

# Cotton Bollworm *Helicoverpa armigera* on cotton in Asia

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# THE REGION'S POSITION IN WORLD COTTON

Country	Cotton farmers (millions)	Cotton area (m ha)	Average cotton holding per farm (ha)	Lint yield (kg/ha)
<b>China</b>	<b>11.00</b>	<b>4.8</b>	<b>0.4</b>	<b>1,103</b>
<b>India</b>	<b>4.00</b>	<b>8.7</b>	<b>2.2</b>	<b>350</b>
<b>Pakistan</b>	<b>1.50</b>	<b>3.1</b>	<b>2.1</b>	<b>593</b>
<b>Region</b>	<b>16.5</b>	<b>16.6</b>	<b>1.0</b>	<b>613</b>
% of World	82.5%	49.5%	59%	97%
<b>World</b>	<b>20.00</b>	<b>33.5</b>	<b>1.7</b>	<b>635</b>

Modified from ISAAA Briefs (2002)

# RANGE OF ACTUAL AND POTENTIAL LOSSES FROM COTTON INSECT PESTS FOR DIFFERENT GLOBAL REGIONS

Region	Actual Losses % (With Control)	Potential Loss % (Without Control)
<b>AFRICA</b>		
Eastern	24	35
Western	23	34
Southern	21	37
North	9	41
<b>ASIA</b>		
Eastern	18	33
Western	17	36
Southern	9	37
North	9	38
<b>AMERICA</b>		
Eastern	13	39
Western	13	39
Southern	11	38
North	7	37
<b>EUROPE</b>	9	35

# COUNTRIES HAVING MORE THAN 70% OF THE COTTON AREA INFESTED BY LEPIDOPTERON PESTS

ASIA		OTHERS	
Countries	Area (m ha)	Countries	Area (m ha)
<b>India</b>	<b>8.70</b>	Australia	0.40
<b>China</b>	<b>4.80</b>	Egypt	0.30
<b>Pakistan</b>	<b>3.10</b>	Spain	0.09
Myanmar	0.30	Argentina	0.20
Thailand	0.05	Paraguay	0.50
Vietnam	0.03	Peru	0.10
Indonesia	0.02	Mexico	0.08
Bangladesh	0.02	Colombia	0.04
Philippines	0.003	Bolivia	0.01
		Ecuador	0.005

38% countries (n=50) fall in HIGH RISK category of pest attack

# VALUE OF GLOBAL COTTON INSECTICIDE AT FARMER LEVEL

Region	\$ Millions
Asia	811
USA	340
Africa	194
Australia	57
Europe	5
Global Total	1,719

# Pests of cotton in the Asian Region

## ■ Bollworms

- cotton bollworm
- pink bollworm
- spiny/spotted bollworms

## ■ Leafworms

## ■ Aphids

## ■ Jassids

## ■ Mites

## ■ Plant bugs



# Cotton bollworm (*Helicoverpa armigera*)



# Pink bollworm (*Pectinophora gossypiella*)



# Spiny bollworm (*Earias insulana*)



# Cotton leafworm (*Spodoptera litura*)



# Whitefly (*Bemisia tabaci*)



# Host Range of Pests of Cotton

- Pest restricted to *Gossypium* and its immediate relatives
  - *Anthonomous grandis*
- Pest associated chiefly with Malvales (*Bombacae*, *Malvaceae*, *Sterculaceae*, *Tiliaceae*)
  - *Pectinophora gossypiella*
  - *Earias* spp.
  - *Dysdercus* spp.
- Polyphagous pests
  - *Helicoverpa*, *Heliothis*, *Spodoptera*, jassid, aphid, whiteflies, leaf eating larvae, armyworms and cutworms

# COTTON BOLLWORMS AS PESTS IN COUNTRIES

Species	No. of countries
<i>Pectinophora gossypiella</i>	26
<i>Earias</i> spp.	19
<i>Heliothis/Helicoverpa</i>	24
<i>Spodoptera</i>	6

# HELIOTHINE SPECIES OF MAJOR AGRICULTURAL IMPORTANCE

Species	Distribution	Principal crop hosts
<i>Helicoverpa armigera</i>	Africa, the Middle East, Southern Europe, India, central and south western Asia, Eastern and northern Australia, New Zealand and many eastern Pacific Islands	Cotton, maize, sorghum, sunflower, tobacco, soybean, pulses, safflower, tomato, rapeseed, groundnut etc.
<i>H. zea</i>	North and south America	Maize, sorghum cotton, tomato, sunflower, soybean
<i>H. punctigera</i>	Australia	Cotton, sunflower, lucerne, soybean, chickpea, safflower
<i>Heliothis virescens</i>	North and South America	Tobacco, cotton, tomato, sunflower, soybean

# DISTRIBUTION OF HELIOTHINE SPECIES IN ASIA

Species	Host range of crop
<i>Helicoverpa armigera</i> <i>H. assulta</i> * <i>Heliothis peltigera</i> *	Food , fibre, oil, fodder, horticultural and ornamental crops

\* Restricted distribution and host range

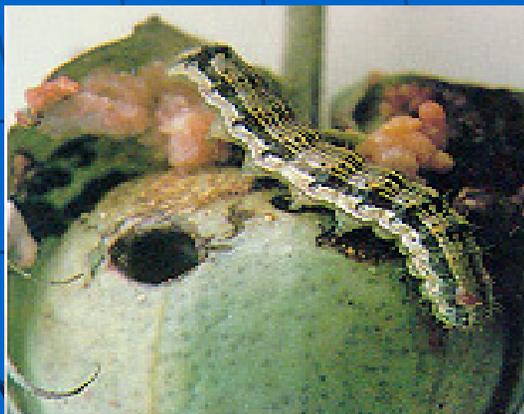
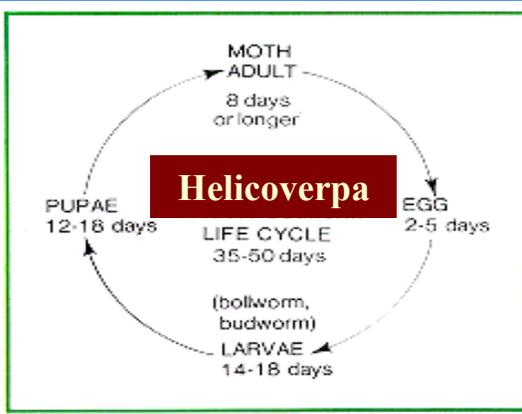
# ECONOMIC LOSSES CAUSED BY HELIOTHINE SPECIES

- Direct yield reduction
- Indirect cost of chemicals, application, scouting

<b>Country</b>	<b>Pest/pest complex</b>	<b>Crop (s)</b>	<b>Monetary losses</b>
<b>USA</b>	<i>Helicoverpa zea</i> <i>Heliothis virescens</i>	All crops	\$ 1 billion
<b>India</b>	<i>Helicoverpa armigera</i>	Legumes	\$ 300 million
<b>Australia</b>	<i>Helicoverpa armigera</i> <i>Helicoverpa punctigera</i>	All crops	\$ 80 million







# BIOLOGY OF *HELCOVERPA ARMIGERA*

Parameter	Population	
	Non-diapausing	Diapausing
Duration (days)		
Egg stage	4-13	3-9
Larval stage	13-23	11-27
Pupal stage	8-23	8-140
Generation	29-97	26-168
Number of generations	8	7

# ECOLOGY OF *HELICOVERPA ARMIGERA*

- Active throughout the year
- 7-11 generations in a year
- Facultative diapause in pupal stage during winter
- Females highly fecund (200- 2,800/ eggs Female)
- Moths efficient fliers
- Polyphagy
- Detoxifying pathways esp.from third instar

# Human factors responsible for the increase in importance of *H.armigera*

- ❖ Introduction of new crops
- ❖ Change in crop varieties
- ❖ Increased cropping intensity
- ❖ Higher use of irrigation and nitrogenous fertilizers
- ❖ Faulty cultural practices
- ❖ Reduced levels of natural control
- ❖ Resistance/ resurgence induced by excessive use of pesticides

# ECOLOGICAL FACTORS EFFECTING *HELICOVERPA* NUMBERS

Factor	Effect
• < 30% RH x reduced soil moisture x 35-40°C during summer	Reduced build up
• < 6% RH	Decreased oviposition
• 27-31°C and >65% RH and suitable host	Favoured development
• Deep ploughing after harvest (during day)	Pupal survival reduced to 12.5%
• Pupal submersion in water for 24 hours	60 % Pupal mortality
• One hour pupal exposure to sun light	100 % pupal mortality
• Reduced soil moisture	Increased pupal mortality
• Increased air and soil temperature in • Early spring	Early build up
• Wet months (May-July)	Early build up on cotton

# STRATEGIES TO COPE WITH SEASONALITY OF HABITATS

- Facultative migration (local and inter-regional)

*H. punctigera* > *H. zea* > *H. virescens* > *H. armigera*

- Facultative diapause in winter or summer
- Diapause may be broken by a cool shock when rains come

# EXPLOITATION OF AGROECOSYSTEM BY *HELIOTHINE* SPECIES

- Population more abundant in diverse cropping system
- High mobility allows rapid colonization of suitable habitats
- Diversification of summer cropping and extension of irrigation greatly favours *Helicoverpa*.
- Uncultivated hosts are helpful in maintaining population or in the initial build up

# HOST PREFERENCE BY *HELIOTHINE* SPECIES

- All species are polyphagous
- Preference depends heavily on availability of hosts
- All species readily attack legumes
- *Helicoverpa zea*, *H. armigera*, prefer maize and grain sorghum over most other crops
- Gramineaceous hosts are not attacked by *Heliothis virescens*
- *H. punctigera* restricted only to dicotyledonous hosts
- Cotton crop is not preferred host of any species.
- Cotton is heavily attacked only after alternate hosts have senesced.

## RESISTANCE HOST PLANTS TRAITS IN COTTON

Trait	Pink bollworm	Bollworms and budworms
Nectriless	R (?)	R (?)
Glabrous	R	R
Okra leaf type	R (?)	N
Reduced bract size	R	-
Red plant colour	-	R
Gossypol	R	R
Tannins	-	R
Helicoides	-	R
Early crop maturity	E	E
Reduced branching	-	R
Pollen colour (yellow/orange)	-	R
Other allelochemicals	-	R

R=Resistant, E=Escape, N=No effect, (?) not verified

Source: Gannaway, 1994

# MORTALITY OF *HELICOVERPA ARMIGERA* ON YOUNG LEAVES OF DIFFERENT COTTON VARIETIES / MATERIAL

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Variety	Neonate mortality (%)
American cotton ( <i>G.hirsutum</i> )	
LH 372	0
LH 900	40
F 286	20
F 414	0
F 505	40
Ganga Nagar Ageti	40
Jhurar	0
Desi cotton ( <i>G.arboreum</i> )	
G 27	80

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# COMPARATIVE BIOLOGY OF *HELICOVERPA* ON DIFFERENT CULTIVARS OF COTTON

Variety/ material	Different stages (x ± Days)	
	Larva	Pupa
<i>G.hirsutum</i>		
F 286	15.5 ± 0.13	9.0 ± 0.20
LH 886	15.8 ± 0.25	8.7 ± 0.36
F 505	16.0 ± 0.26	10.7 ± 0.26
<i>Ganga Nagar Ageti</i>	15.2 ± 0.33	8.8 ± 0.18
<i>Jhurar</i>	12.7 ± 0.20	8.2 ± 0.13
<i>G.Arboreum</i>		
LD 327	19.4 ± 0.19	11.6 ± 0.15

# NEONATE MORTALITY OF HELICOVERPA ON DIFFERENT GENOTYPES OF EGYPTIAN CLOVER

Genotype	% mortality	
	Leaf	Flower
BL 1	0	10
BL 2	0	20
BL 10	40	40
BL 22	10	30
BL 37	20	60
BL 38	0	40
BL 60	20	40
V60	0	50
S-99-1	0	10
Mescavi	0	40

# CULTURAL CONTROL

- Cropping systems/patterns
- Manipulation of crop planting dates
- Deep ploughing after harvest
- Judicious use of fertilizers
- Limiting the number of cotton varieties/materials

# COMPARATIVE INCIDENCE OF *HELICOVERPA ARMIGERA* ON LATE AND TIMELY SOWN COTTON

District	Parameter	Normal sown	Late sown	% Increase(+)/ decrease(-) over normal sowing
Mansa	Egg/ plant	4.1	5.9	+ 43.9
	Larvae/ plant	1.4	1.6	+ 14.3
	Fruiting body attack	7.2	11.9	+ 65.3
	Boll/ plant	19.3	5.9	- 13.4
Bathinda	Eggs / plant	1.1	2.6	+ 136.4
	Larvae/ plant	0.3	0.6	+ 100.0
	Fruiting bodies attack	8.6	30.8	+ 258.1

Observations on August 18-19, 2001

No. of locations: Mansa 34 in normal sown, and 42 in late sown

Bathinda 26 in normal sown, and 11 in late sown

# COMPARISON OF *HELICOVERPA ARMIGERA* WITH OTHER COTTON BOLLWORMS

<b>Parameter</b>	<b><i>H.Armigera</i></b>	<b><i>Earias</i></b>	<b><i>P.gossyp.</i></b>
Occurrence in space and time	<b>Regular</b>	Sporadic, Irregular	Seasonal
Feeding niches/ host range	<b>Polyphagy</b>	Oligophagy	Monophagy
Mobility of the adult	<b>V. High</b>	Low	Poor
Rate of increase	<b>V. High</b>	High	Low
Damage potential	<b>V. High</b>	High	Low
Choice of effective insecticides	<b>V. Limited</b>	Limited	Wide
Effectiveness of available control tactics	<b>Poor</b>	Effective	Most effective
Cost of control measures	<b>V. high</b>	High	Low
Secondary control effects	<b>V. high</b>	High	Low
Required control strategy	<b>Area-wide applications based on forecasting</b>	Precisely targeted application based on monitoring	

# CONSEQUENCES OF IRRATIONAL USE OF INSECTICIDES IN COTTON IN NORTH INDIA

Parameter	Pest	Insecticide group	
		lab report	Field observations
Insecticide resistance	H.armigera Whitefly Earias spp. Jassid	SP, OP, OC, CM SP, OP - -	Poor control  OP, OC, CM OP
Insecticide resurgence	Whitefly Jassid H.Armigera	SP, OP, CM - -	Poor control SP, OP + (?)
Secondary pest + disease problem	Alternaria Myrothecium	-	SP
Residues in lint		SP, OP, CM	Health hazards

SP = Synthetic pyrethroids, CM = Carbamates, OP = Organophosphates, OC = Organochlorinates

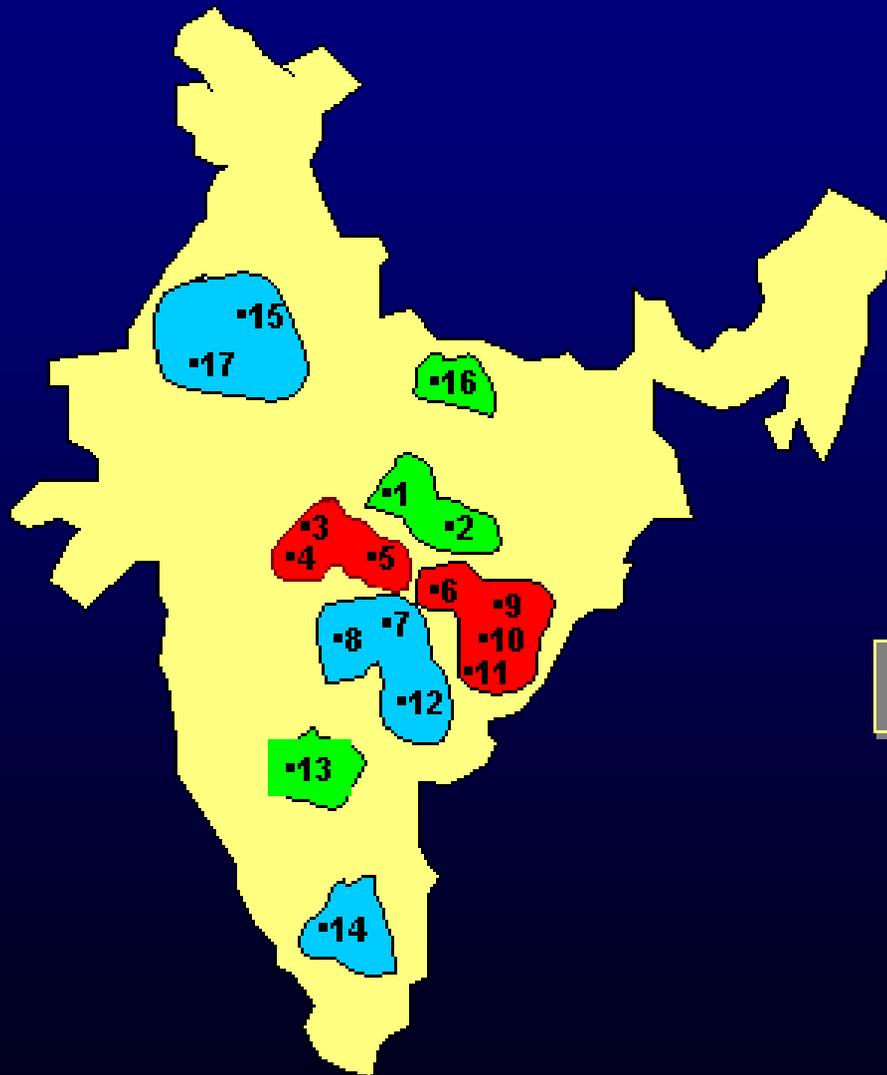
# STATUS OF BIOPESTICIDES, BOTANICALS AND BIOAGENTS IN IPM OF *HELICOVERPA*

<b>Pesticide</b>	<b>Effect</b>
Bt formulation	Not very effective
HaNPV	Inconsistent effects
Neem formulation	Not effective
Bio-agents ( <i>Trichogramma</i> , Chrysopids)	Little effect



**THANK YOU**

## Pattern of insecticide use



### Low insecticide use 2-6 sprays

1. Nagpur
2. Wardha
13. Bangalore
16. Varanasi

### Moderate insecticide use

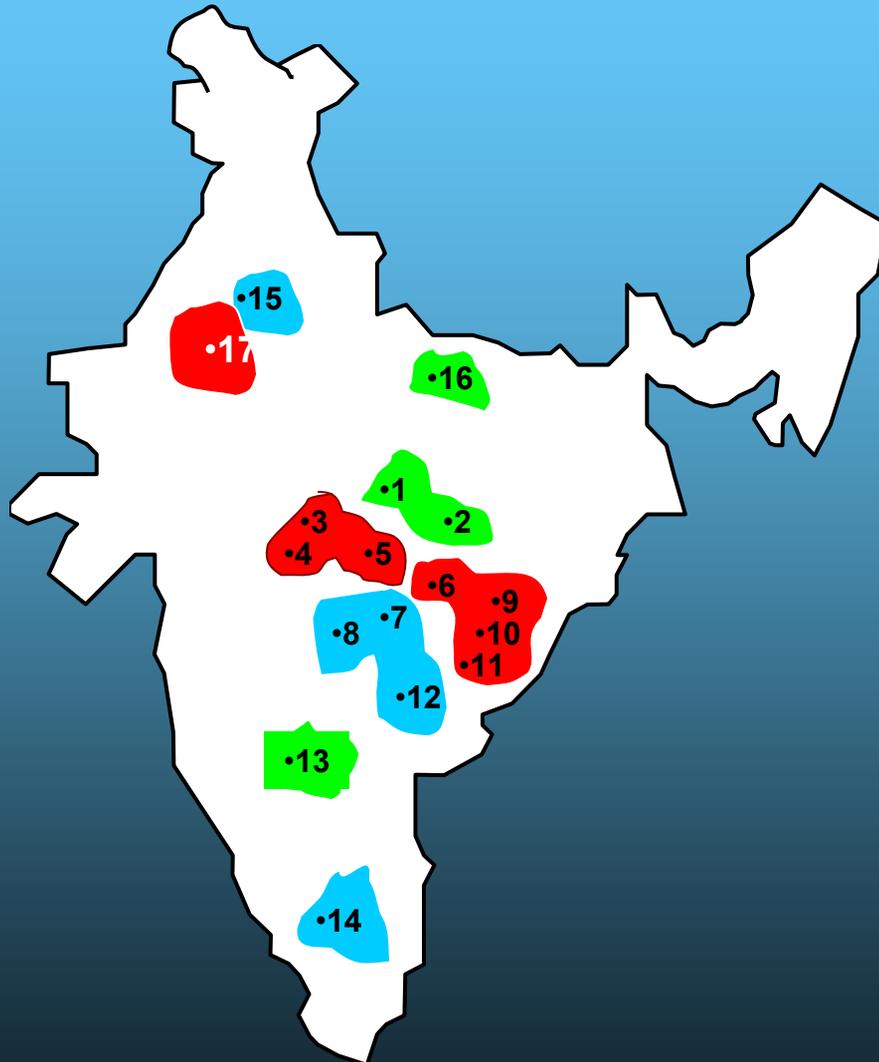
5-10 sprays

7. Siddipet
8. Rangareddy
12. Prakasam
14. Coimbatore
15. Sirsa
17. Bhatinda

### High insecticide use 8-20 sprays

3. Amaravati
4. Akola
5. Yavatmal
6. Warangal
9. Karimnagar
10. Khammam
11. Guntur

# Pyrethroid resistance 1993-2003



## ● Low to moderate

1. Nagpur
2. Wardha
13. Bangalore
16. Varanasi

## ● Moderate to high

7. Siddipet
8. Rangareddy
12. Prakasam
14. Coimbatore
15. Sirsa

## ● Very High

3. Amaravati
4. Akola
5. Yavatmal
6. Warangal
9. Karimnagar
10. Khammam
11. Guntur

# Generalised picture of resistance in cotton pests - India 1995-9

- **Low** resistance, if any, not sufficient to give rise to field control problems
- **Mod** moderate resistance, insecticide still useful but compromised
- **High** resistance sufficiently severe to significantly impare usefulness

*Data from:*

- Kranthi et al. 2000 - Bull. Ent Res. 91: 37-46*
- Kranthi et al 2001 - J. Econ. Ent. 94 (1): 253-263*
- Kranthi et al. 2000 - Pestology 12: 58-67*
- Russell et al 2000 - Proc. PCPC 205-211*

# American bollworm (*H. armigera*) resistance



		<u>North</u>	<u>Central</u>	<u>South</u>
■ <i>Pyrethroid</i>	- cyper/fenval.	high	high	high
■ <i>OP</i>	- quinalphos	low	low	mod
	- chlorpyrifos	mod	mod	mod
	- monocrotophos	high	mod	mod
■ <i>Carbamate</i>	- methomyl	mod	low	mod
■ <i>Cyclodiene</i>	- endosulfan	low	mod	mod

(Kranthi et al. 2000, 2001)

# Pink bollworm (*P.gossypiella*) resistance



		<u>North</u>	<u>Central</u>	<u>South</u>
■ <b><i>Pyrethroid</i></b>	- cypermethrin	mod	low	mod
■ <b><i>OP</i></b>	- quinalphos	high	mod	high
	- chlorpyrifos	high	mod	high
	- monocrotophos	mod	low	low
■ <b><i>Carbamate</i></b>	- methomyl	mod	mod	mod
■ <b><i>Cyclodiene</i></b>	- endosulfan	low	high	mod

(Kranthi et al. 2000, 2001)

# Spotted bollworm (*Earias vitella*) resistance



		<u>North</u>	<u>Central</u>	<u>South</u>
■ <i>Pyrethroid</i>	- cypermethrin	mod	low	low
■ <i>OP</i>	- quinalphos	low	low	low
	- chlorpyrifos	mod	low	low
	- monocrotophos	high	low	low
■ <i>Carbamate</i>	- methomyl	mod	low	low
■ <i>Cyclodiene</i>	- endosulfan	low	low	low

(Kranthi et al. 2000, 2001)

# Cotton leafworm (*Spodoptera litura*) resistance



		<u>North</u>	<u>Central</u>	<u>South</u>
■ <i>Pyrethroid</i>	- cyper/fenval.	low	low	mod
■ <i>OP</i>	- quinalphos	low	mod	high
	- chlorpyrifos	low	mod	low
	- monocrotophos	mod	mod	mod
■ <i>Carbamate</i>	- methomyl	low	low	low
■ <i>Cyclodiene</i>	- endosulfan	low	mod	low

(Kranthi et al. 2000, 2001)

# Whitefly (*Bemisia tabaci*) resistance



		<u>North</u>	<u>South-central</u>
■ <i>Pyrethroid</i>	- cyper/fenvalerate	<b>high</b>	<b>mod</b>
■ <i>OP</i>	- acephate	<b>high</b>	
	- monocrotophos	<b>mod</b>	<b>mod</b>
	- triazophos	<b>low</b>	
	- chlorp/ profen.	<b>low</b>	<b>low</b>
	- quinalphos		<b>mod</b>
■ <i>Carbamate</i>	- methomyl	<b>mod</b>	<b>low</b>
■ <i>Cyclodiene</i>	- endosulfan	<b>low</b>	<b>low</b>
■ <i>Chloronicotinyl</i>	- imidocloprid	<b>low</b>	<b>low</b>

(Russell et al. 2000, Kranthi et al. 2001)

# RELATIVE EFFICACY (% PEST MORTALITY) OF BOLLGARD® AND BOLLGARD®<sup>II</sup>

Insect pest	Bollgard® (Cry 1Ac)	Bollgard® <sup>II</sup> (Cry 2Ab and Cry 1Ac)
Cotton bollworm ( <i>Heliothis virescens</i> )	84.4	92.2
Fall armyworm	16.1	100.0
Beat armyworm	50.1	94.9
Soybean looper	1.2	97.4

Perlak *et al*, 2001