Bt cotton for small farmers in China

EC Inco Dev FPV programme
ICA4-CT-2001-10069
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CHINA'S POSITION IN WORLD COTTON

Country	Cotton farmers (millions)	Cotton area (m ha)	Average cotton holding per farm (ha)	Lint yield (kg/ha)
China	**11.00**	**4.8**	**0.4**	**1,103**
India	4.00	8.7	2.2	350
Pakistan	1.50	3.1	2.1	593
West Asia	0.13	1.0	8.0	-
South East Asia	0.25	0.5	2.0	-
USA	0.03	5.6	187.0	790
Australia	0.001	0.4	330.0	1,658
World	**20.00**	**33.5**	**-**	**635**

ISAAA Briefs (2002)

Pests of cotton in China

Killed by Cry1Ac

- Bollworms
  - cotton bollworm
  - pink bollworm
  - spiny/spotted bollworms

Not affected

- Leafworms
- Aphids
- Jassids
- Mites
- Plant bugs

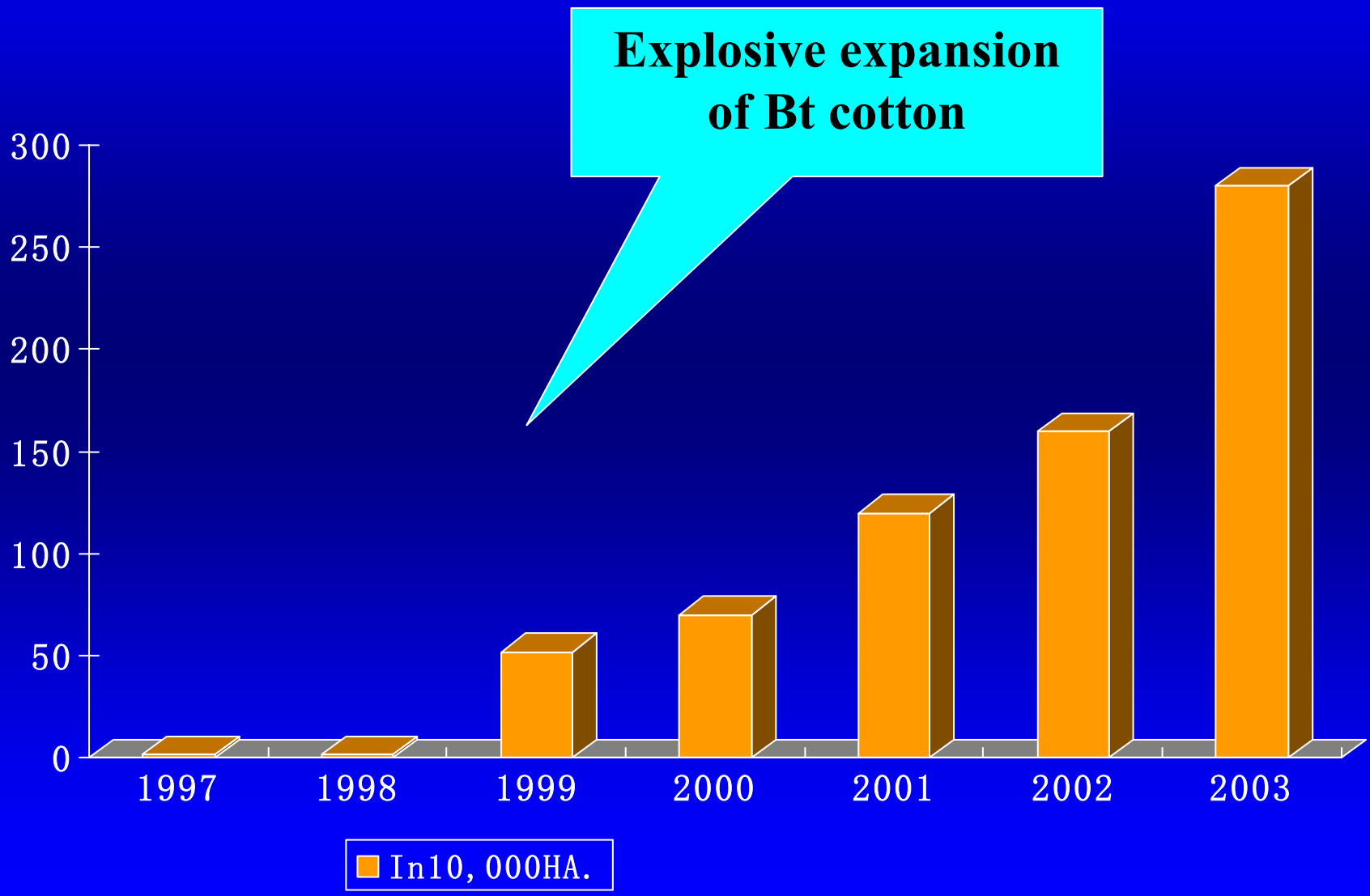
Points to cover

- How farmers use Bt cotton
- Impacts on:
  - Economics
  - Health
  - Target pests
  - Non-target organisms (lab and field)
- Farmer understanding of Bt cotton
- IPM in Bt cotton
- Evolved resistance to Bt cotton

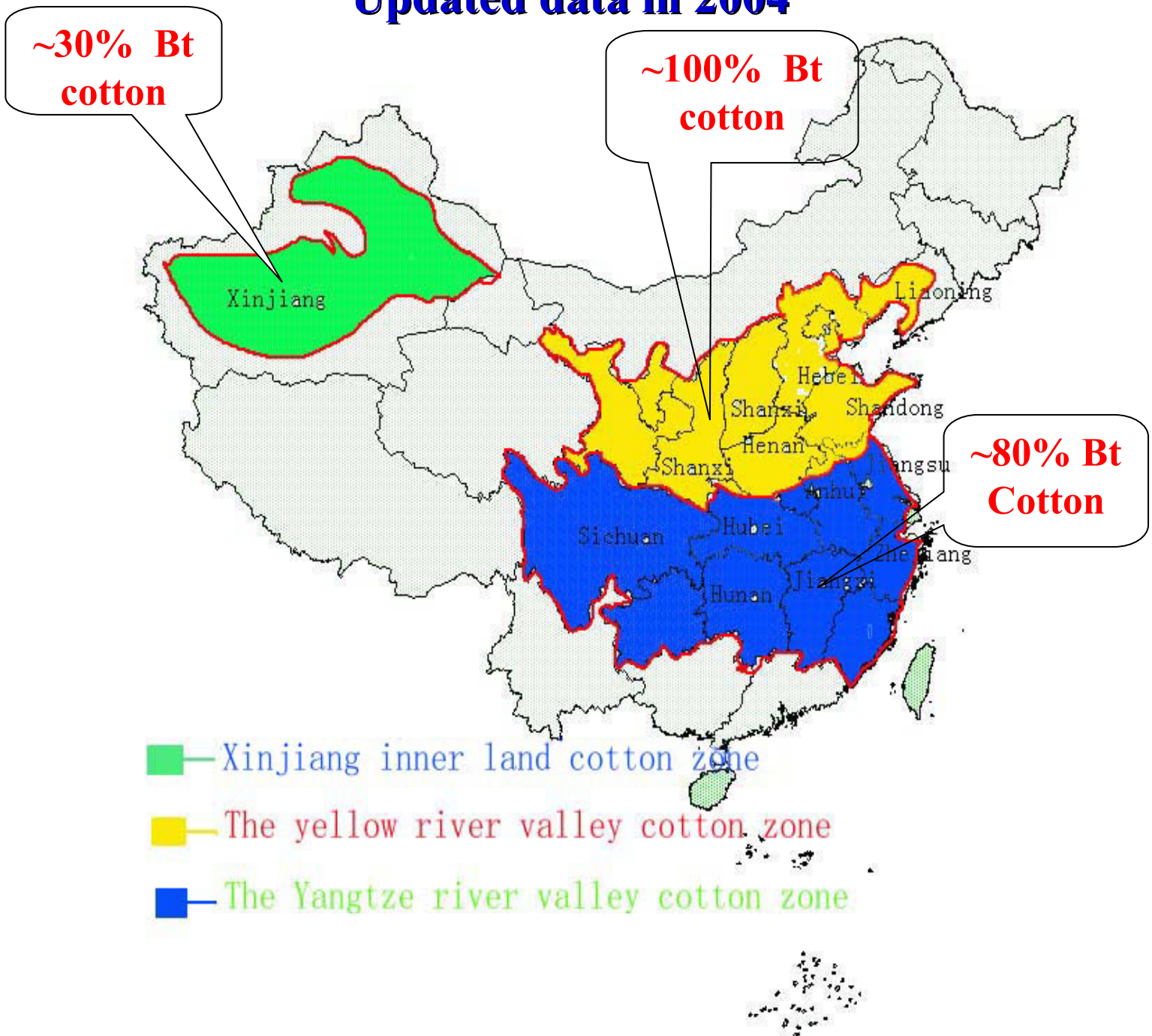
Bt Cotton in China

- Introduced 1994 – commercialised 1997
- 58 % of the national crop in 2004
- c. 5 million Bt farmers – by the far the majority of all the world's GM farmers
- North Eastern Provinces (Shandong, Hubei etc) - close to 100% Bt
- Western provinces (Xinjang) - substantial Bt plantings although bollworm pests are minor

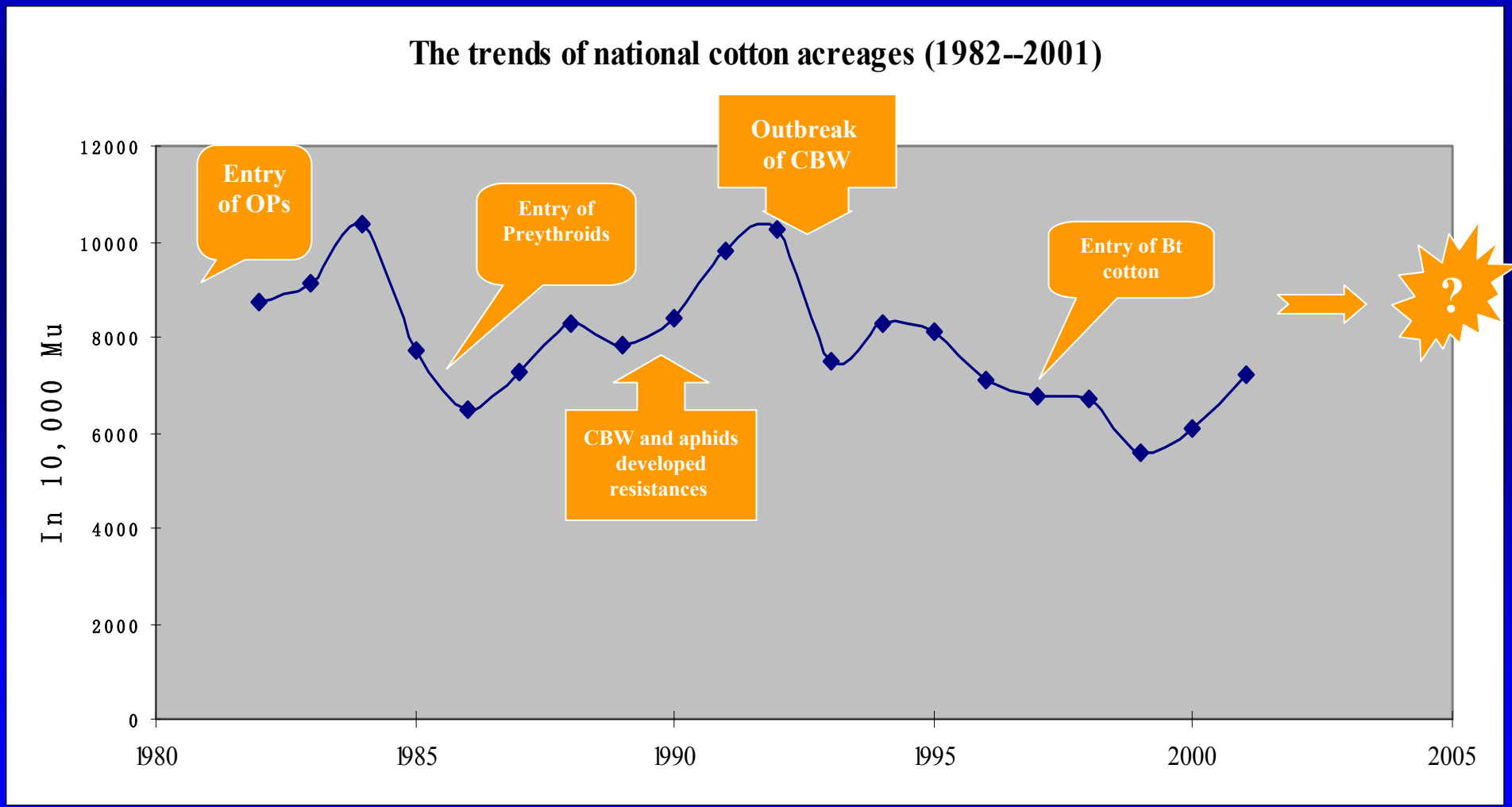
Bt Cotton in China



Updated data in 2004



China cotton production



Our information

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	DIAS (DK)	G.Lovei	
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Chinese Academy of Sciences	CAS	J. Huang	Shandong Hebei Henan Anhui Jiangsu
	Rutgers Univ (USA)	C.Pray, S.Rozelle	

** Plus other literature sources*

BT Cotton material

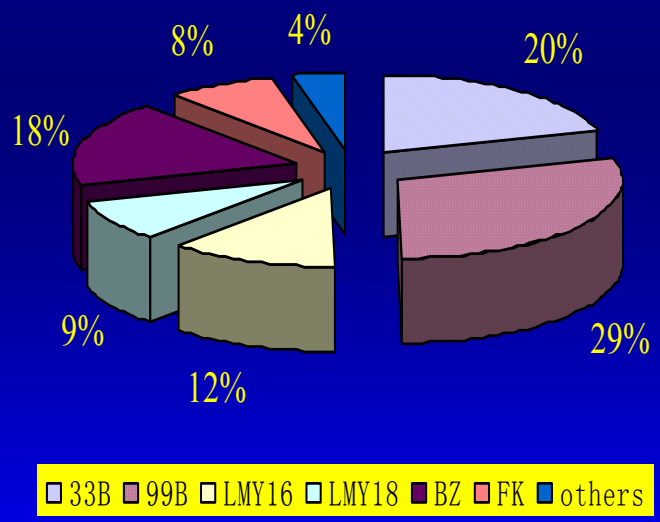
Monsanto *(Cry1Ac) 33B,99B*	▪ High input ▪ High yielding ▪ Expensive ▪ US Acala varieties ▪ not fully IPM compatible	50-70% of the eastern cotton market
Chinese Academy of Agricultural Sciences *(Cy1Ac and 1Ab and CpTPI) >10 varieties*	▪ Lower input ▪ Generally lower yielding ▪ Cheaper ▪ Locally adapted varieties ▪ more IPM compatible	30-50% of the market and growing

* *Unregistered Bt varieties of variable quality are also widespread*

Major commercialized Bt cotton varieties

- 33B, 32B, 99B Monsanto
- Zhongmian No. 29, 38 and 39--- Cotton research institute of Chinese Academy of Agricultural Science.
- GK-1, GK 12, SGK-2, SGK-12 --- Biotechnology Center of Chinese Academy of Agricultural Science.

The composations of different Bt cotton varieties in Lingqing county, Shandong provinces in 2002



Stacked gene Bt products in China

Cry1Ac/Cry2Ab cotton	▪Better bollworm mortality ▪Extends effectiveness to leafworms ▪Should delay resistance
Cry1Ac/ Cowpea trypsin inhibitor cotton	▪ Provides a moderate level of suppression of number of key pests ▪ Should delay resistance

Target – bollworms

Efficacy:

Spiny bollworms
(Earias sps) - Very effective

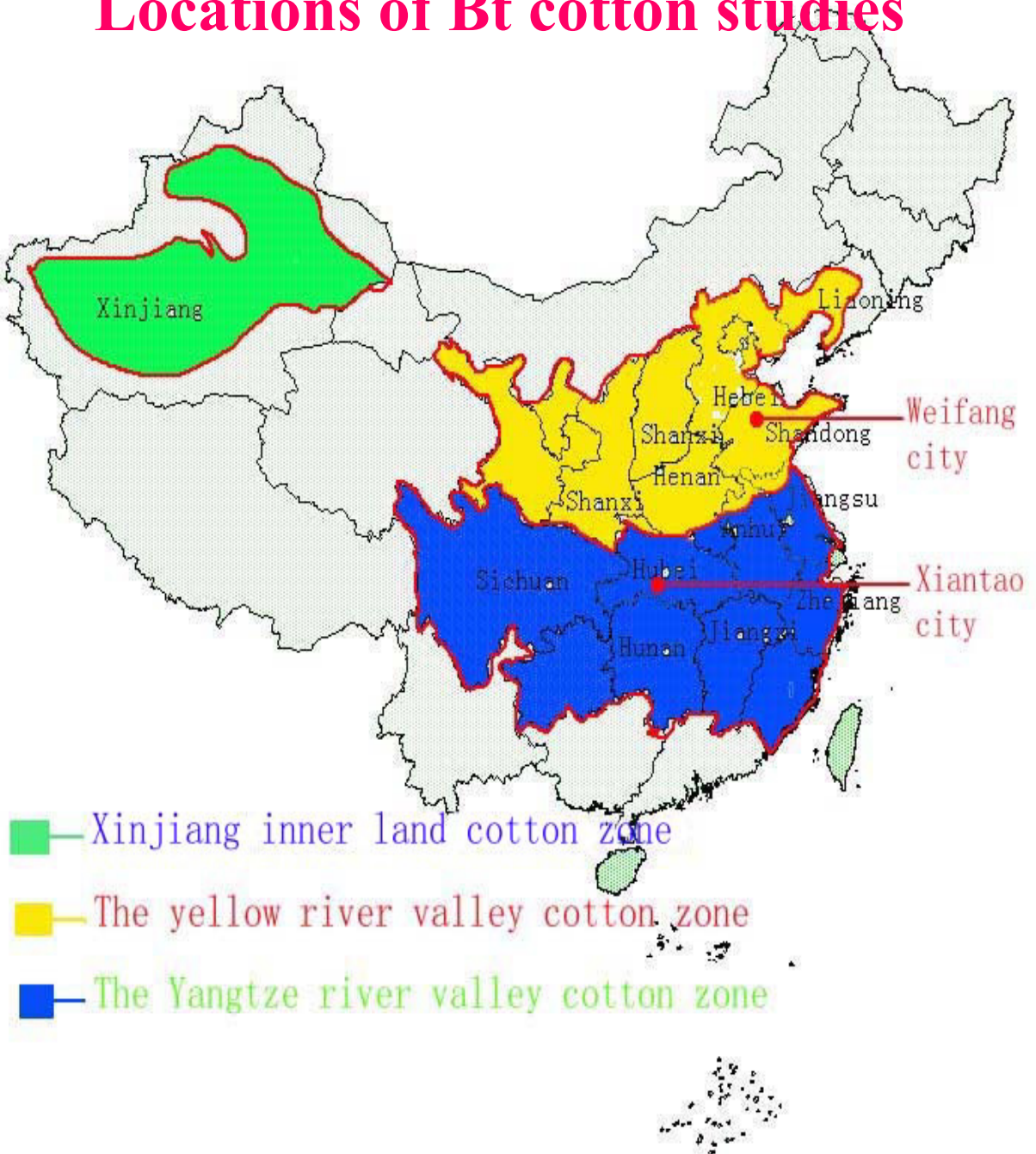
Pink Bollworm
(Pectinophora gossypiella) - Very effective

American bollworm
(Helivoverpa armigera) - Good mid-season
- Poor in late season
(reduction in bio-availability of toxin)

Insecticide use:

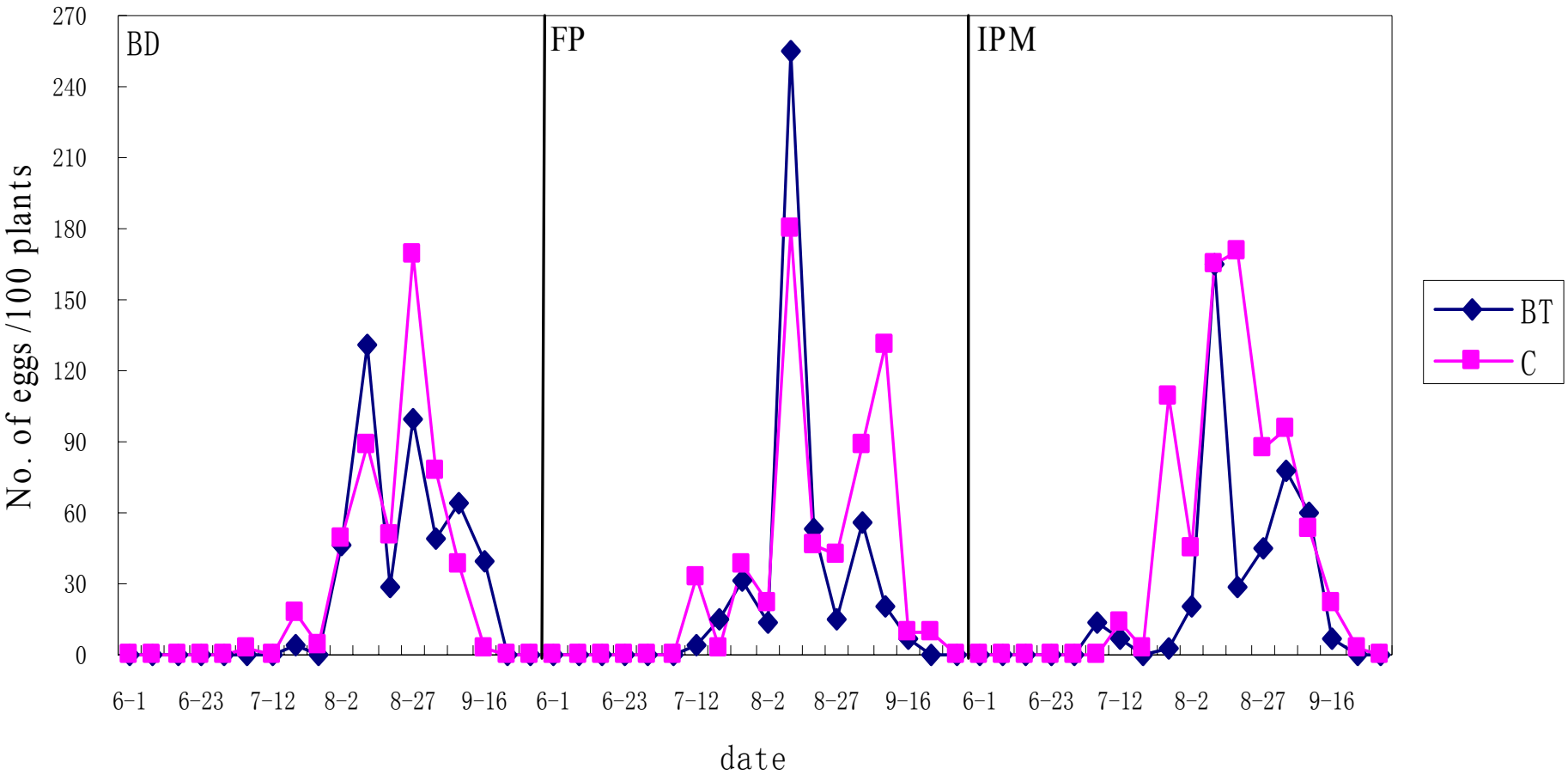
Average reduction c.60% in the number of applications

Locations of Bt cotton studies



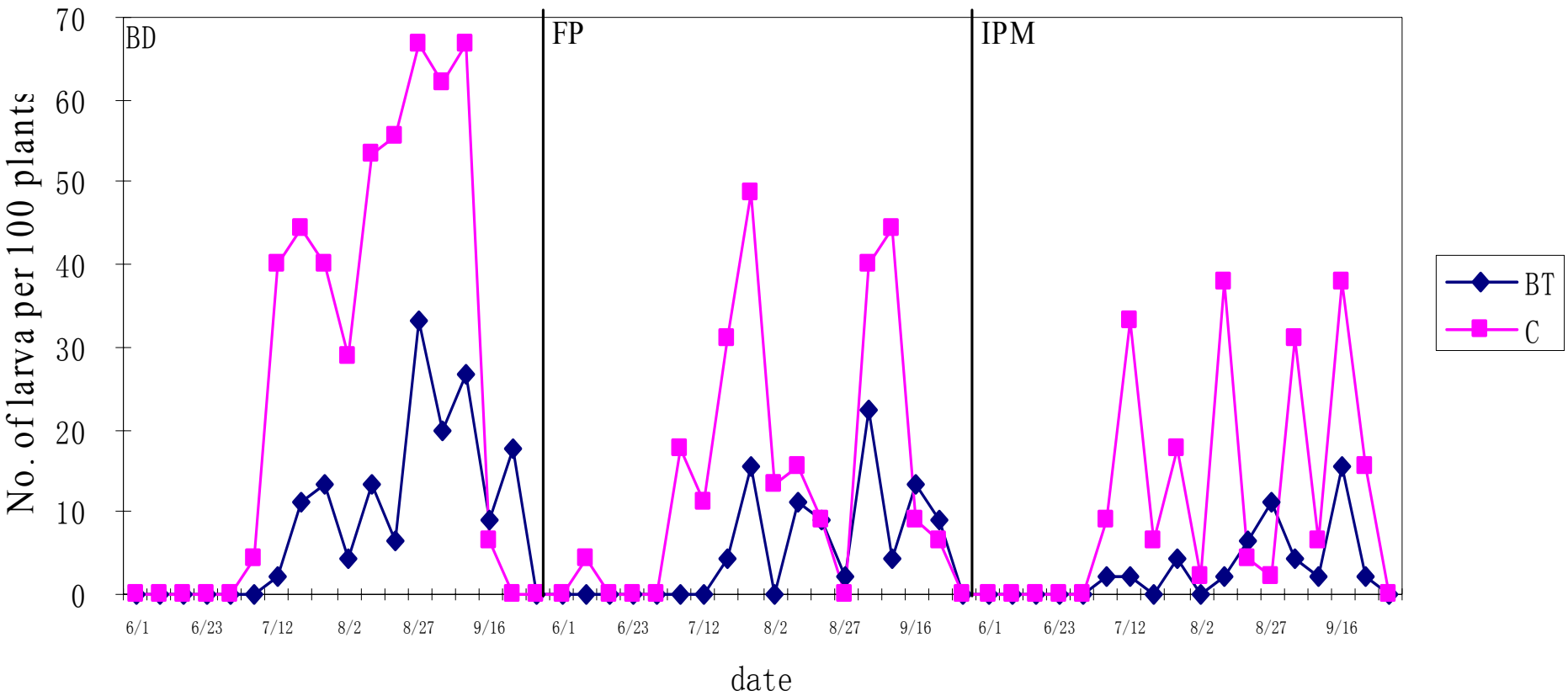
No significant difference in the oviposition of cotton bollworm

Figure 9 Population dynamics of cotton bollworm eggs in the study plots



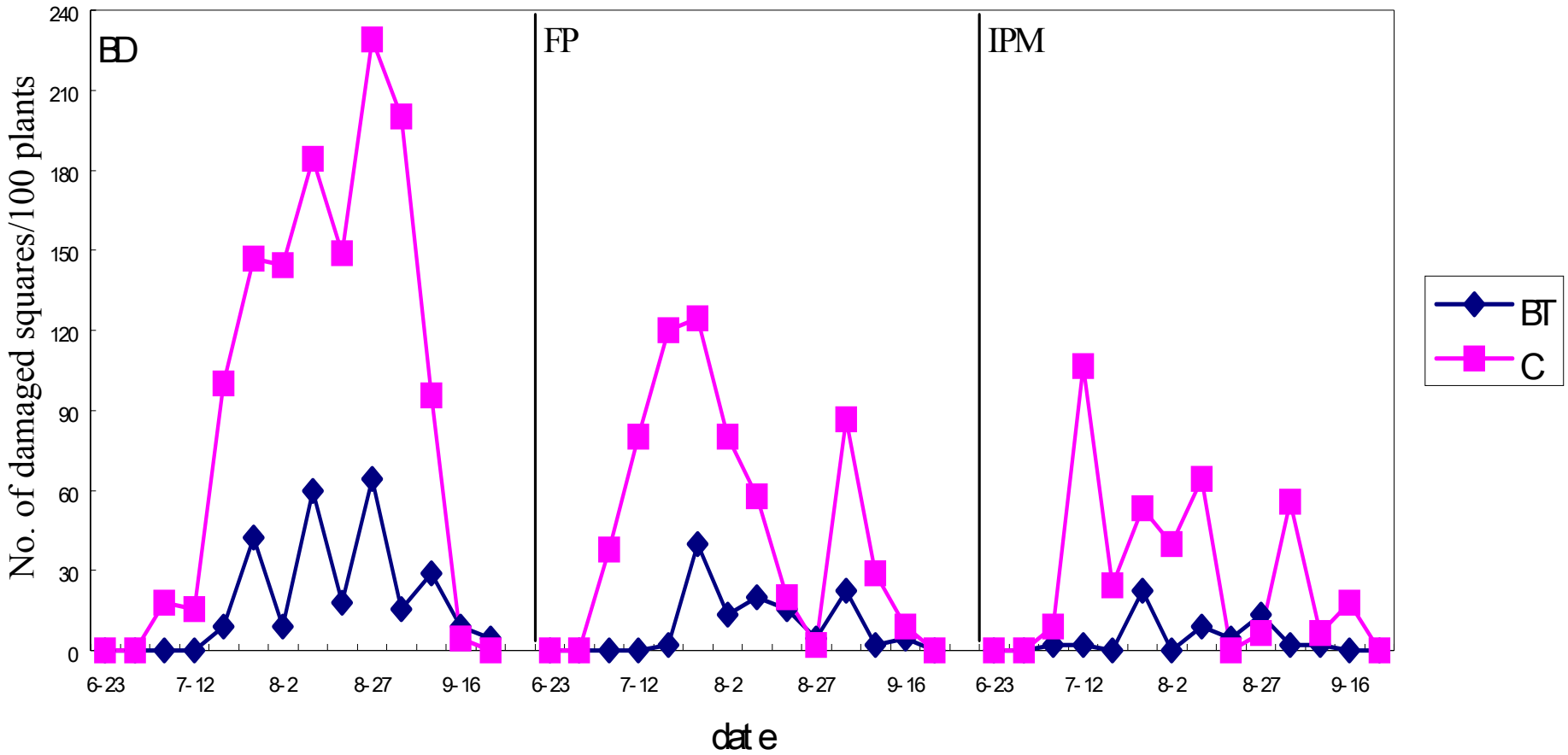
High resistance to cotton boll worm larvae

Figure 10 Population dynamics of cotton bollworm larva in the study plots



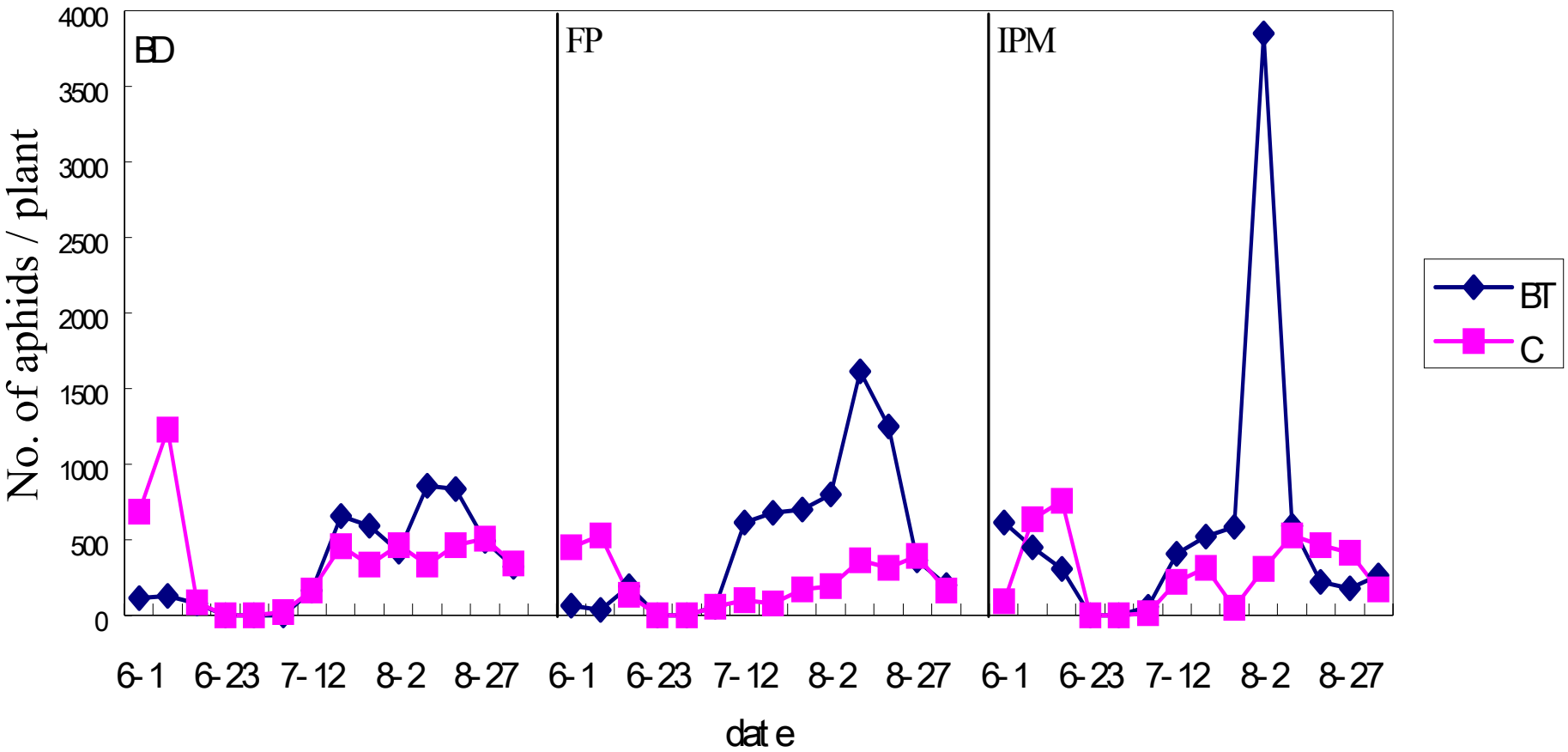
Low level of damaged Squares in the Bt cotton plots

Figure 7 The dynamics of damaged squares in the study plots



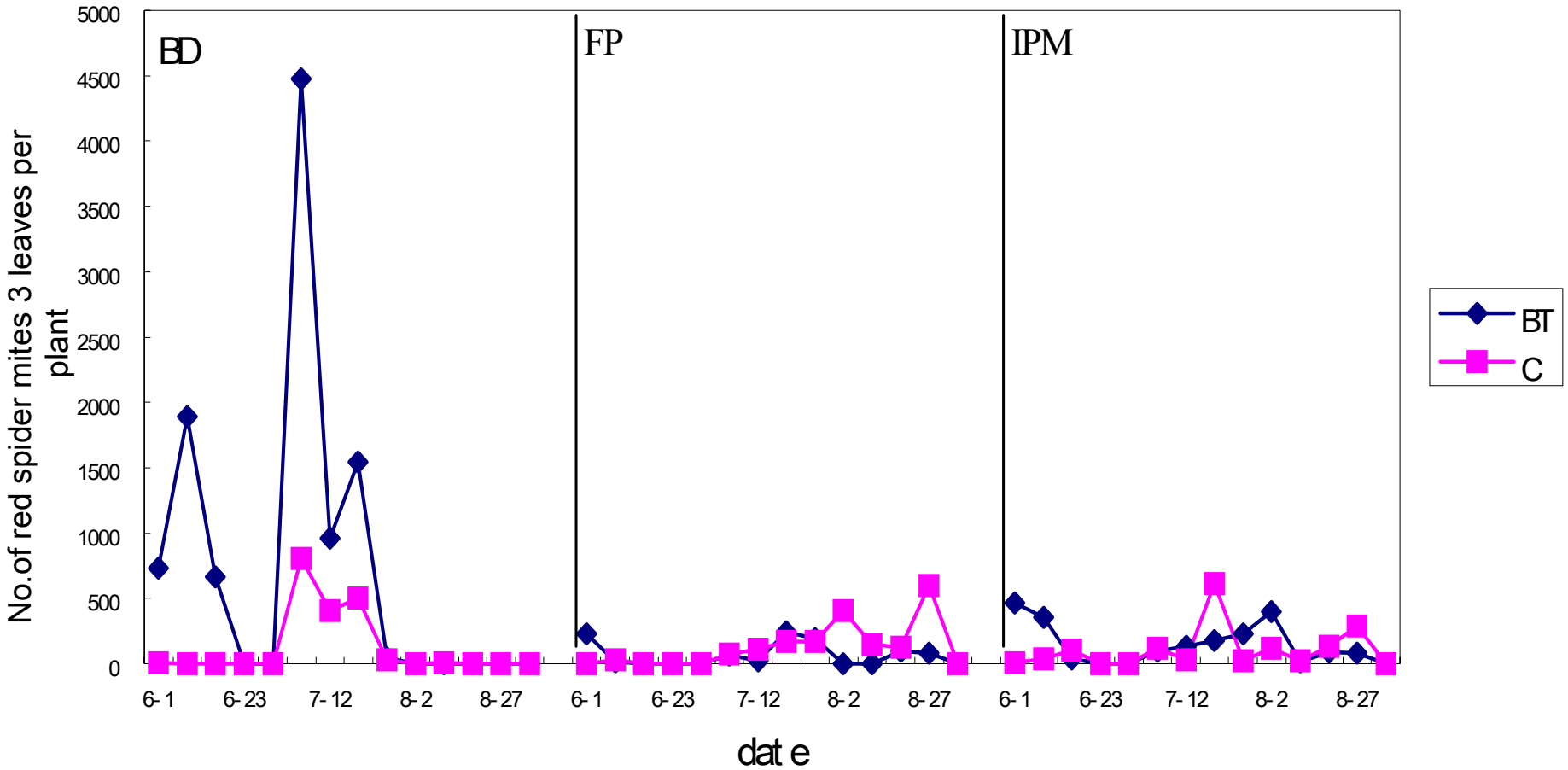
The resurgence of cotton aphids in Bt cotton after the application of pesticides

Figure 11 the Population dynamics of cotton aphids the study plots



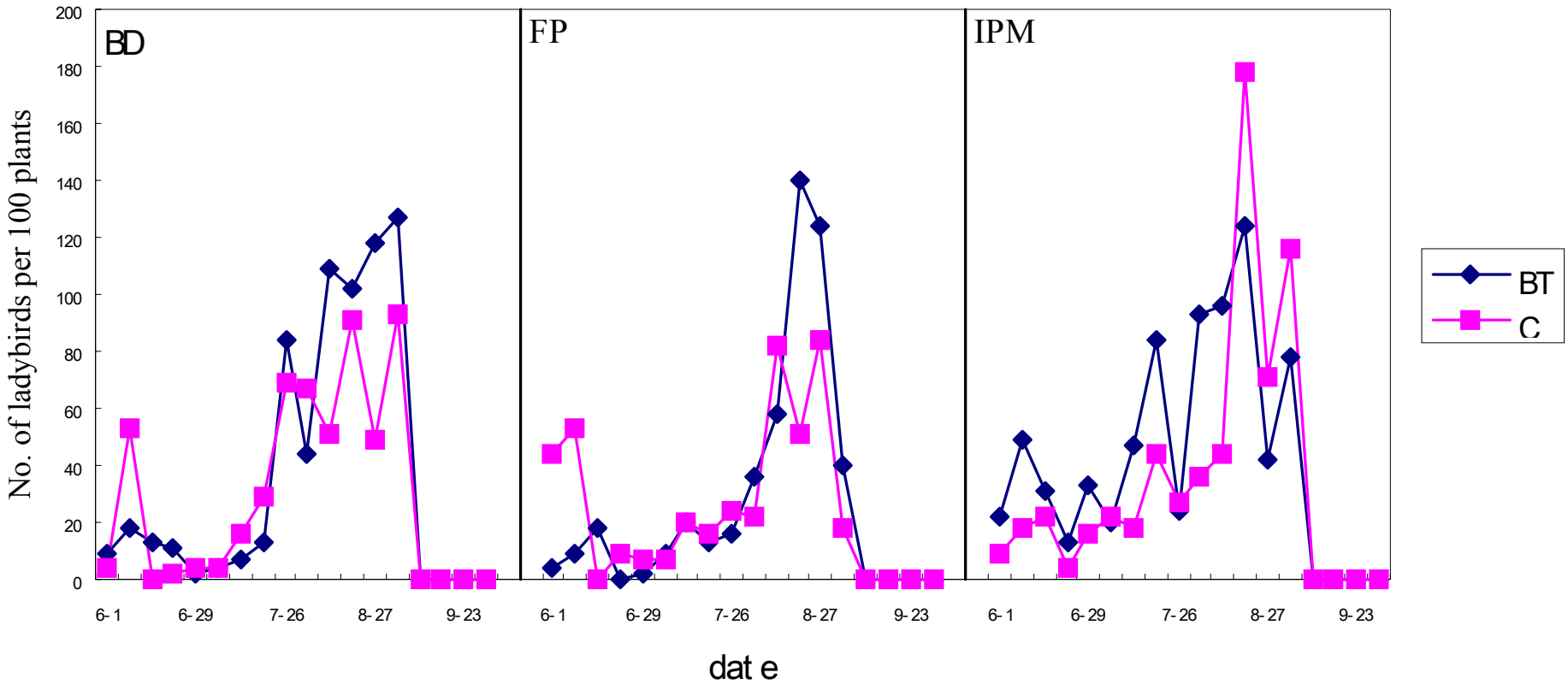
The resurgence of red spider mites in Bt cotton in BD plots

Figure 12 The population dynamics of the red spider mites in the study plots



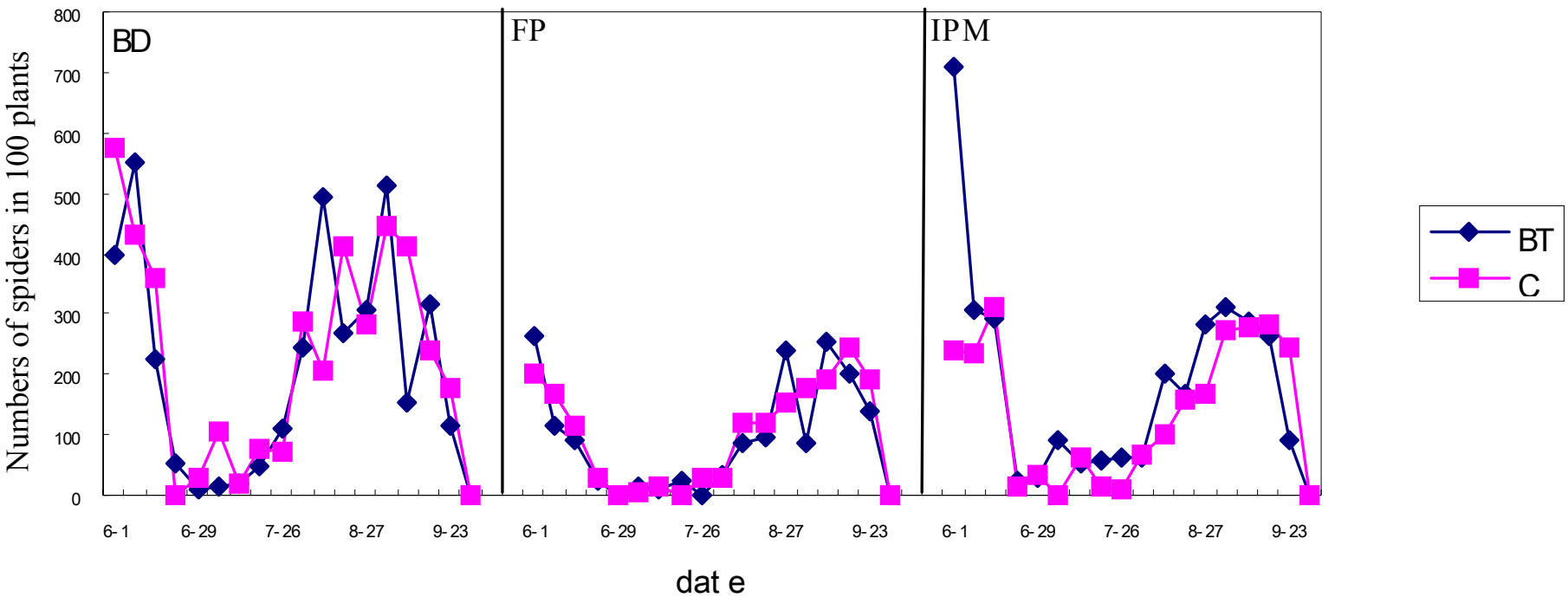
The abundance of ladybirds in the BD and IPM plots

Figure 15 The population dynamics of ladybirds in the study plots



The abundance of spiders in the BD and IPM plots

Figure 16 the population dynamics of spiders in the study plots



Non-target impacts (lab)

Using : *Bt* : NuCton 33B and GK12
Non-Bt : Si-main3 (parent of GK12)

Pests		
Leafworm	*Spodoptera litura*	Some growth reduction and mortality
Whitefly	*Bemisia tabacci*	No effect
Decomposers		
Springtail	*Sinella curviseta*	No effect

Non-target impacts (lab)

Using : *Bt* : NuCton 33B and GK12
Non-Bt : Si-main3 (parent of GK12)

Predators

Ladybeetles	*Propylaea japonica*	No effect
	Harmonia axyridis	Lighter when fed on affected pests
Lacewings	*Chrysopa sinica*	>mortality and development effects with 33B only.
	Chrysopa formosa	Smaller cocoon mass, longer pre-ovip. period, fewer eggs

Natural Enemy Complex ability to control aphids

Ladybird	*Coccinella septempunctata*	}	
Predatory bug	*Orius majusculus*	}	No effect
Parasitoid	*Aphidius colmani*	}	

Non-target impacts (field)

Using : Bt: 33B,99B,GK-12, GK12, SGK-321
Non-Bt: Si-main3, Si-yuan 321

Pests

Green leaf bug	*Lygus lucorum*	No effect
Whitefly	*Bemisia tabacci*	No effect

Decomposers

Springtails		More species and individuals but lower diversity index

Predators

Ladybeetles	*Propylaea japonica*	No effect
Predatory Bug	*Orius sauteri*	Some reduction in feeding in later nymphs
Spiders	*Many species*	Bt – 11 fams. 25 species Pesticide – 8 fams. 12 species IPM – 9 fams. 14 species

Bt seed cost in relation to other inputs

INPUT	Cost/ha	% total costs
Seed	$61	10%
Fertiliser	$271	43%
Pesticide	$112	18%
Labour	$186	29%

* Land rent 363 $US/ha

National Average Results *

*ICAC 2004

	Bt cotton	Non-Bt cotton	% difference	References
No of sprays	8.1 6.6	19.8 19.8	-59% -56%	Pray et al 2002 Huang et al 2003
Insecticide Kg/ha	21.7 12.1 18	65.5 60.7 46	-70% -80% -61%	Pray et al 2002 Huang et al 2003 Lu et al 2002
Yields Kh/ha	3,246 3,290	2,741 3,186	+19 +3	Pray et al 2002 Lu et al 2002

Economics of Bt cotton
(Shandong 2002-3)

Yield	4,109 Kg/ha (seed cotton)
Net profit from cotton*	1,024 US$/ha
Increase in net profit over non-Bt	c.47%
Total farm income - all sources (avg.0.25ha cotton)	c.1,000 $US
Increase in total farm income	c.12%

** No price difference for Bt cotton*

Health implications of Bt use

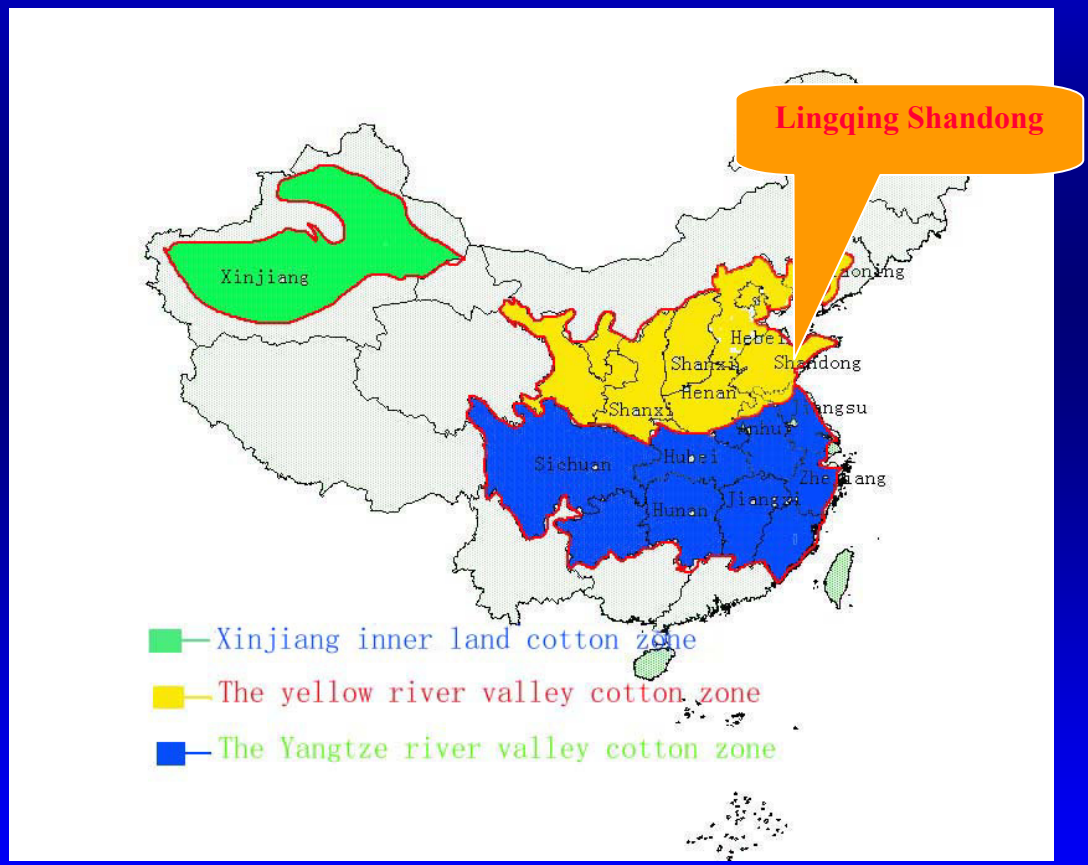
- **The problem**
  - 600,000 cases of pesticide poisoning in 1995 (1% died)
  - Farmers reporting health problems *(Huang et al 2001)*
    - Non-Bt farmers 22% (small sample)
    - 5% of Bt farmers (large sample)

- **Reduction in toxic material applied**

  (*Huang et al 2001)*
  - Pyrethroids 95%
  - Organochlorines 88%
  - Organophosphates 82%

  (Yang et al 2003)
  - 60% reduction in all insecticides
  - 80% reduction in bollworm sprays

Farmers' perceptions and practices on Bt cotton



Study location

Lingqing county, Shandong province

Sample

92 Bt cotton farmer households in three villages

Study period

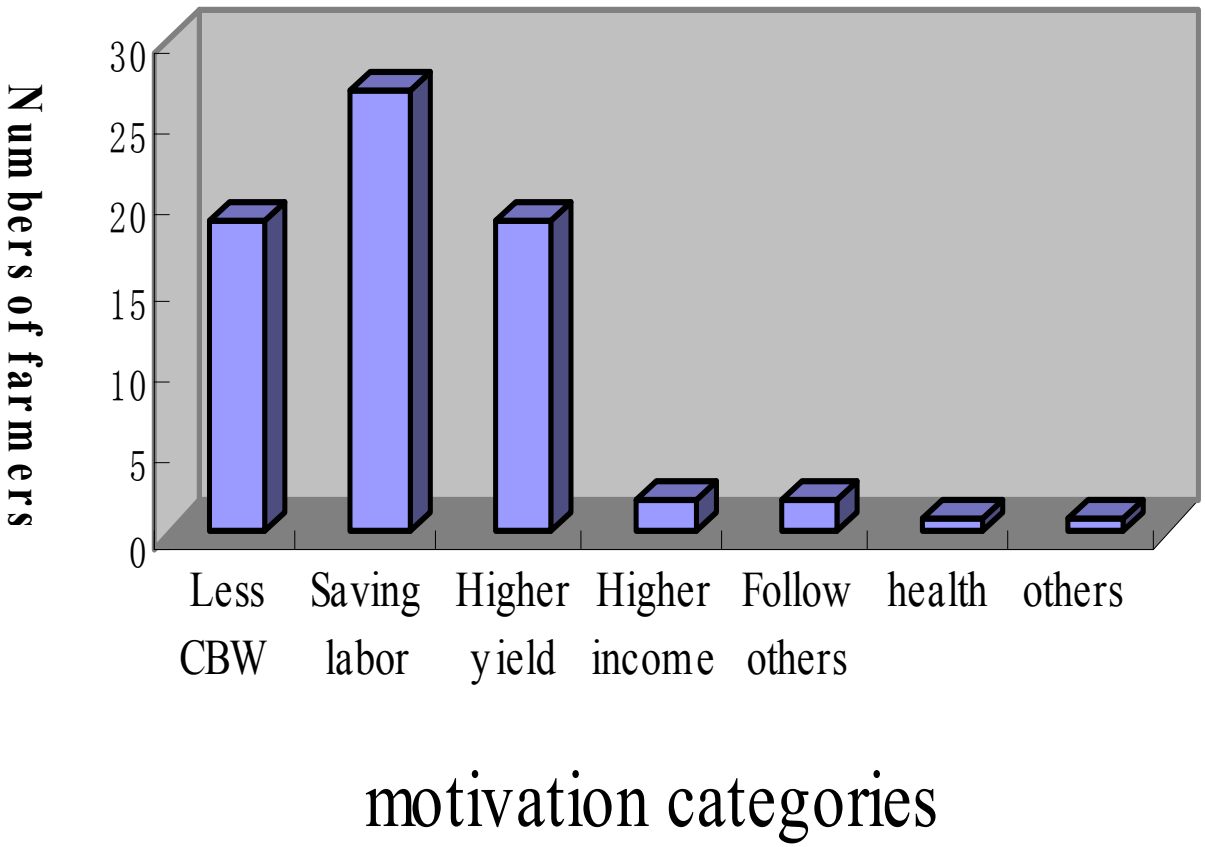
From April 2001 to Dec 2002 Season-long survey in 2002.

Farmer use of Bt cotton

- Bt seed cost 50-60% more than non-Bt cotton *(c.$US21/ha increase)*
- <50% of Bt cotton area is farmer-saved seed *(29% in Shandong)*
- Large amount of unauthorised movement of germplasm
- Bt cotton is varietal *(not hybrid as in India)*
- 17% of the Bt area intercropped with vegetables, maize, peanuts or watermelon

Farmers' motivation for adoption of Bt cotton

(Total sample of 92 farmer households in Lingqing, Shandong, 2002)



The proportions of inputs in Bt cotton plots

(Xiantao city, Hubei 2001)

Figure 18 the components of Inputs in Bt- FP plots

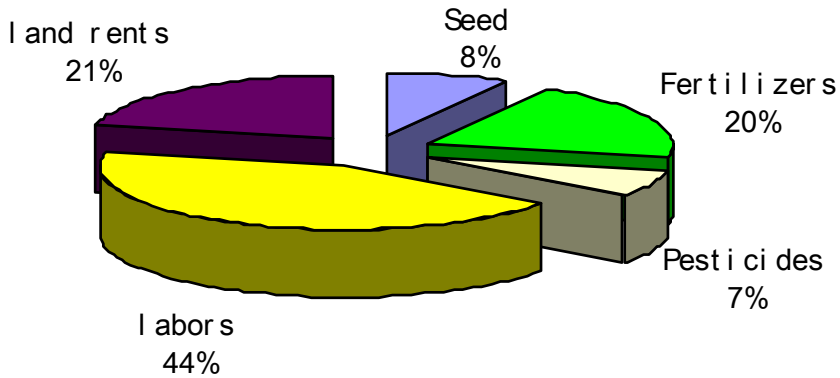
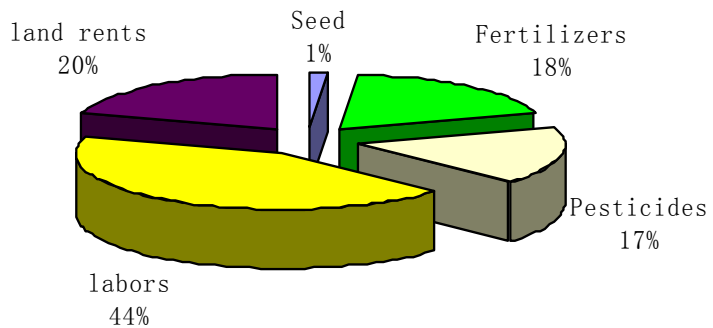


Figure 19 the components of inputs in The C-FP plots



Farmer* understanding of the Bt cotton system

Why grow it?	▪ Saves labour - 95% ▪ Requires less spraying - 91% ▪ Higher yields - 88% ▪ More profitable – 85%
Is it safe?	▪ Safe to eat – 75% ▪ Safe in blankets – 72%
Is bollworm still a problem?	▪ It is – 65%
Identification of natural enemies?	▪ Ladybirds – 50% ▪ Lacewings – 17% ▪ Spiders – 12%
Indentification of mites and diseases?	▪ Not at all

** No differences with gender or educational level*

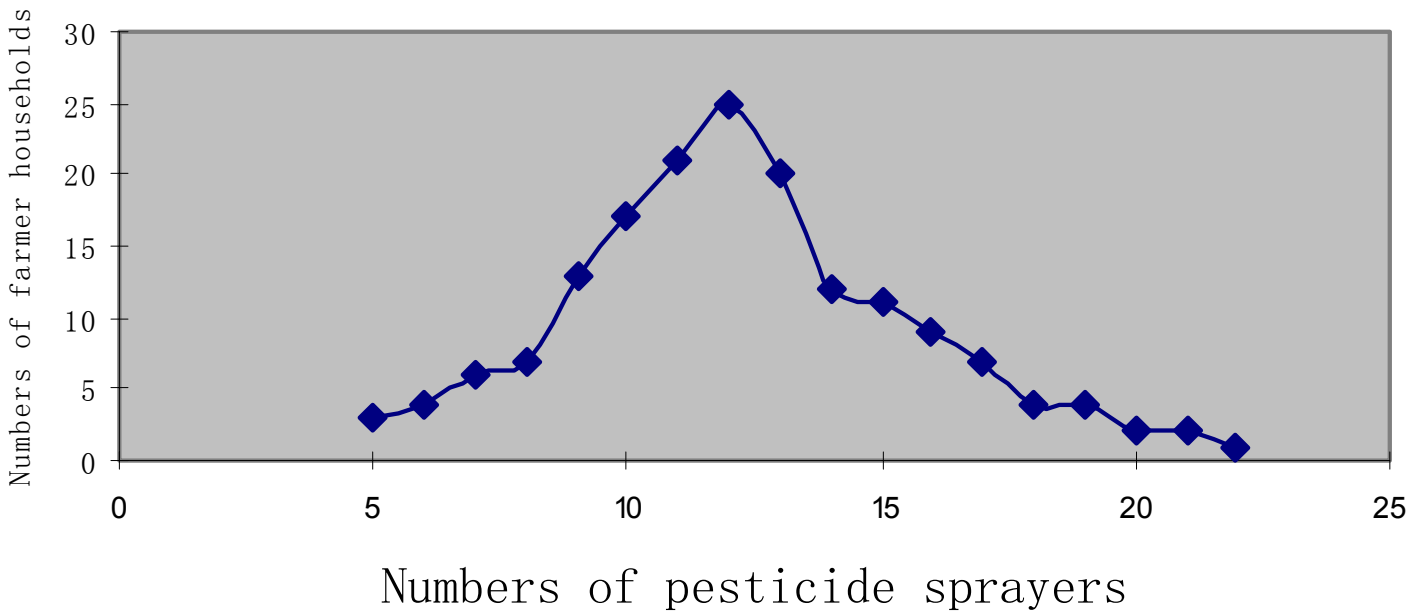
Insecticide Spraying on Bt cotton

Farmers sprayed 12.7 times on average

(national average 8.1 v.19.8 on non-Bt cotton)

Pesticide costs in Bt cotton - 111.8 US$/hectare on average

The distribution spraying frequencies of 92 sample farmers in Bt cotton
(Lingqing, Shandong 2002)



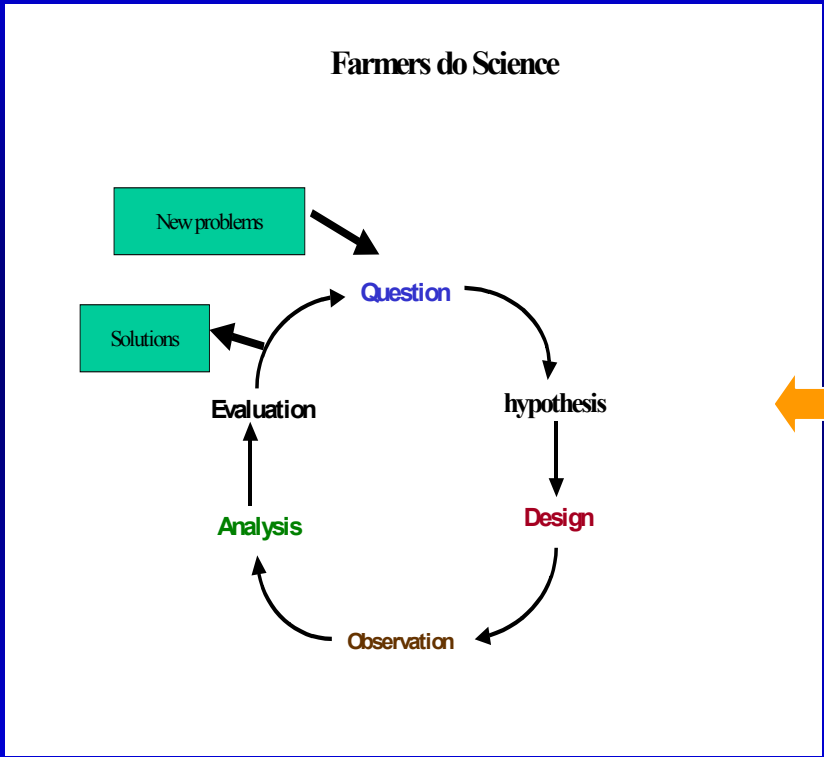
Improving IPM integration of Bt cotton

FAO Farmer Field School on Cotton IPM in Asia (2002-6 $12 mill)

China, India, Pakistan, Vietnam, Philippenes, Bangladesh

- Working in China on enhancing farmer benefit from Bt

Principles of farmer participatory Bt cotton study in the program



- Help farmers to be critical and creative in solving their problems
- Research process follows the learning cycle and the discovery approach
- Lead to new question and new discovery by farmers
- Results in farmer's success and accomplishment

Farmer participatory studies in six FSS in 2003

Study	Findings
• Efficacy testing	• Effective in bollworm generations 2 and 3 but not 4.
• Parasites of cotton aphids	• Survived better and had more impact in Bt cotton
• Foliar predators	• Ladybeetles were more numerous and effective in Bt cotton
• Ground predators	• Predatory beetles more numerous and effective in Bt cotton

Benefits of cotton FFS
(data from FFS report 2003)

FFS in Conventional cotton	
Net profit	1,150 US$/ha
Increase in net profit over non-FFS	220%
FFS in Bt cotton	
Net Profit	c.1,600 $US/ha
Increase in net profit over non-Bt/non-FFS	307%
Increase in net profit over FFS in conventional cotton	140%

Conclusion: **Benefits of Bt and FFS are additive**

Conclusions

- Biological impacts

- Effective for bollworm control except in the late season
- Non-target pests are only marginally affected
- Impact on beneficial complex is minor

But

- More work required on soil faunal diversity
- Some evidence of secondary pests increasing in importance
- Bollworm resistance is a real threat. Dual gene deployment may delay this.

- Farmer suitability

- Saves labour
- Significantly increases profit
- Benefit is further increased if combined with IPM
- Health impact considerable (but not well measured to date)

But

- Farmer understanding is poor
- Spraying still too high
- This is a continuing need for IPM training

Thank you for your attention

Acknowledgements:

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Funding: EU Framework V – Inco Dev 'COTRAN'