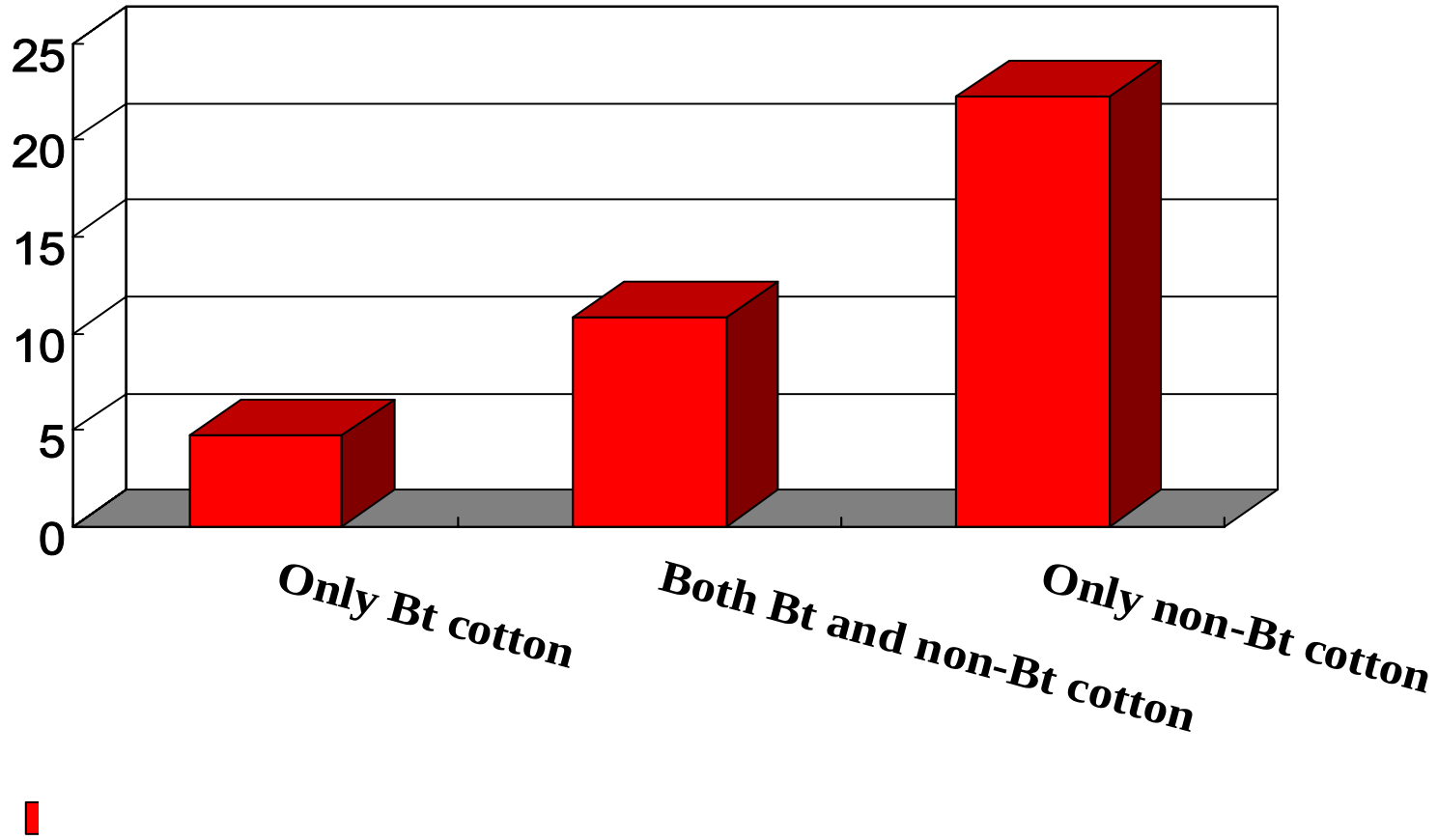
• **Reduce pesticide use:**	**34 kg**	**923 yuan**
• **Increase yield:**	**9.6%**	**930 yuan**
• **Increase seed cost:**		**570 yuan**
• **Reduce labor input:**	**41days**	**574 yuan**
• **Increase net income:**		**1283-1857 yuan (US$ 155-225)**

A net increase of net income: about 30% …

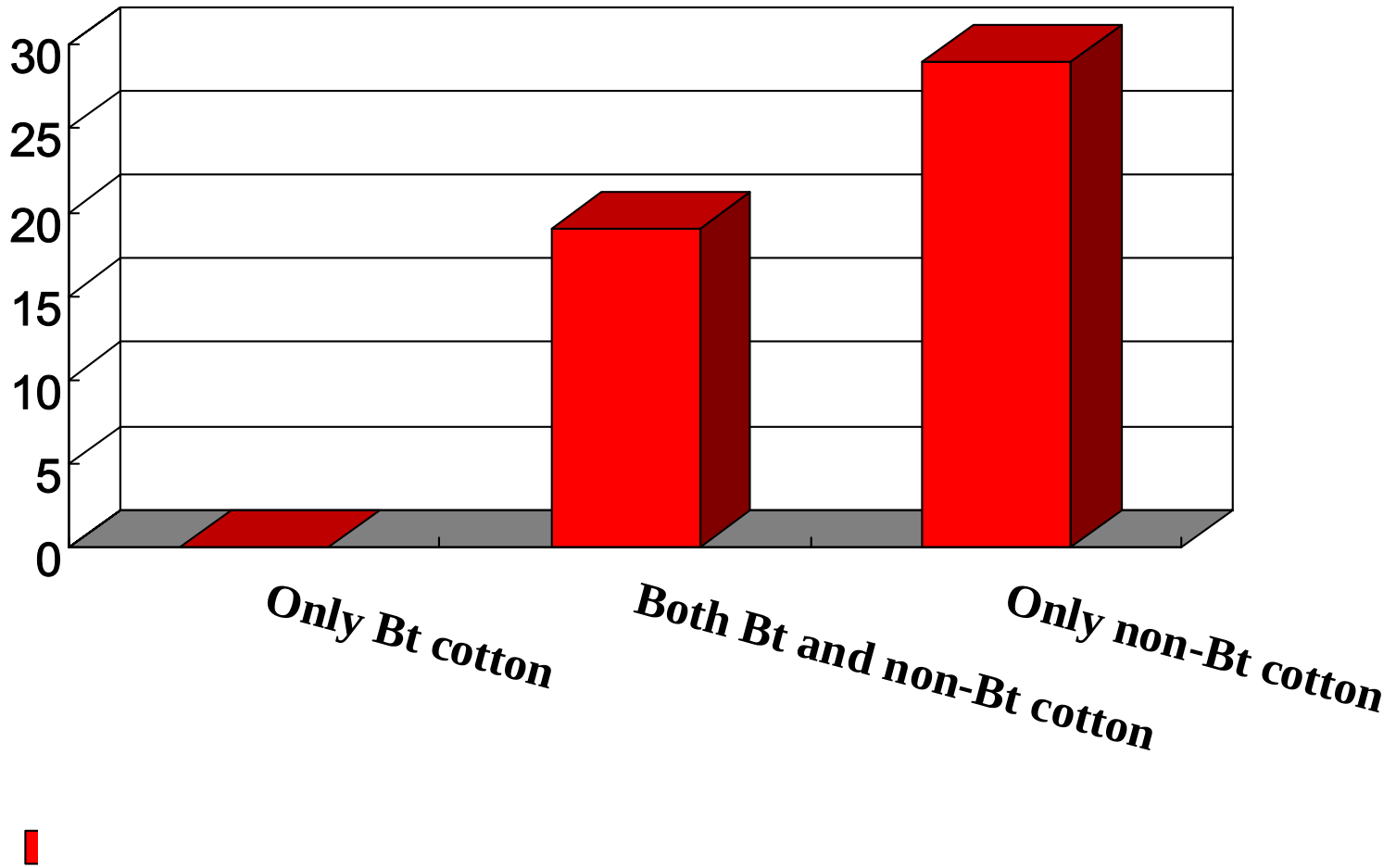
this is a HUGE increase in productivity!

GM technology’s benefits surpass the direct profitability metrics

Percentage (%) of poisonings reported as numbers of farmers interviewed in Hebei and Shandong in 1999

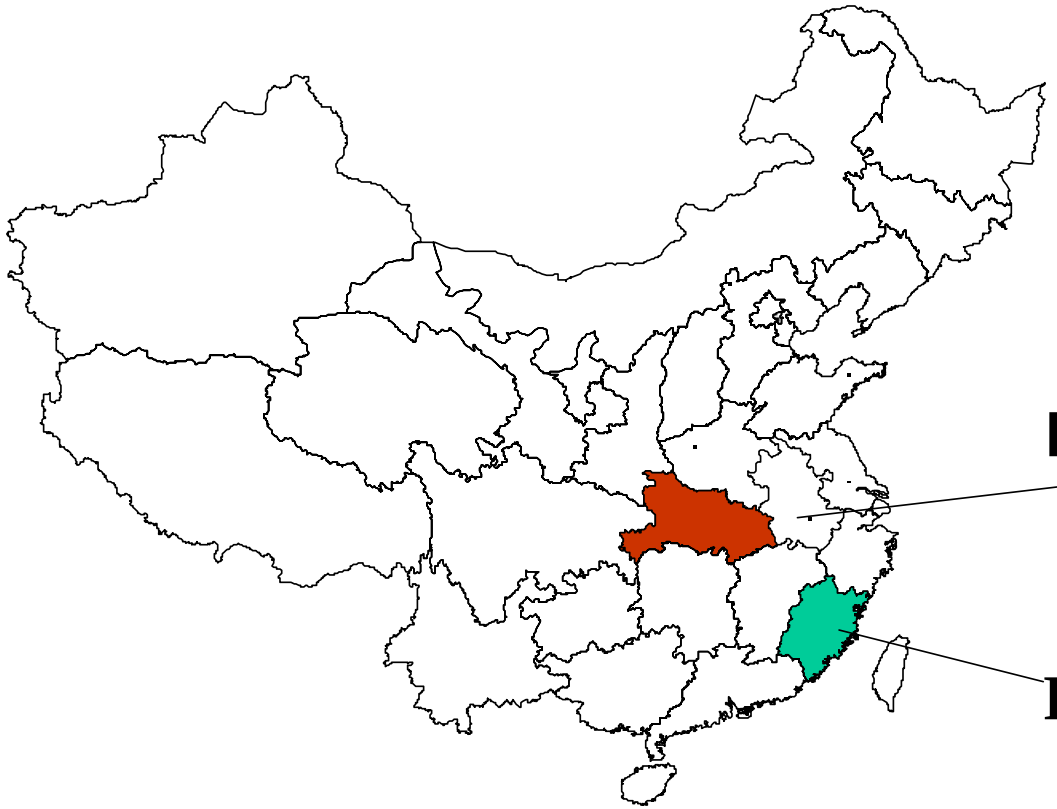


Percentage (%) of poisonings reported as numbers of farmers interviewed in Henan in 2000



GM rice: Pre-production

(2001-2003)



Hubei: 2001-2003

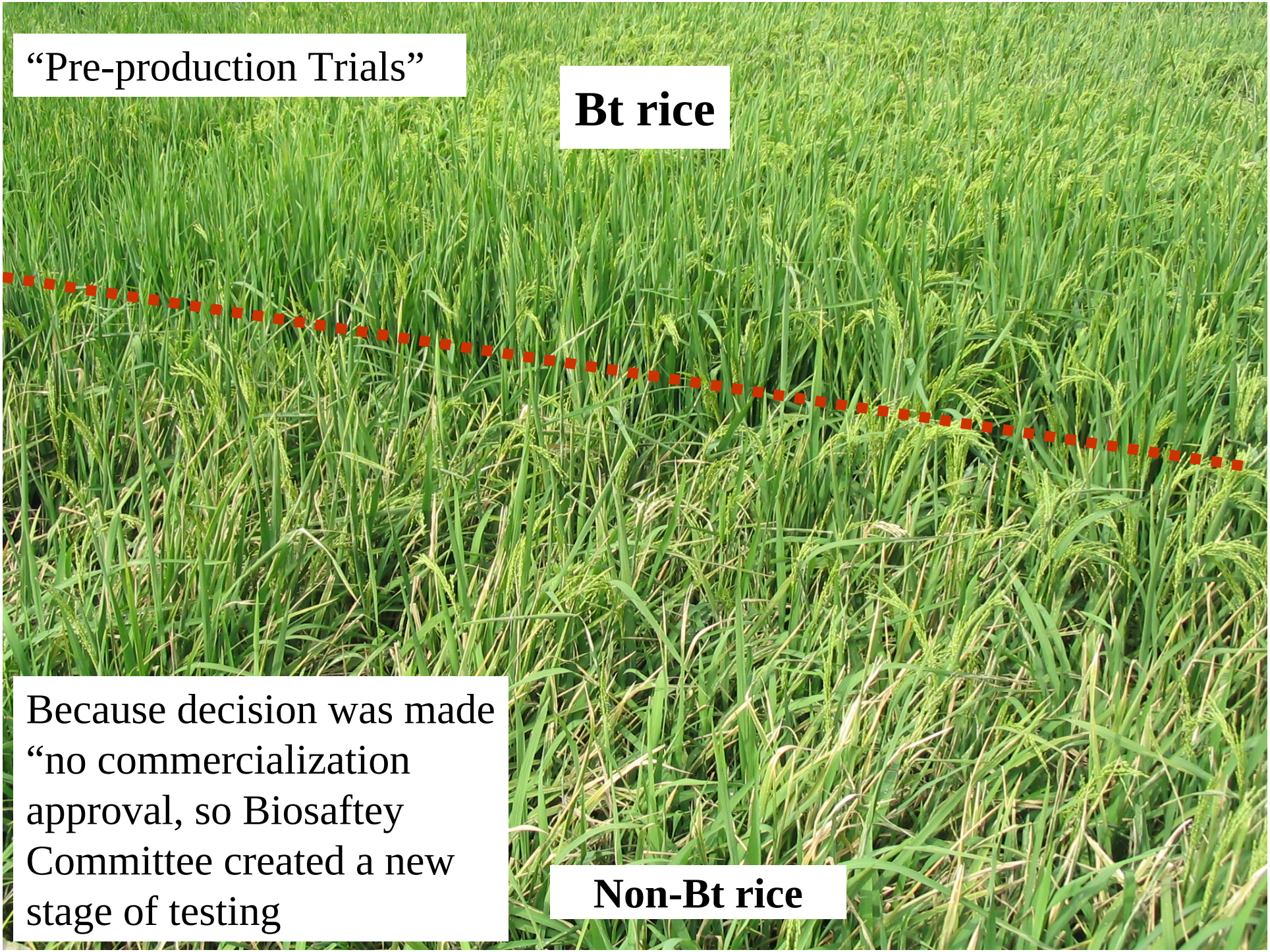
Fujian: 2002-2003

123 households, 512 plots

Bt rice: approved from “environmental release trials” in 2001 and 2002

2002年5月8日播种，6月1日插秧，抗虫转基因水稻恢复系株系及其配制的杂交稻组合各18个；恢复系及杂交稻组合的对照分别为明恢86及II优明86；转基因材料与对照在横竖二个方向间隔种植如国际象棋棋盘，每个方块为正方形，边长为3m。

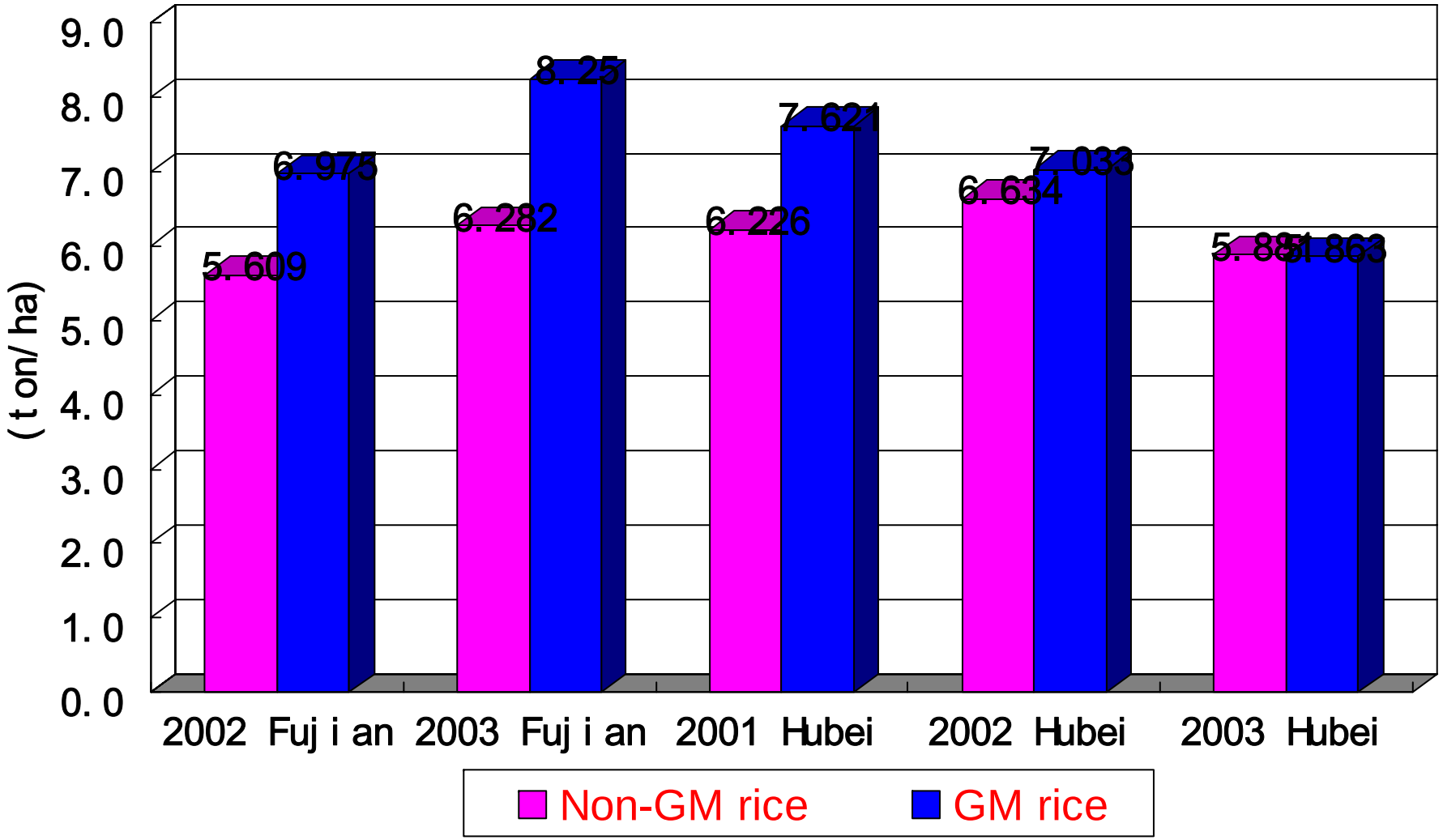
Source: Zhu Zhen


“Pre-production Trials”
Bt rice
Because decision was made “no commercialization approval, so Biosaftey Committee created a new stage of testing
Non-Bt rice

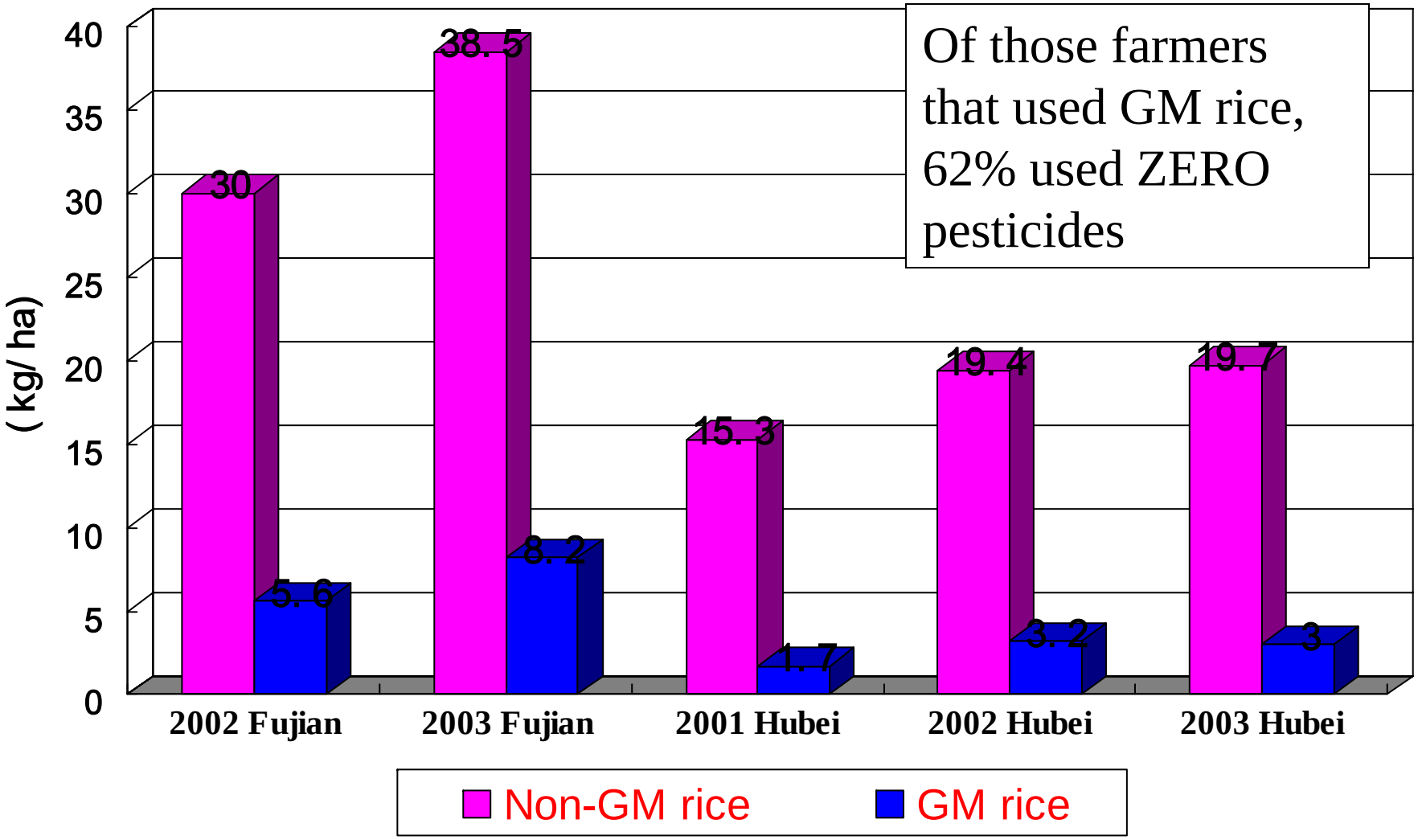
Three different types of technologies in Pre-production Trials

	part of our study
• Bt Rice	√
• Bt/CPTI stacked gene	√
• Xa21 Blight Resistant	

Yields of GM and non-GM rice： (ton/ha)



Pesticide uses (kg/ha)：GM and non-GM rice

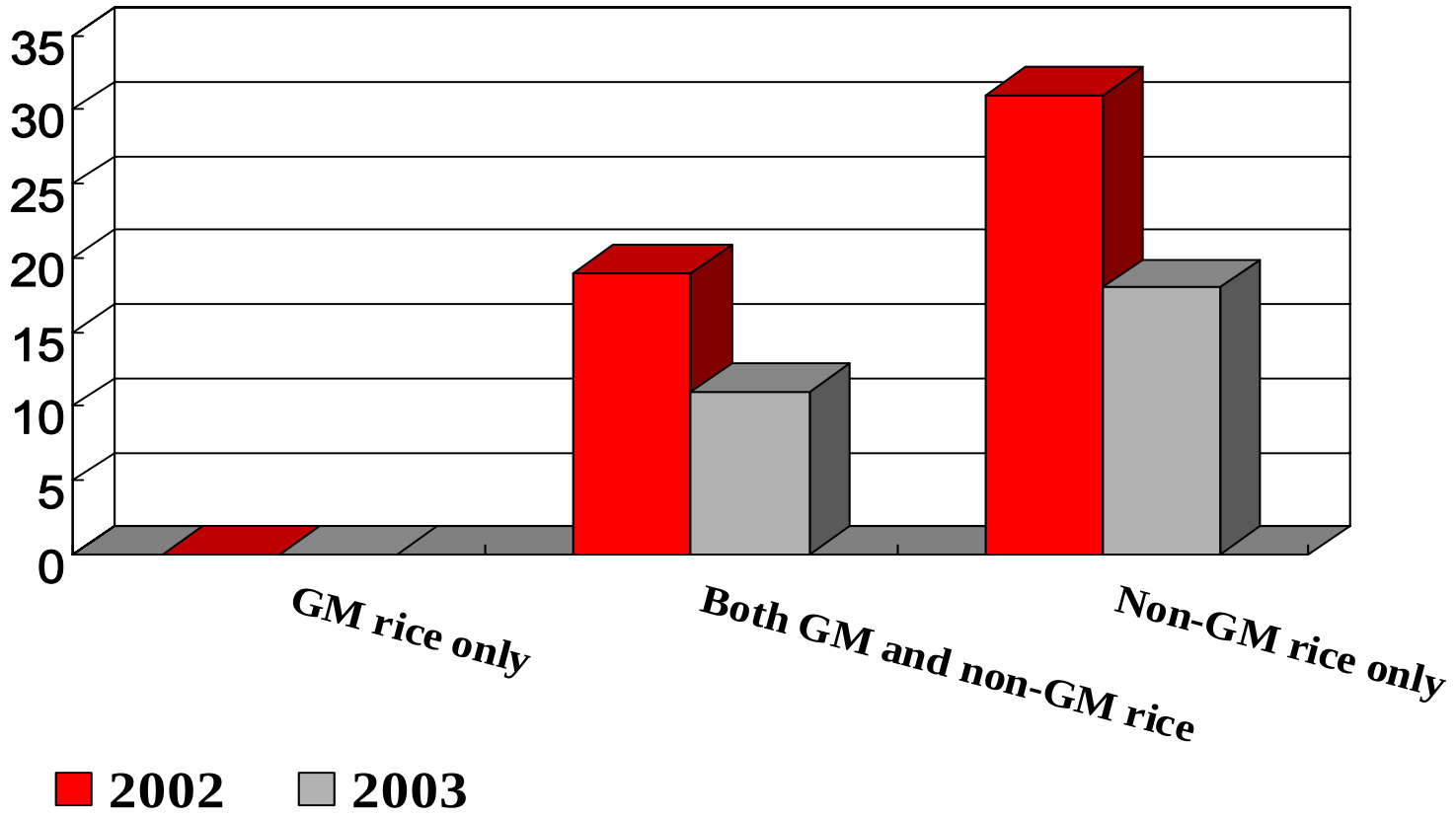


Major findings on GM rice impacts
(per hectare)

• **Reduce pesticide use:**	**16.9 kg**	**270 yuan**
• **Increase yield:**	**4-8 %**	**406 yuan**
• **Increase seed cost:**		**?? yuan**
• **Reduce labor input:**	**8.4 days**	**168 yuan**
• **Increase net income:**		**676-844 yuan (US$ 82-102)**

Between 10 and 15 percent increase in productivity

Percentage (%) of poisonings reported as numbers of farmers interviewed in Fujian and Hubei in 2002-2003



Economy-wide impacts

- **Price**
- **Supply and demand**
- **Trade**
- **Economy welfare**

Scenarios

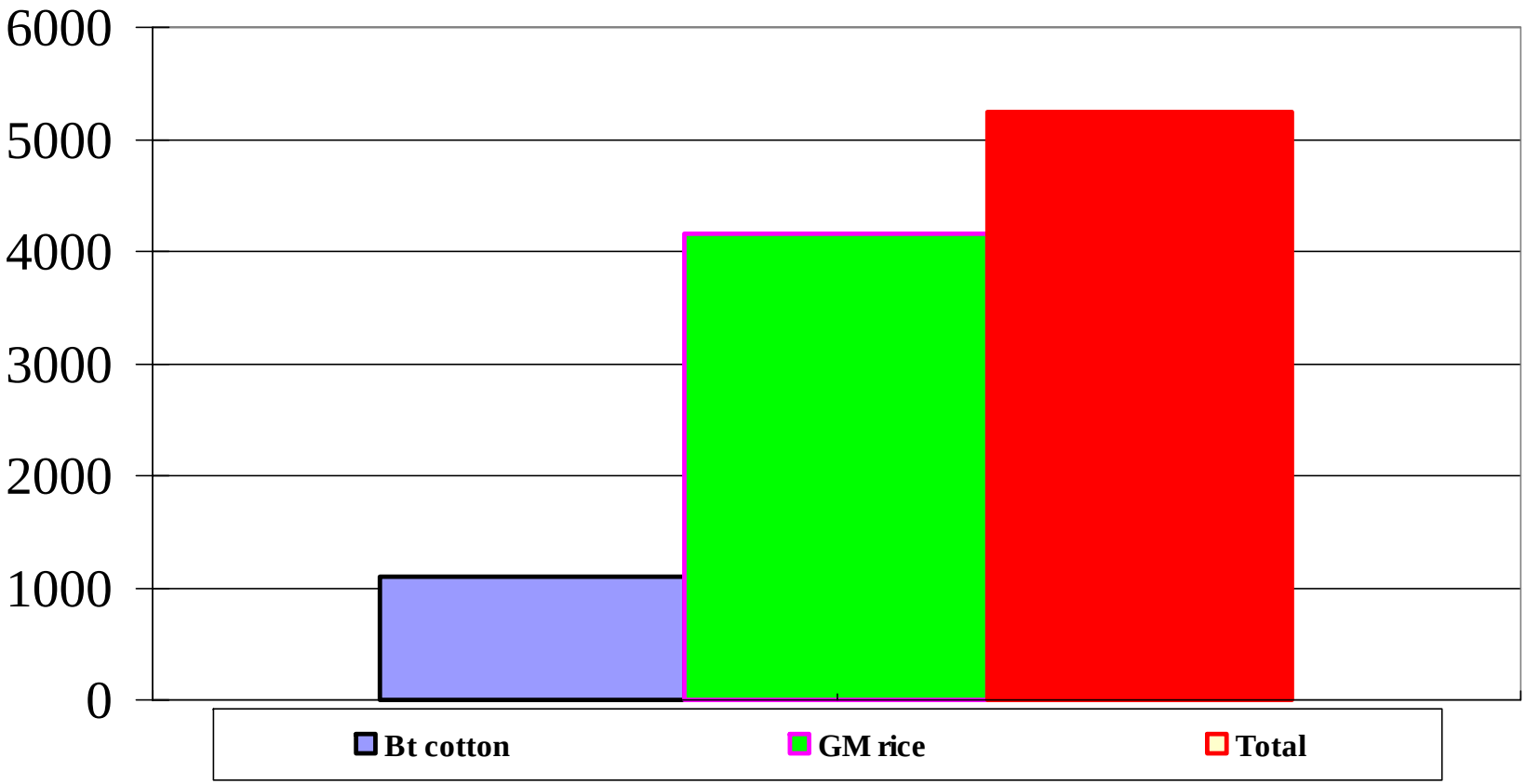
- **A = [not shown]**

- **B = Commercialise Bt Cotton + Commercialise GM rice + trade patterns not affected by GM adoption**

- **C = B + Trade ban on GM rice by Japan, Korea, SE Asia, and EU.**

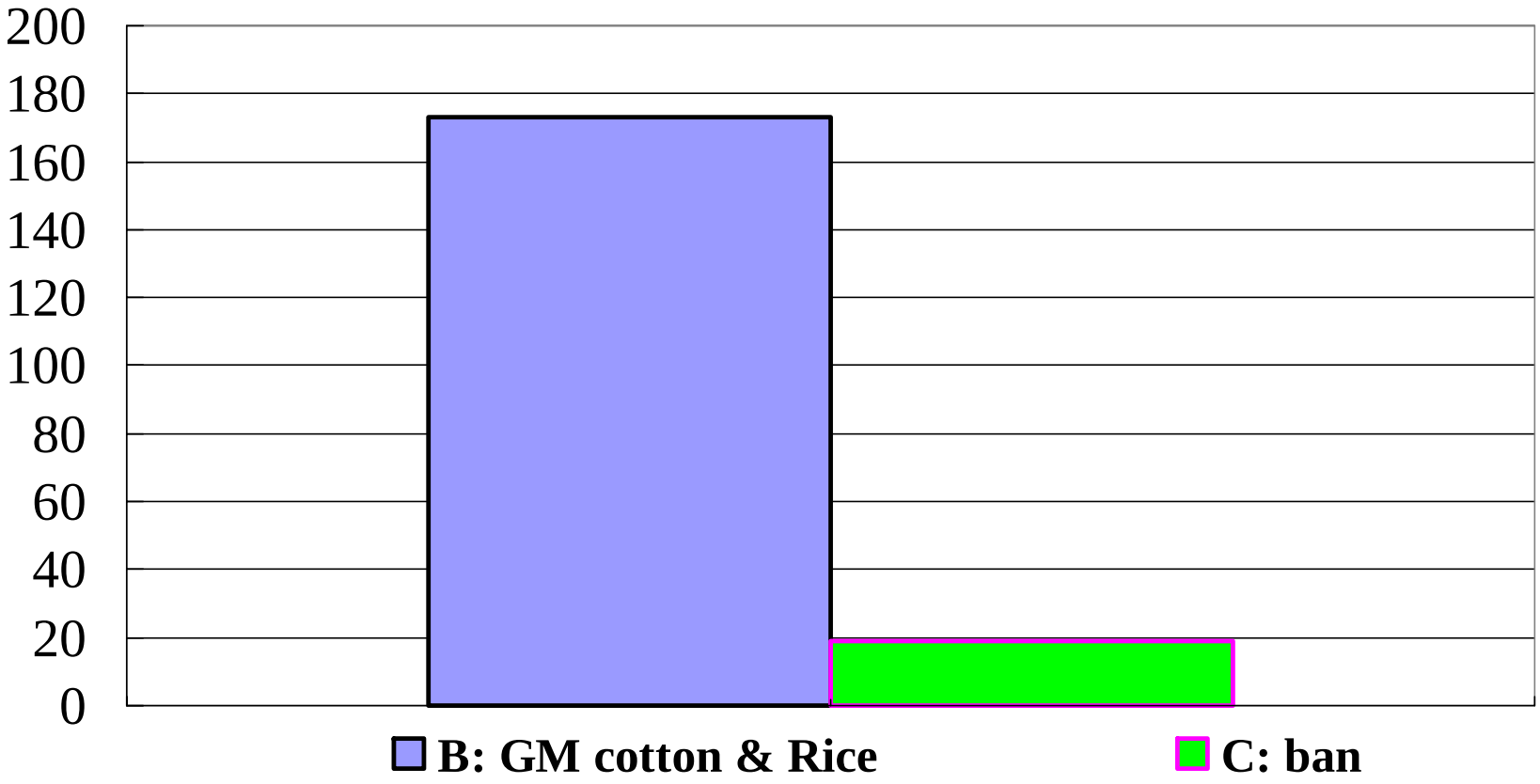
Scenario B: Bt cotton + GM rice

Impacts on *Welfare* (EV, million US$) in 2010



Comparing scenarios B and C

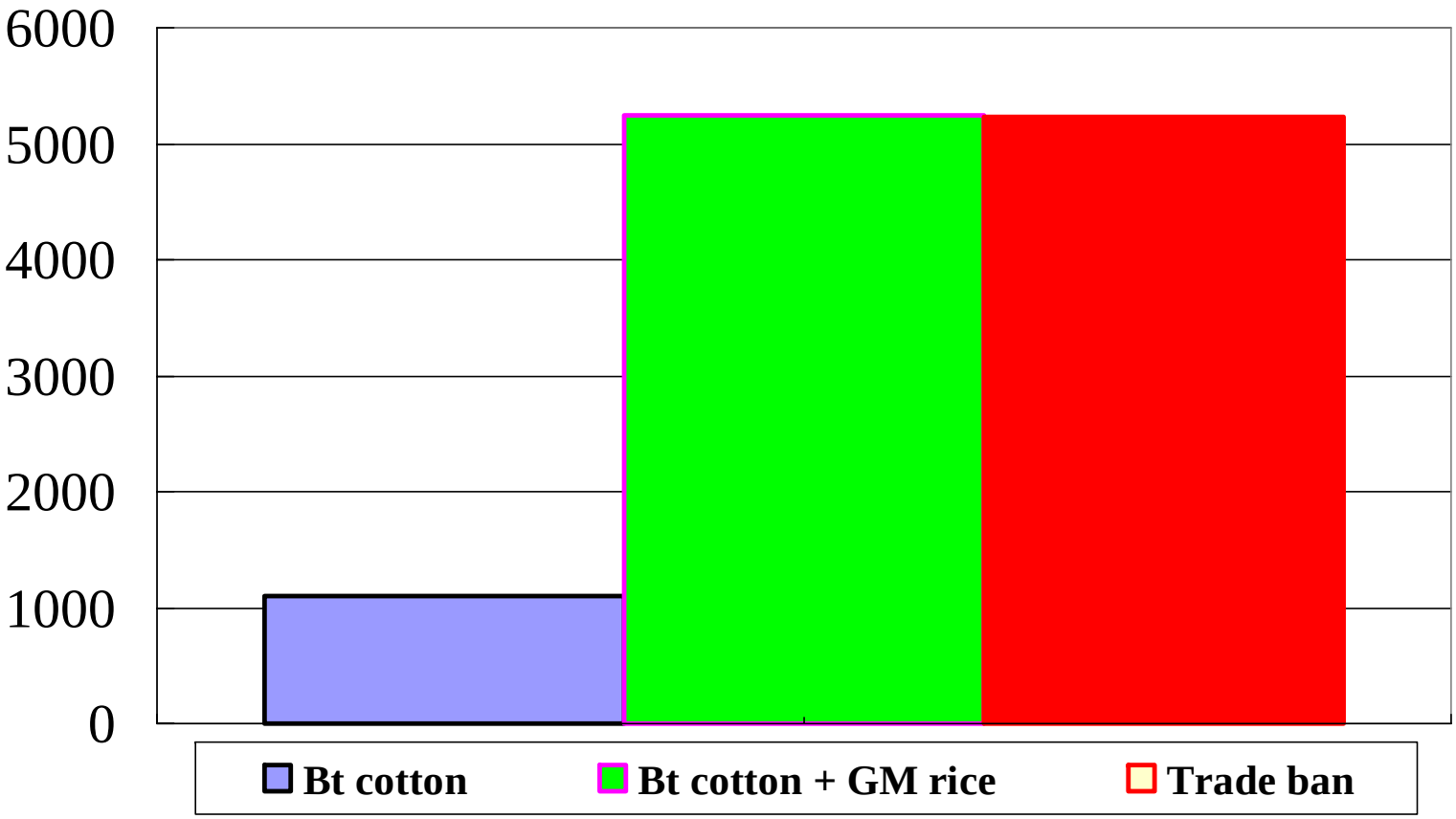
Rice *net export* changes (million US$, relative to baseline)



But share of export is only about 1% of production

Comparing Scenarios A, B, and C

Impacts on *Welfare* (EV, million US$) in 2001



Also other concerns about sustainability of gain: e.g, Bio-saftey and IPR

- IPR issues:
  - Much higher seed price from Monsanto/CAAS varieties. What is impacts of IPR?
    - Farmers income
    - Biosafety
  - Bt cotton seed sales of life science firms are less than 20% of sown area
  - All GM rice varieties being bred with hybrids in order to avoid some of these problems (even though conventional varieties are sometimes more in demand by farmers).

- UC Davis-CCAP study on effect of bio-safety and IPR improvement on farm sector
- In our analysis we seek to measure the economic impact of building an effective set of institutions to manage Bio-safety and IPRs
- Do so, using our Bt Cotton dataset

Approach

Pesticide Use or Yields =

f (Prices
Plot characteristics
Farmer characteristics
----- plus -----
IPR measures
Bio-safety measures
Seed industry reforms)

Regression results for pesticide use and cotton yields in China.

	Pesticide Use (kg/ha)	Log(Yield)
Bt Seed source:		
Seed company:		
Legitimate MDP	-39.77***	0.26***
Illegitimate MDP	-30.57**	0.13***
Legitimate CAAS	-41.45***	0.19***
Illegitimate CAAS	-33.52***	0.01
Unapproved	-38.53***	0.08
Traditional channels:		
Ag Extension Station	-34.68***	-0.004
Cotton office	-30.19***	-0.01
Self-saved	-33.29***	0.15***
Seed production base	-34.88***	0.20***

Hu, Pray, Huang, Rozelle, Fan and Zhang, 2005

Summary of Findings

- Improvements to IPR
- Improvements to Bio-safety management
- Improvements to Seed Industry

ALL LEAD TO BETTER VARIETIES IN THE HANDS OF FARMERS ➔ LOWER PESTICIDE USE，HIGHER YIELDS AND HIGHER INCOME GAIN…

Concluding remarks

- **China has gained significantly from commercialising Bt cotton through its direct impact on cotton sector and indirect impact on textile industry**
- **China could even gain much more from commercialising GM food crops (i.e. GM rice)**
- **Most of the gains from Chinese biotech are realised independently from foreign trade**
- **Gains would be higher with a more effect biosaftey system in place domestically**

  [internationally, China's biosaftey regulation is better]

Concluding remarks

- **Will China continue to promote biotech and commercialize its GM food?**
  - **Almost certainly.**

    Not spending $1 billion per year for nothing

    Also: large gains from agricultural biotech development?
    - **US$ 5 billion in 2010**

      (1 from bt cotton and 4 from GM rice)

    Plus health effects

    Effect of trade restrictions on GM products are small