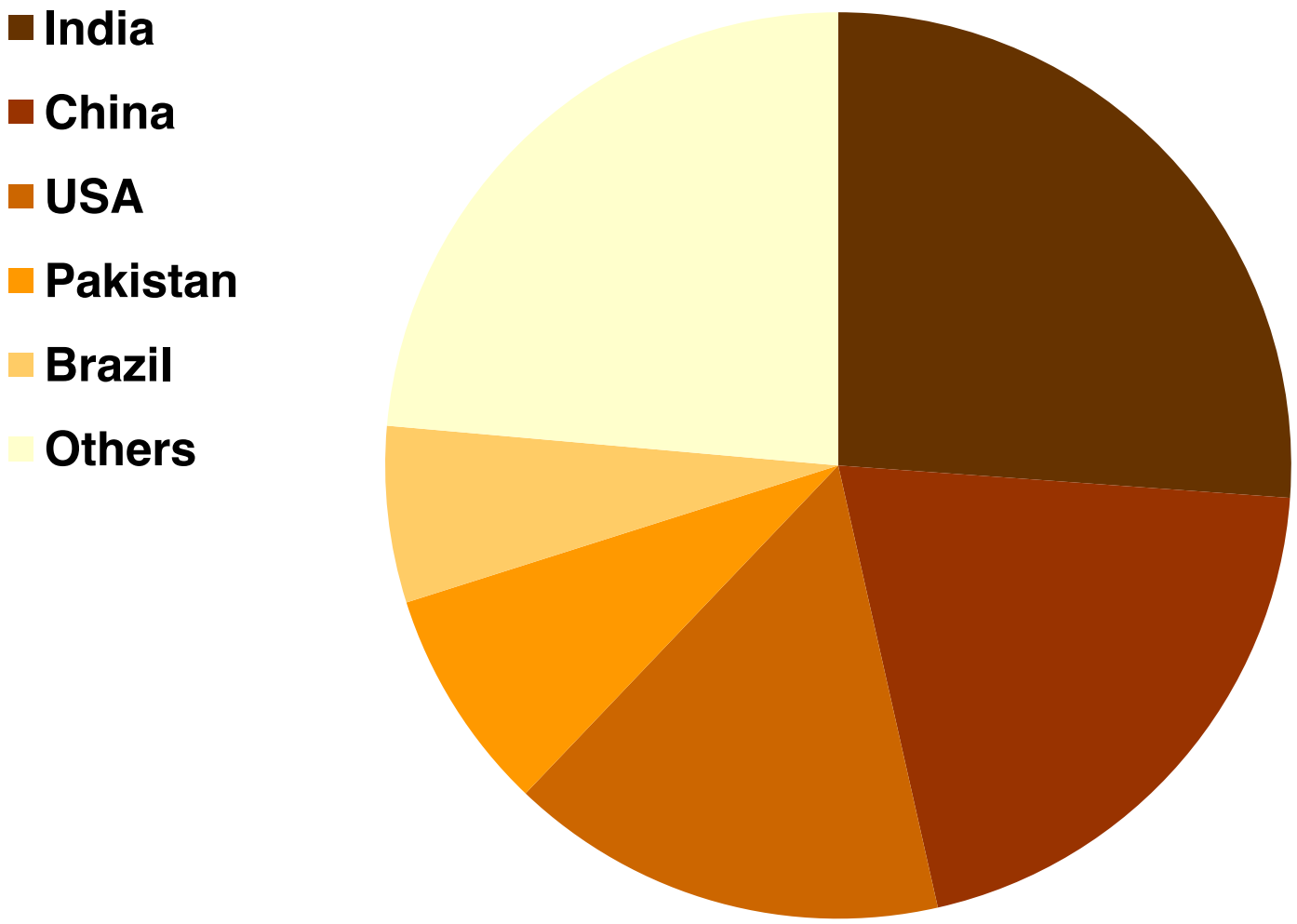
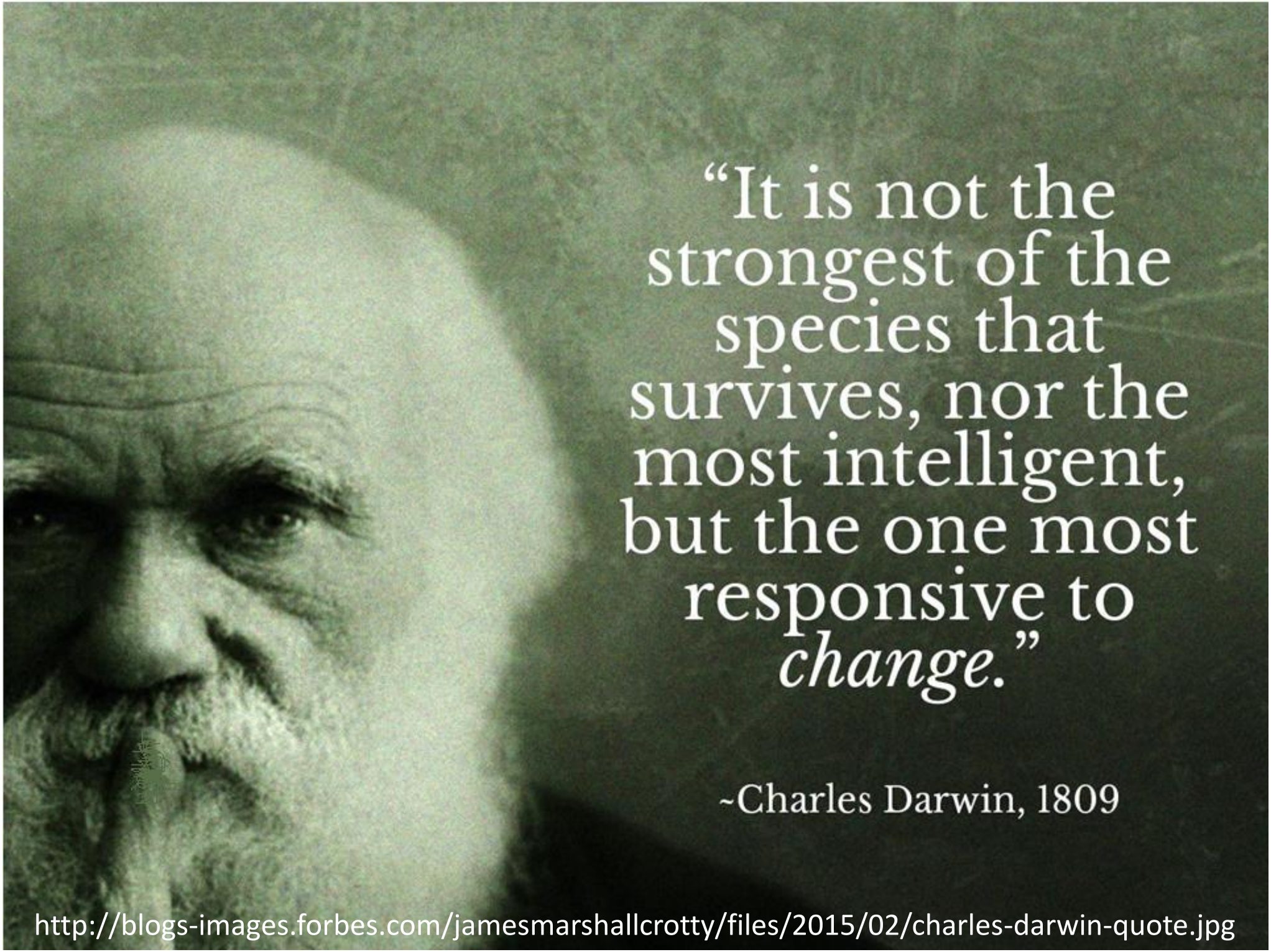

CALM BEFORE THE STORM
INSECTS AND INSECTICIDES
Keshav Kranthi, ICAC

# >75.0% Global production comes from 5 countries






http://blogs-images.forbes.com/jamesmarshallcrotty/files/2015/02/charles-darwin-quote.jpg

*....Most responsive to change*

*Resistant Insects..*

# *The impending storm*

# THE IMPENDING STORM

## INSECTS & INSECTICIDES

**USA:** Insecticides against thrips and bugs
**Budworms** and **bollworms** may strike Bt-cotton soon

**BRAZIL:** **Boll weevils** are back..Insecticides are at a peak

**CHINA & PAKISTAN:** Had only Cry1Ac. ***Helicoverpa armigera*** will strike soon..Insecticides are on the rise.

**PAKISTAN & INDIA** **Whiteflies & Leaf curl disease**. Insecticides are on a high

**INDIA:** **Pink Bollworm** is on a rampage. Pyrethroids & OPs are back. ***Helicoverpa armigera*** will be back after a break.

*All worms are most responsive to changes*


Boll weevil in Brazil
entoweb.okstate.edu
UGA1327126

Agrícola

## CHEMICAL APPLICATIONS

| DATE | PRODUCTS | DOSAGE |
|---|---|---|
| | HERBICIDES | litros.hectare⁻¹ |
| 05/12/2015 | AURORA (CARFENTRAZONA ETÍLICA) | 0,040 |
| 05/12/2015 | GAMIT STAR (CLOMAZONA) | 1,125 |
| 05/12/2015 | PREMERLIN (TRIFLURALINA). | 2,000 |
| 05/12/2015 | HERBURON (DIUROM) | 2,000 |
| 21/01/2016 | LIBERTY (GLUFOSINATO-SAL DE AMÔNIO) | 2,000 |
| 21/01/2016 | STAPLE (PYRITHIOBAC-SODIUM) | 0,200 |
| 22/02/2016 | LIBERTY (GLUFOSINATO-SAL DE AMÔNIO) | 2,000 |
| | FUNGICIDES | litros.hectare⁻¹ |
| 12/01/2016 | PRIORI TOP (AZOXISTROBINA)+ (DIFENOCONAZOL) | 0,300 |
| 26/01/2016 | OPERA ULTRA (PYRACLOSTROBINA)+(METCONAZOL) | 0,500 |
| 26/01/2016 | SCORE (DIFENOCONAZOL) | 0,300 |
| 12/02/2016 | PRIORI TOP (AZOXISTROBINA)+ (DIFENOCONAZOL) | 0,300 |
| 27/02/2016 | SCORE (DIFENOCONAZOL) | 0,400 |
| 11/03/2016 | SCORE (DIFENOCONAZOL) | 0,300 |
| 11/03/2016 | MERTIN (HIDRÓXIDO DE FENTINA) | 0,500 |
| 24/03/2016 | SCORE (DIFENOCONAZOL) | 0,400 |
| 02/04/2016 | SCORE (DIFENOCONAZOL) | 0,300 |
| 02/04/2016 | MERTIN (HIDRÓXIDO DE FENTINA) | 0,500 |
| 08/04/2016 | SUPPORT (TIOFANATO METÍLICO) | 0,800 |
| 13/04/2016 | SCORE (DIFENOCONAZOL) | 0,400 |
| 27/04/2016 | MERTIN (HIDRÓXIDO DE FENTINA) | 0,500 |
| | GROWTH REGULATOR | litros.hectare⁻¹ |
| 20/01/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,060 |
| 26/01/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,080 |
| 01/02/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,100 |
| 16/02/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,080 |
| 11/03/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,060 |
| 17/03/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,080 |
| 24/03/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,100 |
| 02/04/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,250 |
| 08/04/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,250 |
| 13/04/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,800 |
| 19/04/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,250 |
| 23/04/2016 | PIX HC 250 G/L (MEPIQUATE) | 0,250 |

| DATE | PRODUCTS | DOSAGE | |
|---|---|---|---|
| | INSECTICIDES | litros.hectare⁻¹ | PRAGUE TARGET |
| 29/12/2015 | MARSHAL 400 G/L(CARBOSULFANO) | 0,500 | *Aphis gossypii* |
| 02/01/2016 | MARSHAL 400 G/L(CARBOSULFANO) | 0,400 | *Aphis gossypii* |
| 02/01/2016 | TURBINE 500 G/L (FLONICAMIDA) | 0,120 | *Aphis gossypii* |
| 12/01/2016 | MARSHAL 400 G/L(CARBOSULFANO) | 0,500 | *Aphis gossypii* |
| 12/01/2016 | MOSPILAN 200 G/L (ACETAMIPRIDO) | 0,200 | Bemisia tabaci |
| 20/01/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 20/01/2016 | MOSPILAN 200 G/L (ACETAMIPRIDO) | 0,200 | Bemisia tabaci |
| 26/01/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 26/01/2016 | MOSPILAN 200 G/L (ACETAMIPRIDO) | 0,200 | Bemisia tabaci |
| 26/01/2016 | MATCH 50 G/L (LUFENUROM) | 0,400 | Spodoptera frugiperda |
| 01/02/2016 | KRAFT 36G/L (ABAMECTINA) | 0,300 | *Tetranychus urticae* |
| 01/02/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 12/02/2016 | POLO 500 G/L (DIAFENTIUROM) | 0,800 | *Tetranychus urticae* |
| 16/02/2016 | BELT 480 G/L (FLUBENDIAMIDA) | 0,130 | Spodoptera frugiperda |
| 16/02/2016 | METHOMEX 215 G/L (METOMIL) | 1,500 | Spodoptera frugiperda |
| 27/02/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 01/03/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 02/03/2016 | TIGER 100 G/L (PIRIPROXIFEM) | 0,250 | Bemisia tabaci |
| 02/03/2016 | MOSPILAN 200 G/L (ACETAMIPRIDO) | 0,250 | Bemisia tabaci |
| 07/03/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 08/03/2016 | PIRATE 240 G/L(CLORFENAPIR) | 1,000 | Helicoverpa sp |
| 11/03/2016 | TALSTAR 100 G/L (BIFENTRINA) | 0,700 | Helicoverpa sp |
| 11/03/2016 | TIGER 100 G/L (PIRIPROXIFEM) | 0,250 | *Bemisia tabaci* |
| 11/03/2016 | GALIL 250+50 G/L (IMIDACLOPRIDO)+(BIFENTRINA) | 0,300 | *Bemisia tabaci* |
| 12/03/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 17/03/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 17/03/2016 | TURBINE 500 G/L (FLONICAMIDA) | 0,120 | *Aphis gossypii* |
| 17/03/2016 | MOSPILAN 200 G/L (ACETAMIPRIDO) | 0,200 | Helicoverpa sp |
| 21/03/2016 | TALSTAR 100 G/L (BIFENTRINA) | 0,700 | *Anthonomus grandis* |
| 24/03/2006 | PARACAP 450 G/L (PARATIONA METÍLICA) | 1,330 | *Anthonomus grandis* |
| 24/03/2006 | POLO 500 G/L (DIAFENTIUROM) | 0,800 | *Tetranychus urticae* |
| 30/03/2016 | PARACAP 450 G/L (PARATIONA METÍLICA) | 1,330 | *Anthonomus grandis* |
| 02/04/2016 | TALSTAR 100 G/L (BIFENTRINA) | 0,600 | *Helicoverpa sp* |
| 05/04/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 08/04/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 15/04/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 19/04/2016 | MALATHION 1000 EC | 1,000 | *Anthonomus grandis* |
| 19/04/2016 | POLO 500 G/L (DIAFENTIUROM) | 0,800 | *Tetranychus urticae* |
| 23/04/2016 | POLO 500 G/L (DIAFENTIUROM) | 0,800 | *Tetranychus urticae* |
| 24/04/2016 | MALATHION UL 117 G/L | 1,000 | *Anthonomus grandis* |
| 27/04/2016 | POLO 500 G/L (DIAFENTIUROM) | 0,800 | *Tetranychus urticae* |
| 28/04/2016 | MALATHION UL 117 G/L | 1,000 | *Anthonomus grandis* |

# Brazil

# 74 Chemical interventions

**7 Herbicides**

**13 Fungicides +**

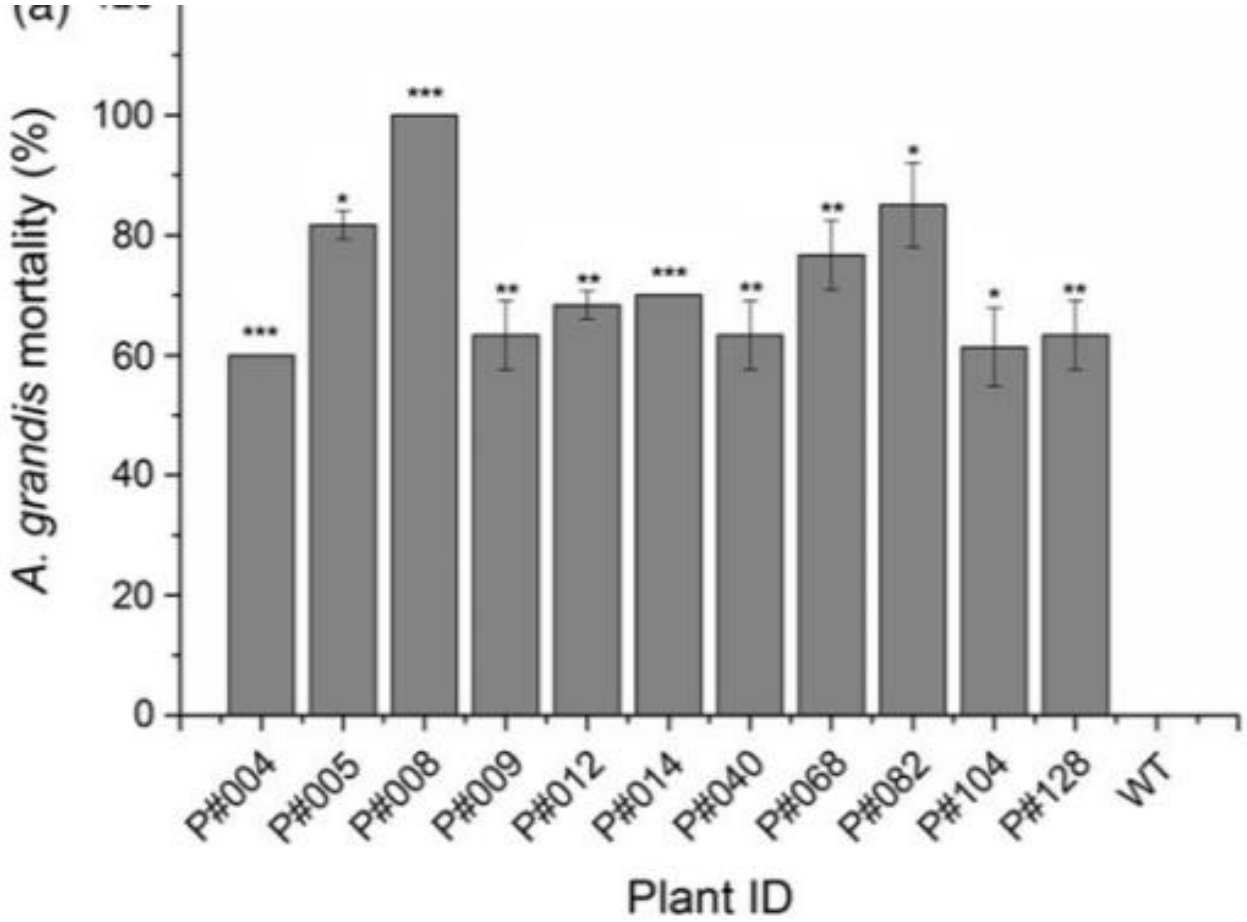
**12 Growth Regulators +**

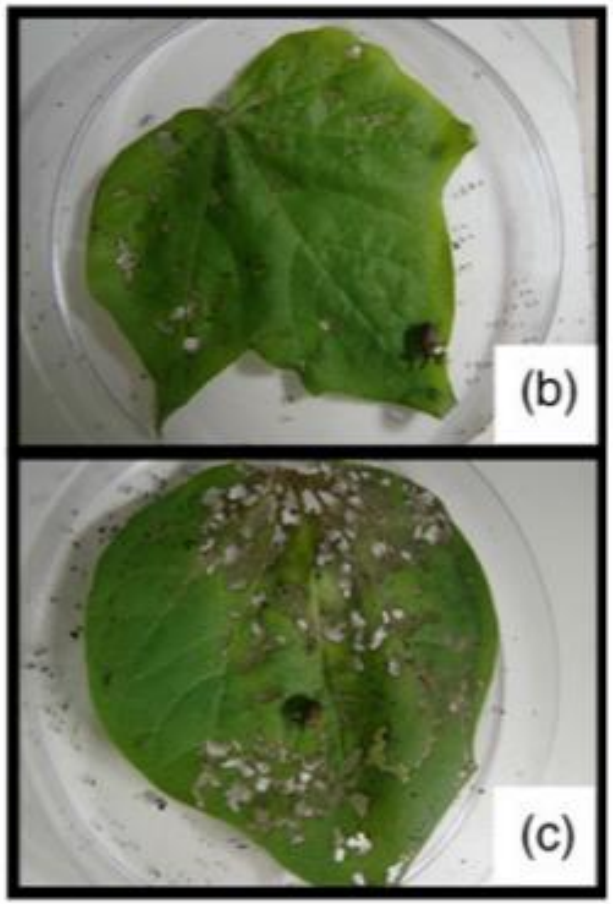
**42 Insecticides**

*Plant Biotechnology Journal* (2017), pp. 1–13 doi: 10.1111/pbi.12694

# Transgenic cotton expressing Cry10Aa toxin confers high resistance to the cotton boll weevil

Thuanne Pires Ribeiro[1,2], Fabricio Barbosa Monteiro Arraes[2,3], Isabela Tristan Lourenço-Tessutti[2], Marilia Santos Silva[2], Maria Eugênia Lisei-de-Sá[2,4], Wagner Alexandre Lucena[2,5], Leonardo Lima Pepino Macedo[2], Janaina Nascimento Lima[2], Regina Maria Santos Amorim[2], Sinara Artico[6], Márcio Alves-Ferreira[6], Maria Cristina Mattar Silva[2] and Maria Fatima Grossi-de-Sa[2,7,*]




India: Pink Bollworm

# Pink Bollworm Resistance to BOLLGARD-II (2016)

Gujarat: Anand, Ahmedabad, SurendraNagar Bharuch, Vadodara, Amreli

Telangana: Warangal, Adilabad, Khammam

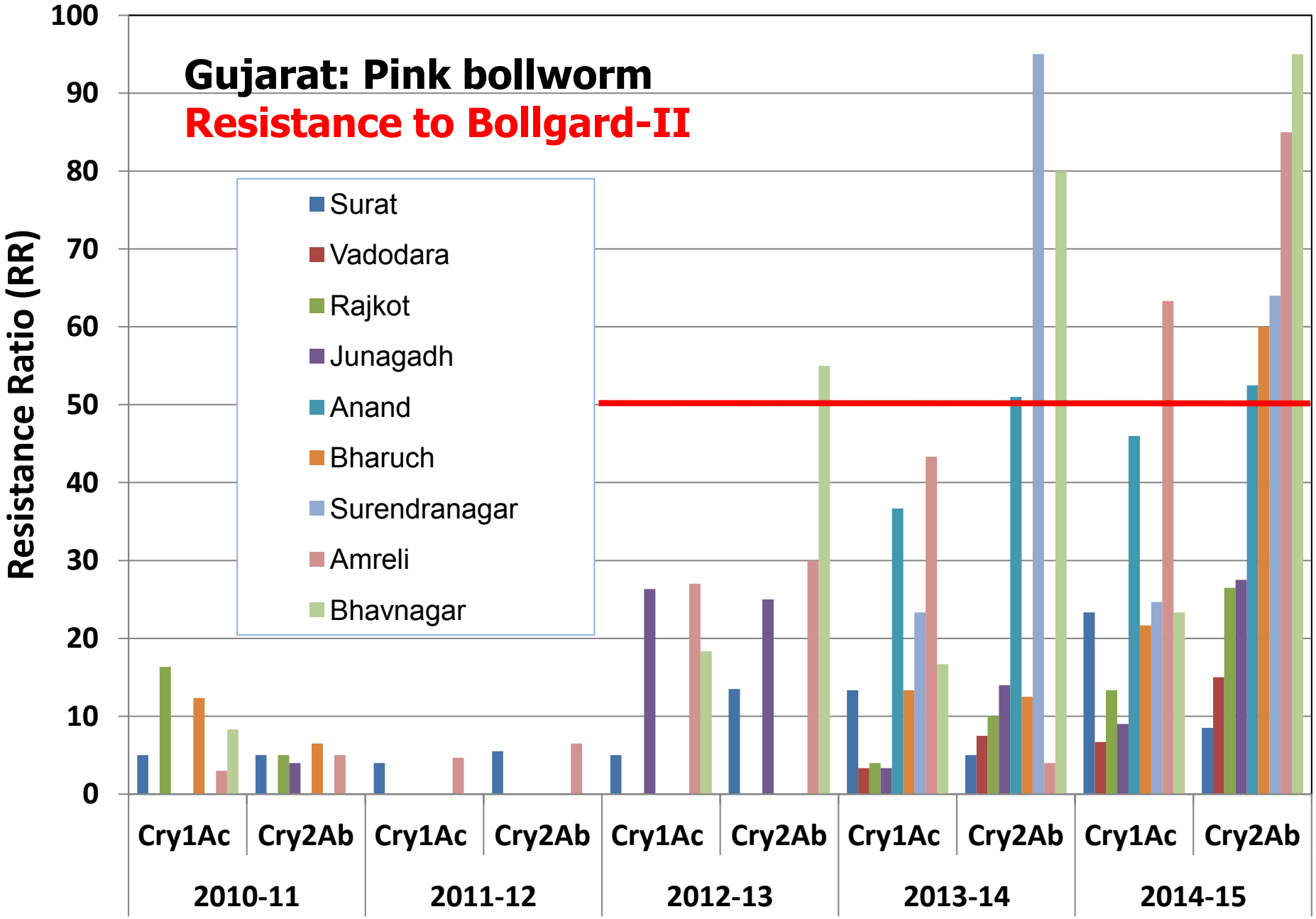
Andhra Pradesh: Guntur, Kurnool

Madhya Pradesh: Khandwa

Maharashtra: Nandurbar, Nanded

Karnataka: Raichur

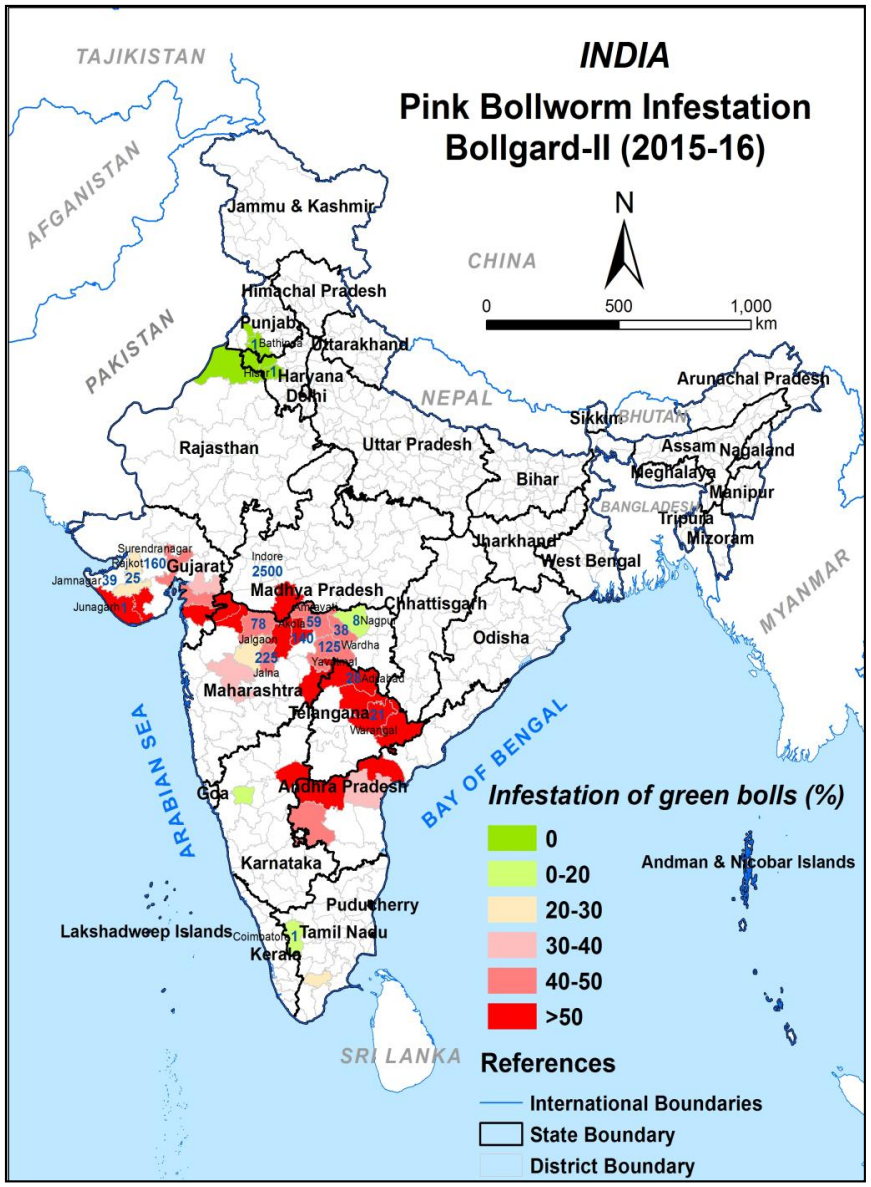
Chinna Babu et al., unpublished (CICR, Nagpur, India)

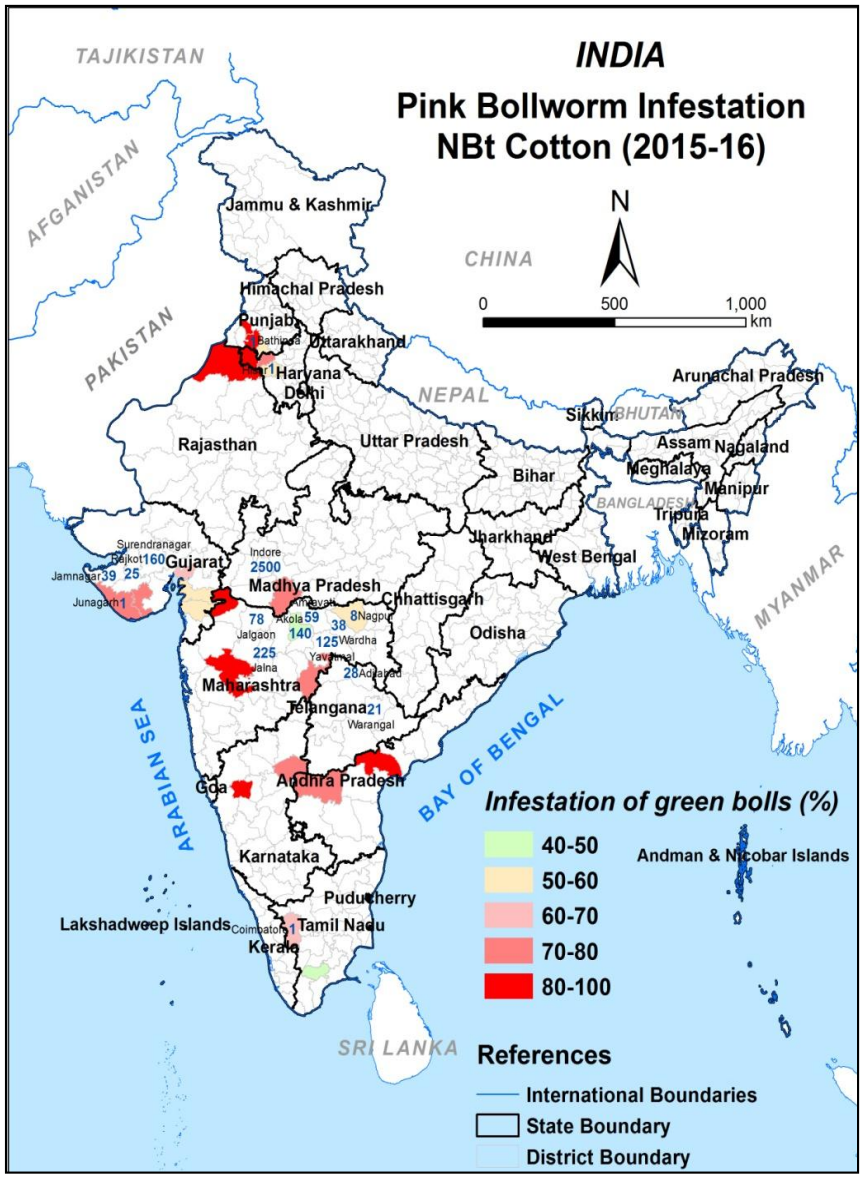


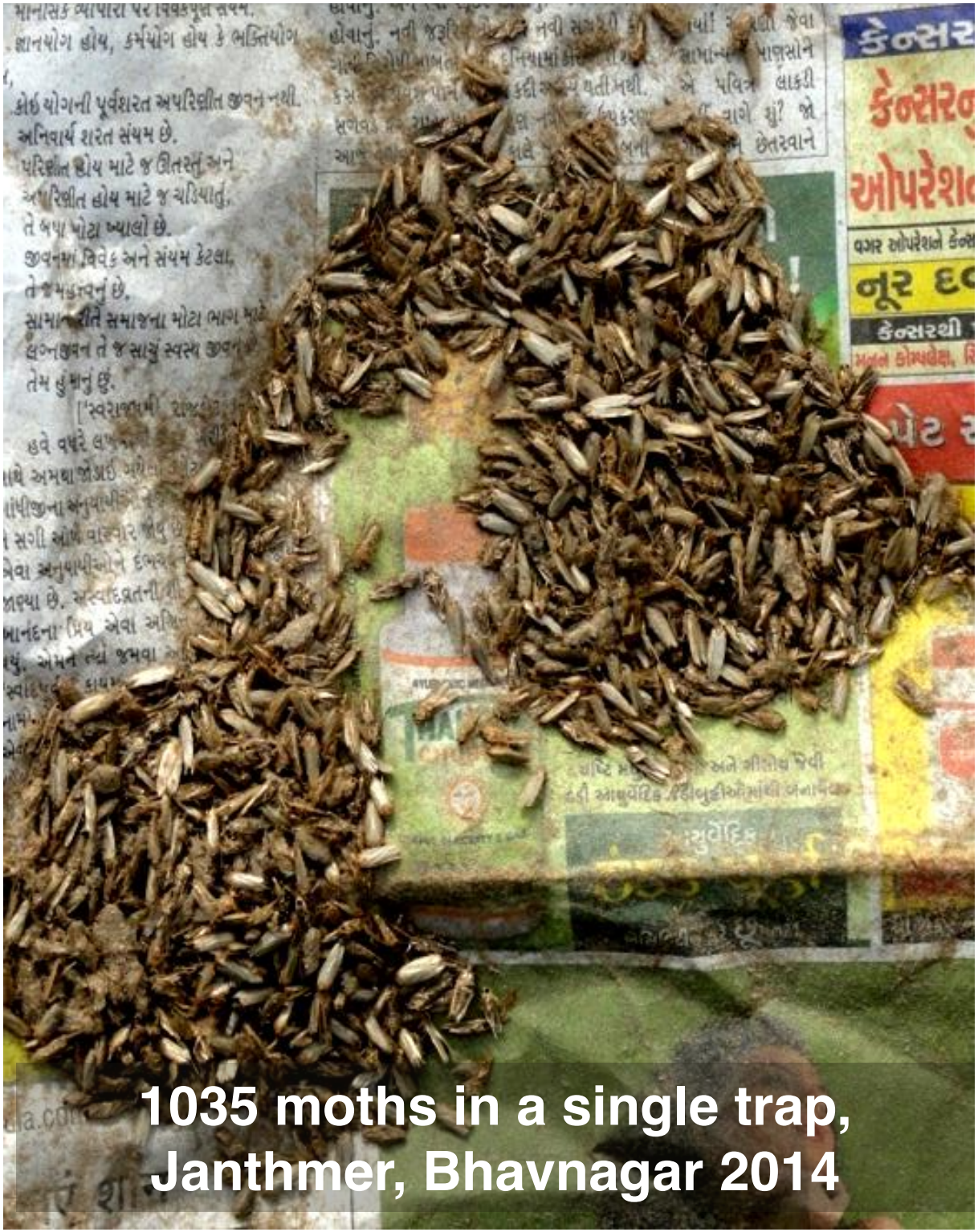

Chinna Babu et al., unpublished (CICR, Nagpur)

# Pink Bollworm Infestation 2015-16

Chinna Babu et al., unpublished (CICR, Nagpur, India)



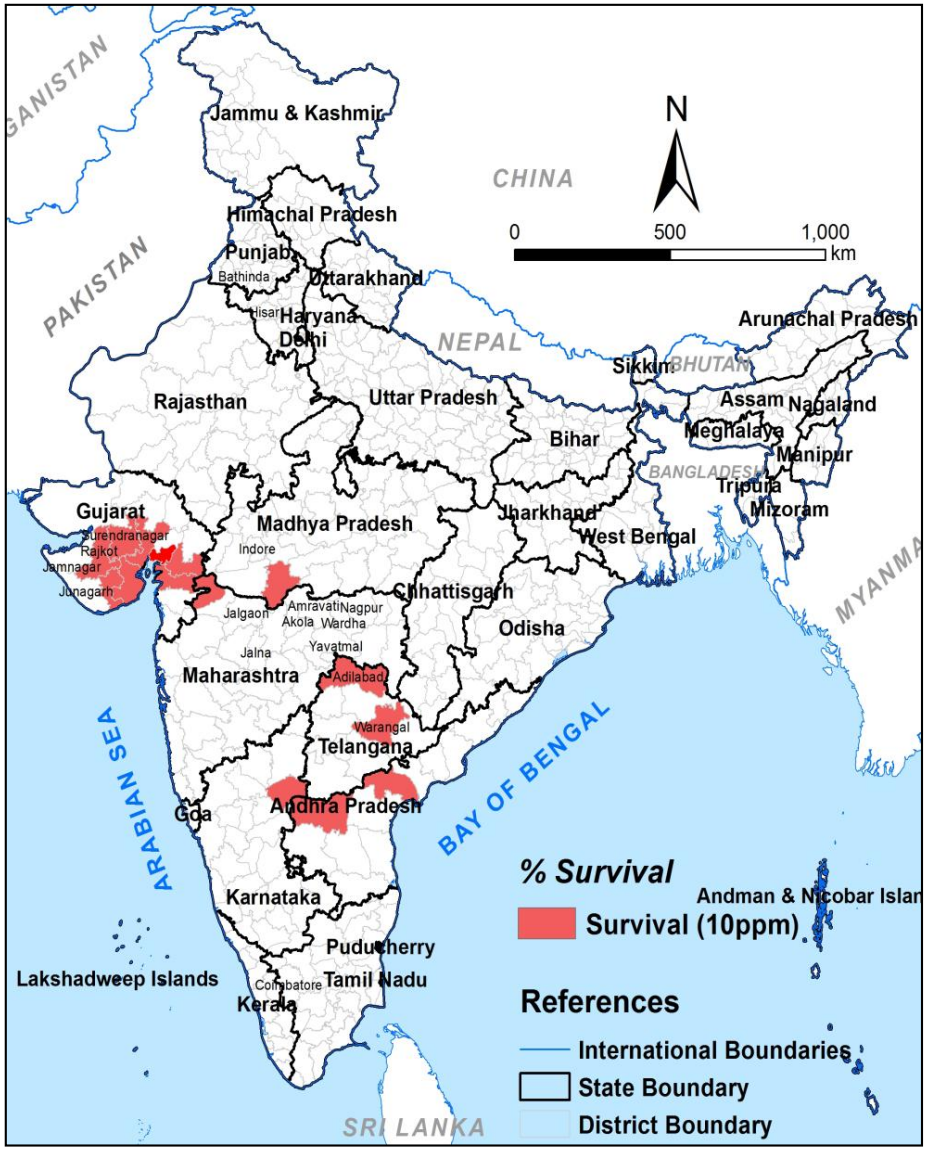





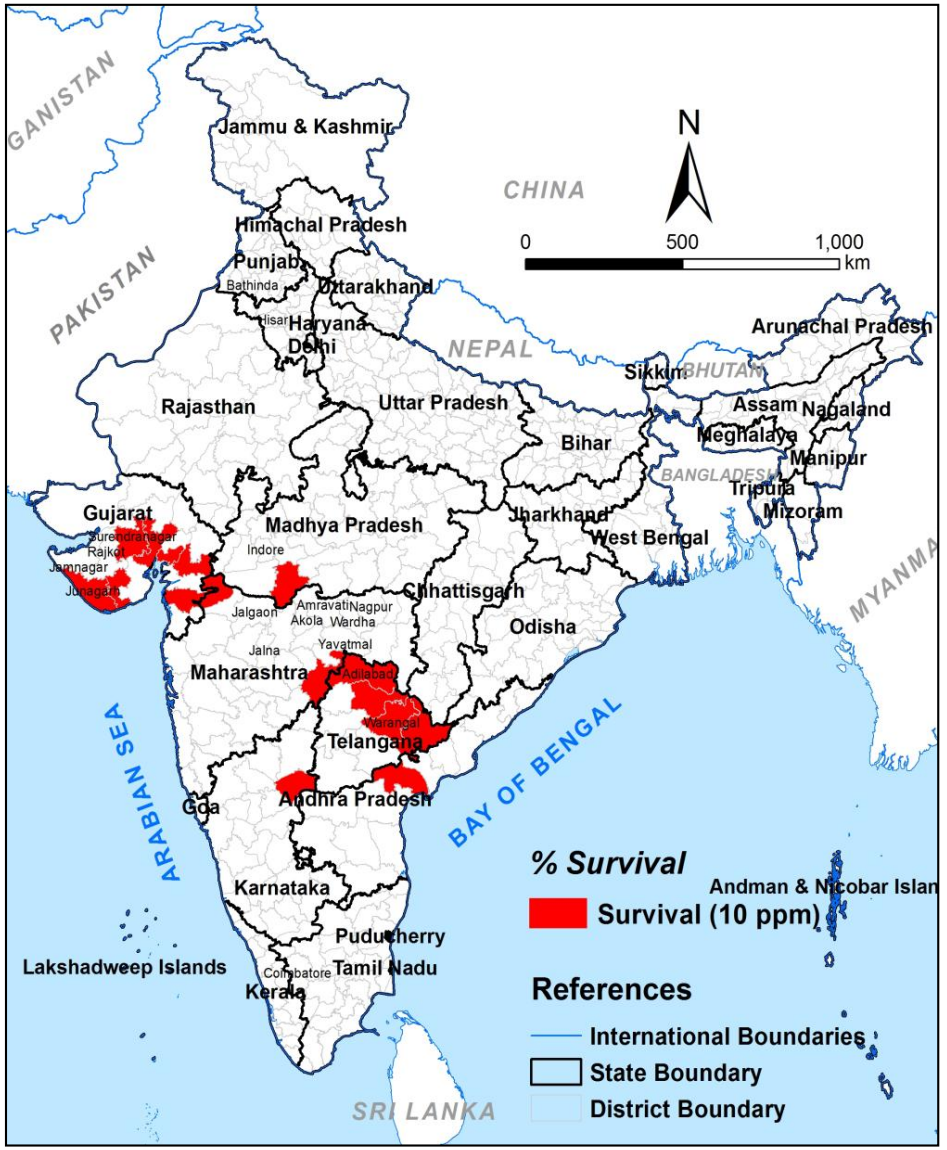
1035 moths in a single trap,
Janthmer, Bhavnagar 2014

# PINK BOLLWORM RESISTANCE TO BOLLGARD-II

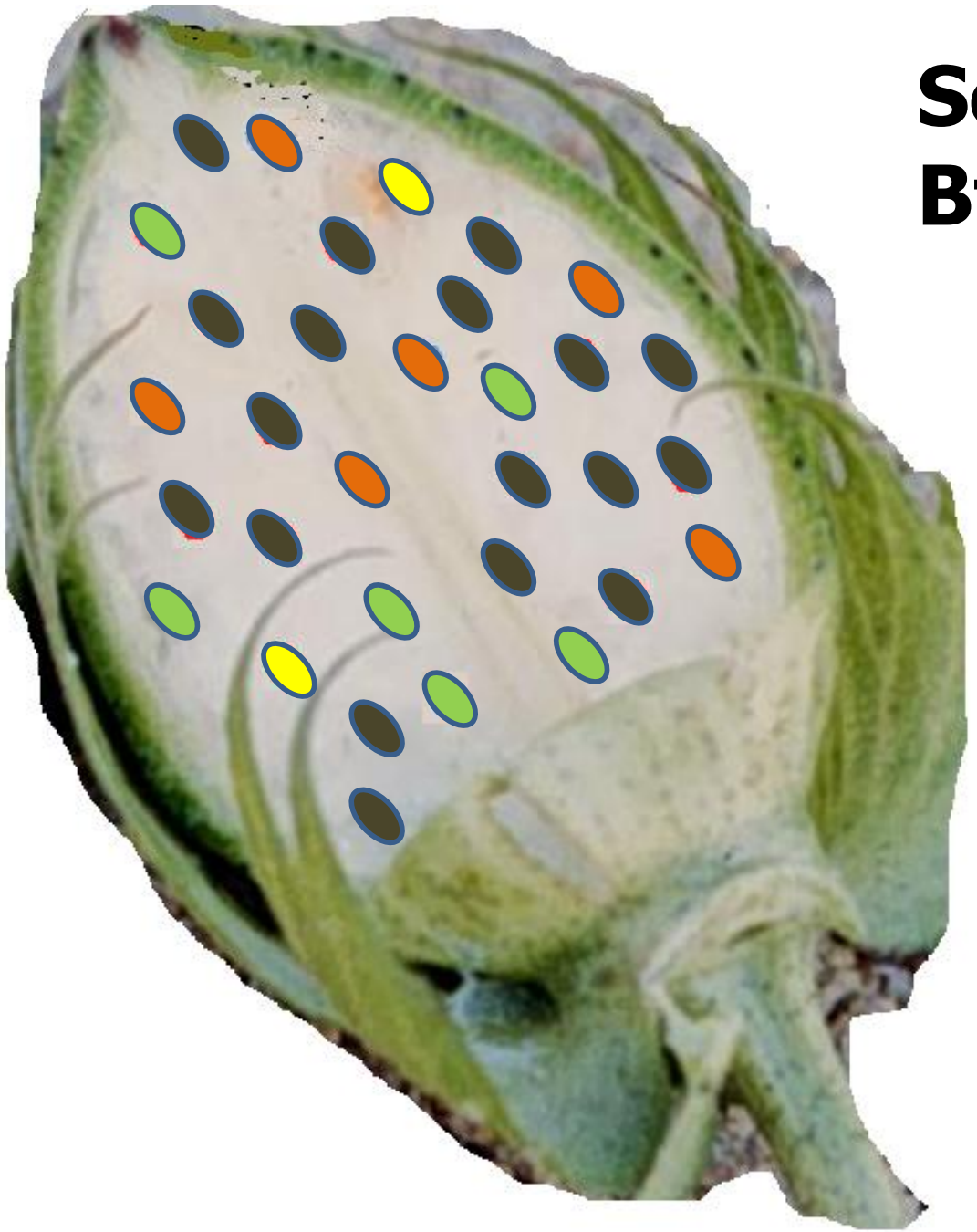
## Resistance to Cry1Ac




## Resistance to Cry2Ab




Chinna Babu et al., ICAR-CICR data unpublished



# Segregation of Bt in BG-II bolls

- Cry1Ac+Cry2Ab
- Cry1Ac
- Cry2Ab
- Non-Bt

**All other countries have Bt varieties**

**100% seeds have both Cry toxins in bolls**

# MANAGEMENT

**Early sowing**

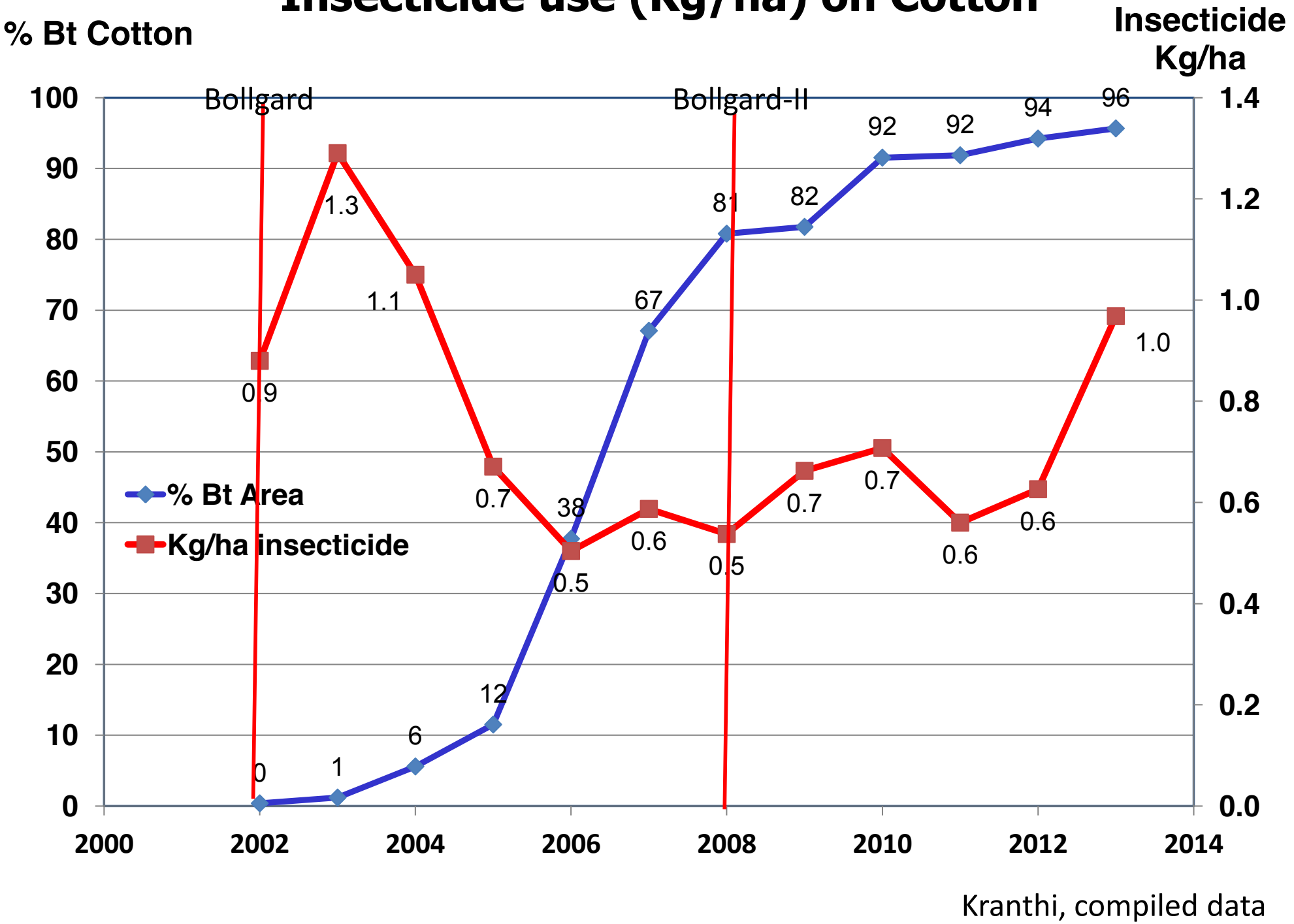
**Short duration- early maturing crop**

**Early stage Pheromone mass trapping**

**Mating confusion**

**Bt-cotton + insecticides**

# Insecticide use (Kg/ha) on Cotton




Kranthi, compiled data

# Pyrethroids are back
# Organophosphates are back

# Insecticides & Resurgence

**Pyrethroids:** Cause Helicoverpa and whitelfly resurgence

**Pyrethroid+OP:** Hormoligosis and outbreaks

**Organophosphates:** Switching off towards vegetation, resurgence of some sucking pests

**Methomyl & Thiodicarb**: Cause leaf reddening





Cotton Bollworm in
China, USA, Pakistan & India

# Pakistan & China have only Cry1Ac Bt-cotton

# *Helicoverpa* will strike soon anytime now

# *Helicoverpa armigera* Resistance to Cry1Ac

| Year | Sites | Highest $IC_{50}$ | Resistance Ratio | Highest $LC_{50}$ | Resistance Ratio |
|---|---|---|---|---|---|
| 1999 | 10 | 0.034 | 2 | 0.67 | 7 |
| 2002 | 45 | 0.043 | 2 | 0.54 | 5 |
| 2003 | 20 | 0.023 | 1 | 0.38 | 4 |
| 2004 | 21 | 0.104 | 5 | 0.74 | 7 |
| 2005 | 39 | 0.166 | 9 | 0.72 | 7 |
| 2006 | 27 | 0.195 | 10 | 0.79 | 8 |
| 2007 | 49 | 0.201 | 11 | 1.15 | 12 |
| 2008 | 26 | 0.58 | 31 | 3.12 | **31** |
| 2009 | 31 | 0.59 | 31 | 3.14 | **31** |
| 2010 | 27 | 0.24 | 13 | 3.26 | **33** |
| 2011 | 17 | 0.36 | 19 | 5.10 | **51** |
| 2012 | 35 | 0.61 | 32 | 6.54 | **66** |
| 2013 | 28 | 0.92 | 46 | 7.98 | **80** |

*Kranthi et al (unpublished)*

**Resistance in *Helicoverpa armigera* populations can be a major concern**

Exit

# Bt-Adapt -II

K. R. KRANTHI

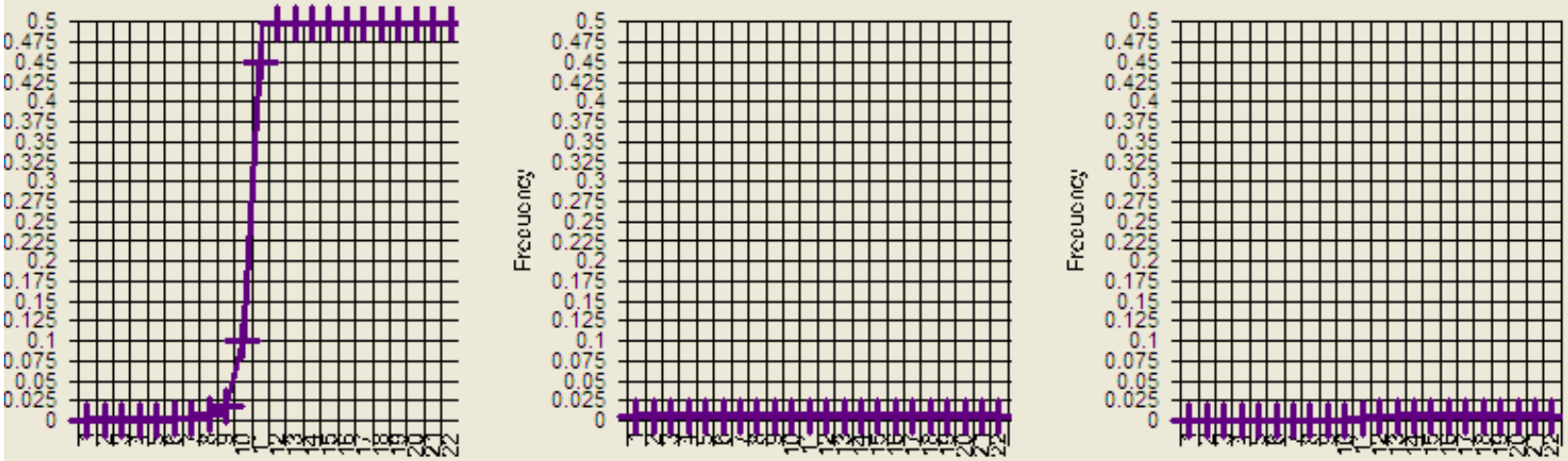
## A SIMULATION MODEL TO PREDICT ADAPTABILITY OF BOLLWORMS TO BT-COTTON

CICR
Central Institute for Cotton Research

un Exit

| ears | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| of Non-Bt Cotton | 99 | 98 | 94 | 88 | 80 | 72 | 58 | 48 | 42 | 22 | 16 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| of BG (Cry1Ac) | 1 | 2 | 6 | 12 | 20 | 28 | 42 | 52 | 58 | 78 | 84 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| of Refugia-BG | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| of BG2 (1Ac+2Ab) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| of Refugia-BG2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| untry Name | Region Name | State Name | District Name | No. of Years | | |
|---|---|---|---|---|---|---|
| DIA | Central | Maharashtra | Nagpur | 22 | ◉ BG1 ○ BG2 | OK |




◉ Cry1Ac ○ Cry2Ab ○ Cry1Ac+Cry2Ab

| enerations: | G0 | G1 | G2 | G3 | G4 | G5 | G6 | G7 | G8 |
|---|---|---|---|---|---|---|---|---|---|
| requency: | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| urvival Pest Control in Bt: | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| urvival Pest Control in NonBt: | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Dominance: | | 0.42 | 0.42 | 0.42 | | | | | |
| Survival frequency of RR on Bt-cotton: | | 1 | 1 | 1 | | | | | |
| Survival frequency of SS on Bt-cotton: | | 0.001 | 0.001 | 0.001 | | | | | |

Imigration Rate= 0.2

Initial Frequency of R allele= 0.001

Report

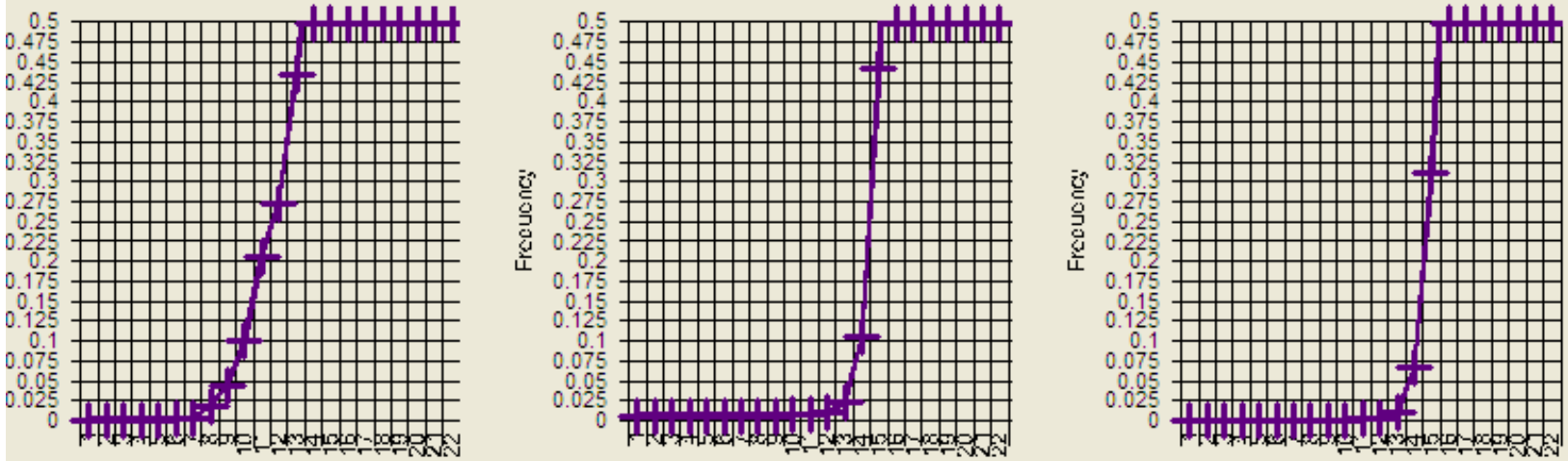
Close

**With only Cry1Ac it would have taken 12 years for resistance**

un Exit

| ears | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| of Non-Bt Cotton | 99 | 98 | 94 | 88 | 79 | 68 | 47 | 16 | 24 | 18 | 16 | 18 | 8 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| of BG (Cry1Ac) | 1 | 2 | 6 | 12 | 20 | 28 | 42 | 52 | 31 | 24 | 20 | 8 | 8 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| of Refugia-BG | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| of BG2 (1Ac+2Ab) | 0 | 0 | 0 | 0 | 1 | 4 | 11 | 32 | 45 | 58 | 64 | 74 | 84 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| of Refugia-BG2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| untry Name | Region Name | State Name | District Name | No. of Years | | |
|---|---|---|---|---|---|---|
| DIA | Central | Maharashtra | Nagpur | 22 | ◉ BG1 ○ BG2 | OK |




◉ Cry1Ac ○ Cry2Ab ○ Cry1Ac+Cry2Ab

| enerations: | G0 | G1 | G2 | G3 | G4 | G5 | G6 | G7 | G8 |
|---|---|---|---|---|---|---|---|---|---|
| requency: | 0.9991 | 0.9994 | 0.9996 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 |
| urvival Pest Control in Bt: | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| urvival Pest Control in NonBt: | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Dominance: | | 0.42 | 0.42 | 0.42 | | | | | |
| Survival frequency of RR on Bt-cotton: | | 1 | 1 | 1 | | | | | |
| Survival frequency of SS on Bt-cotton: | | 0.001 | 0.001 | 0.001 | | | | | |

Imigration Rate= 0.2

Initial Frequency of R allele= 0.001

Report

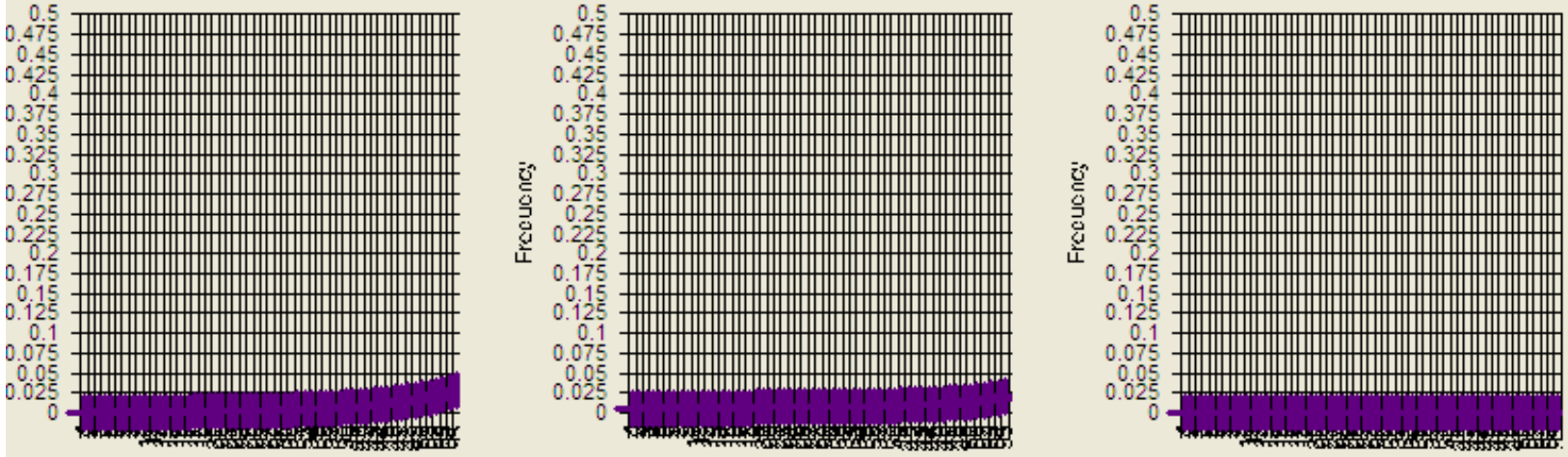
Close

**Bollgard + Bollgard-II as in India it would take 18 years**

un Exit

| ears | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| of Non-Bt Cotton | 99 | 98 | 94 | 88 | 72 | 58 | 42 | 26 | 10 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| of BG (Cry1Ac) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| of Refugia-BG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| of BG2 (1Ac+2Ab) | 1 | 2 | 6 | 12 | 28 | 42 | 58 | 74 | 90 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 |
| of Refugia-BG2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| untry Name | Region Name | State Name | District Name | No. of Years | | |
|---|---|---|---|---|---|---|
| DIA | Central | Maharashtra | Akola | 55 | ◉ BG1 ○ BG2 | OK |




○ Cry1Ac ○ Cry2Ab ○ Cry1Ac+Cry2Ab

| enerations: | G0 | G1 | G2 | G3 | G4 | G5 | G6 | G7 | G8 |
|---|---|---|---|---|---|---|---|---|---|
| requency: | 0.0252 | 0.0268 | 0.0286 | 0.0286 | 0.0285 | 0.0284 | 0.0283 | 0.0282 | 0.0281 |
| urvival Pest Control in Bt: | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| urvival Pest Control in NonBt: | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Dominance: | | 0.42 | 0.42 | 0.42 | | | | | |
| Survival frequency of RR on Bt-cotton: | | 1 | 1 | 1 | | | | | |
| Survival frequency of SS on Bt-cotton: | | 0.001 | 0.001 | 0.001 | | | | | |

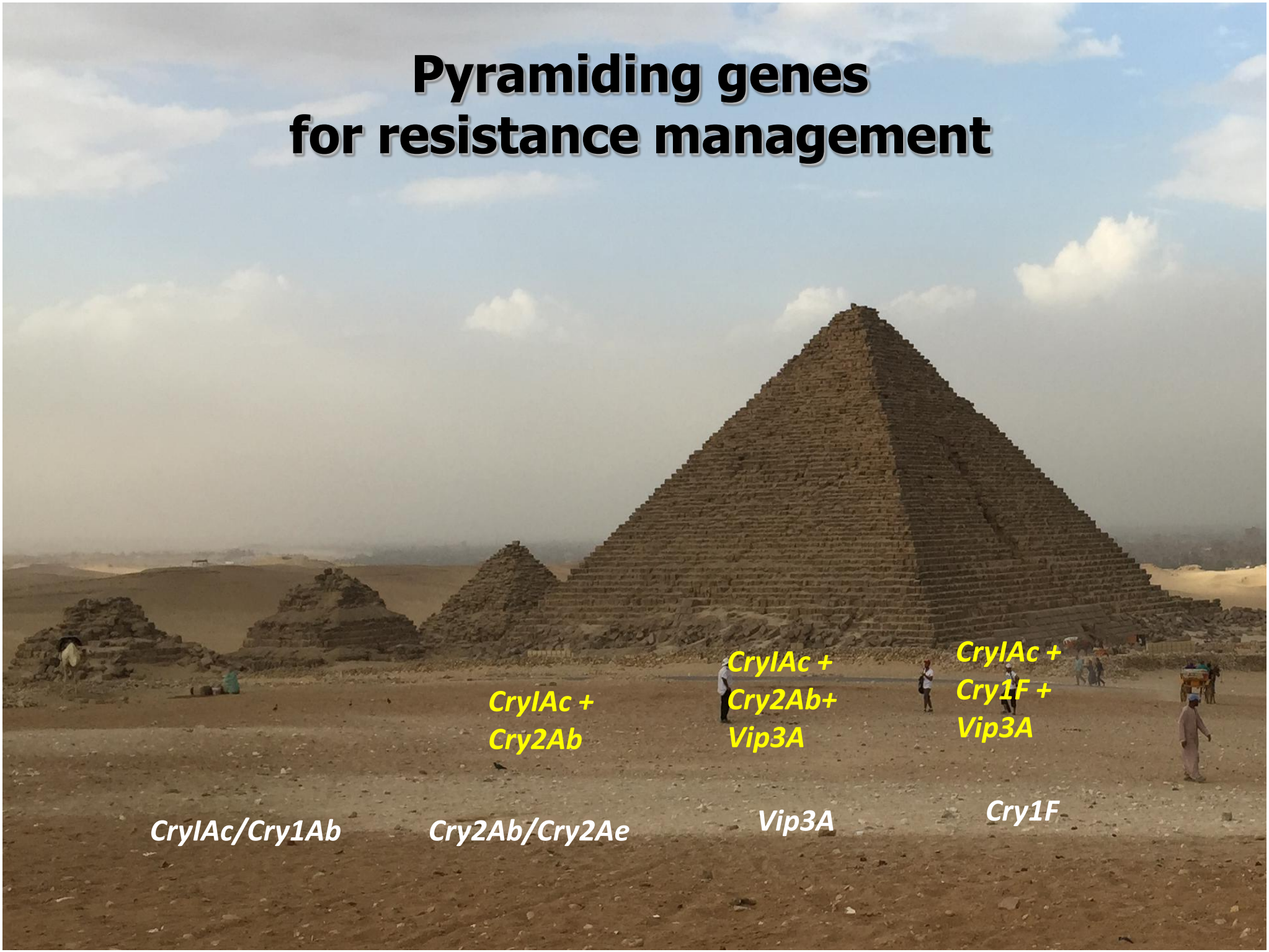
Imigration Rate= 0.2

Initial Frequency of R allele= 0.001

Report

Close

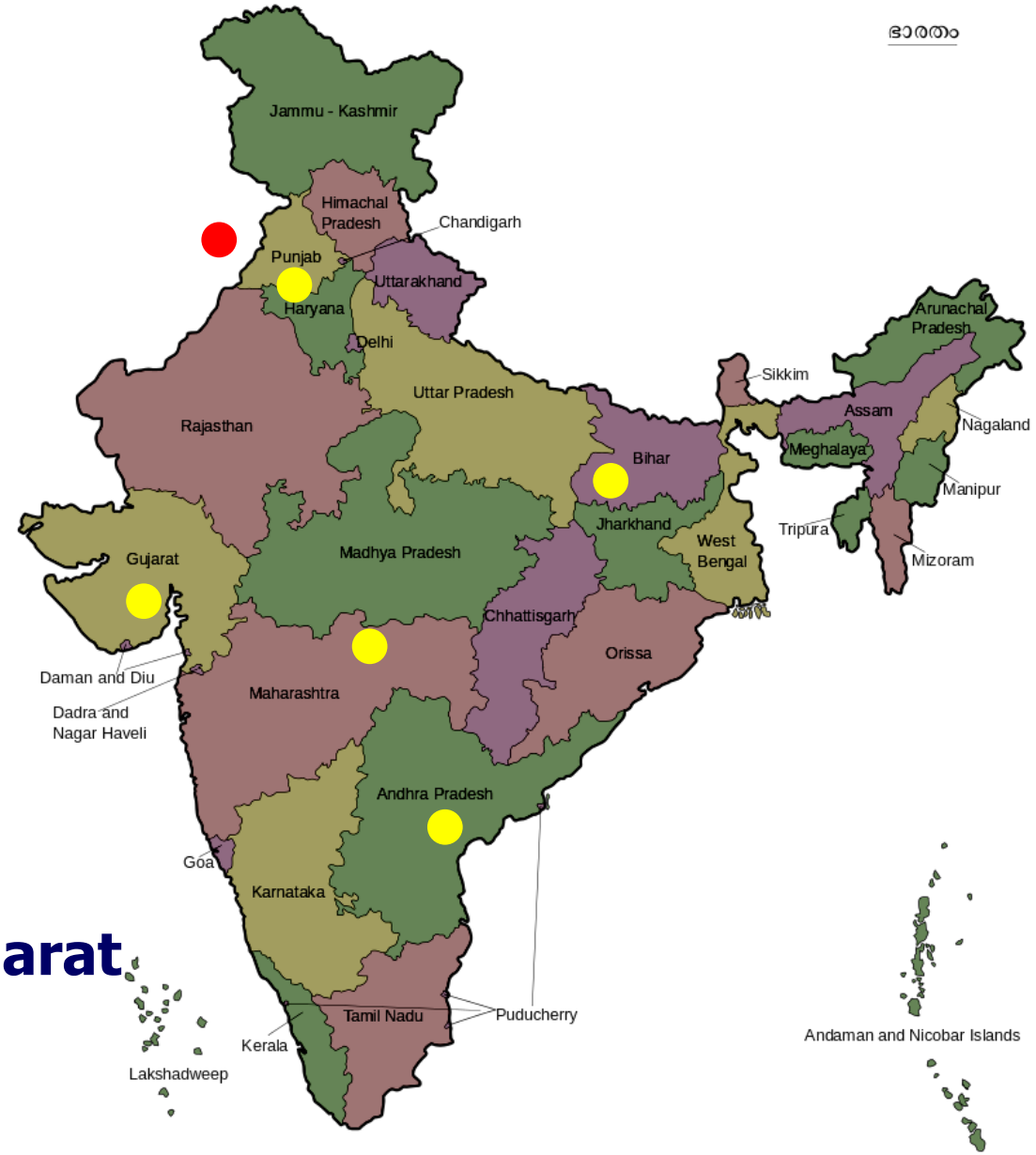
f Bollgard-II would have been introduced in 2002 in India, instead of the Bollgard in 2002 nd Bollgard-II in 2006; it would have taken *H armigera* >55 years to develop resistance.


Pyramiding genes
for resistance management
CrylAc/Cry1Ab
Cry2Ab/Cry2Ae
Vip3A
Cry1F
CrylAc +
Cry2Ab
CrylAc +
Cry2Ab+
Vip3A
CrylAc +
Cry1F +
Vip3A

# How long will Vip3A last?
# Is the 4-gene Bt-cotton ready?

# **Whitefly & leaf curl**
in India & Pakistan

# Whitefly Outbreaks in India




**1905 Bihar**
**1929 Punjab**
**1987 AP, Maharashtra, Gujarat**
**1996 Punjab**
**2015 Punjab**


Damage was most severe in 2015

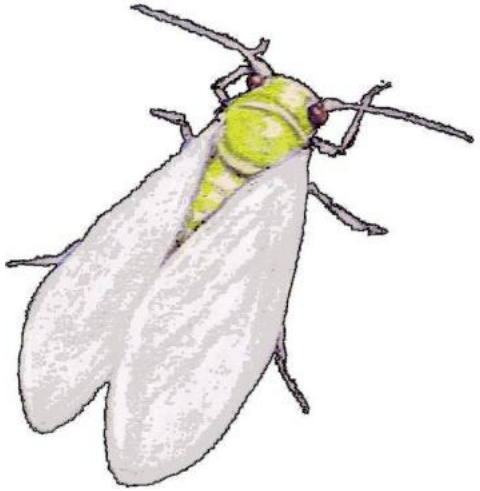
# Insecticide Resistance Ratios in *WHITEFLY* 2015

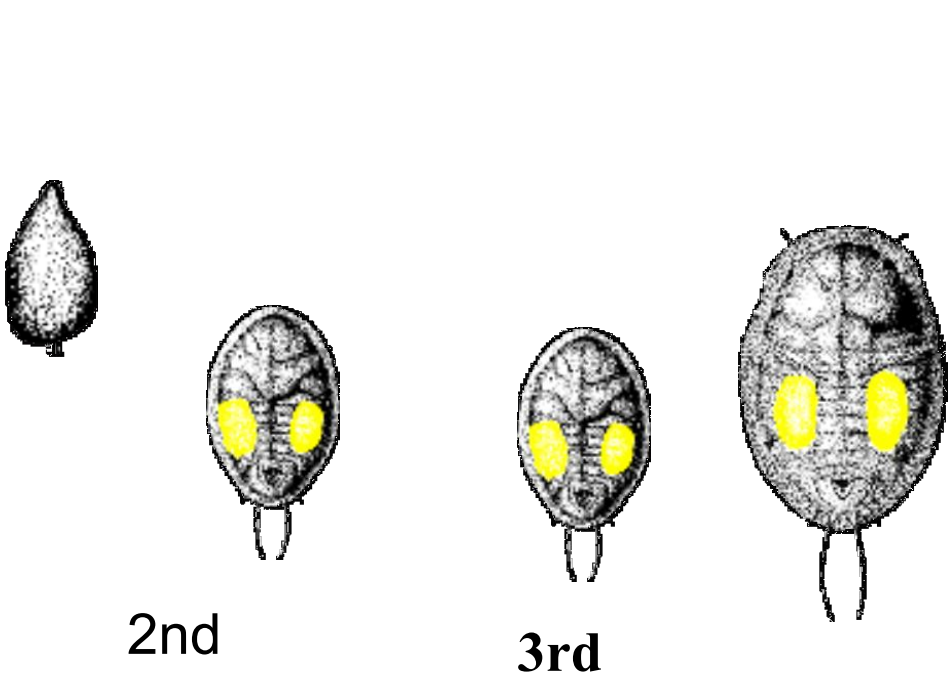
| | Rajasthan | Haryana | Punjab |
|---|---|---|---|
| Acetamiprid | 83 | 331 | 21 |
| Imidacloprid | 231 | 512 | 116 |
| Dinotefuran | 45 | 137 | 44 |
| Clothianidin | 3 | 7 | 2 |
| Thiamethoxam | 2 | 0 | 0 |
| | | | |
| Triazophos | 532 | 2237 | 934 |
| Acephate | 95 | 131 | 60 |
| Ethion | 3 | 12 | 2 |
| Chlorpyriphos | 2 | 14 | 5 |
| Monocrotophos | 2 | 2 | 1 |
| | | | |
| Buprofezin | 706 | 78 | 51 |
| Spiromesifen | 293 | 50 | 9 |
| Diafenthiuron | 347 | 65 | 40 |
| Pyriproxifen | 2 | 23 | 3 |
| Azadirachtin | 10 | 12 | 4 |
| | | | |
| Fipronil | 204 | 340 | 192 |
| Bifenthrin | 498 | 1400 | 605 |
| Flonicamid | 4 | 6 | 4 |

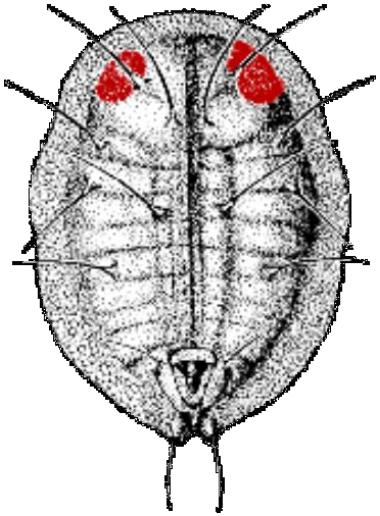
Rishi et al (ICAR-CICR unpublished)

# Four Steps in tandem

1. **Timely sowing**
2. **Tolerant varieties**
3. **Urea management**
4. **IRM based IPM**

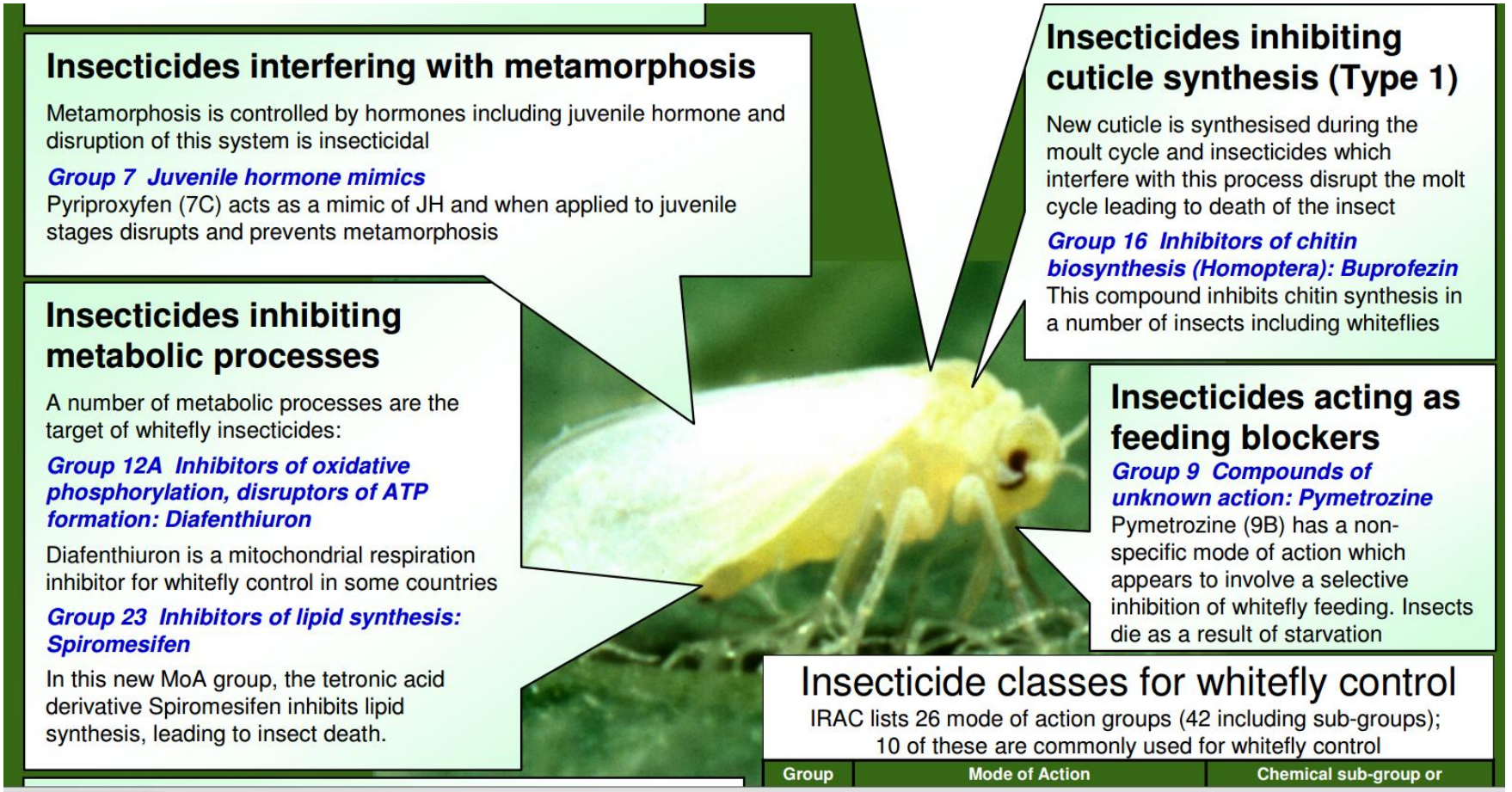




# The Five IRM Recommended Insecticides

1. **Neem oil / Castor oil** etc., ; Antifeedants
2. **Pyriproxyfen:** Juvenile hormone mimic
3. **Buprofezin:** Chitin biosynthesis inhibitor
4. **Diafenthiuron:** Oxidative phosphorylation inhibitor
5. **Spiromesifen:** Lipid synthesis inhibitor



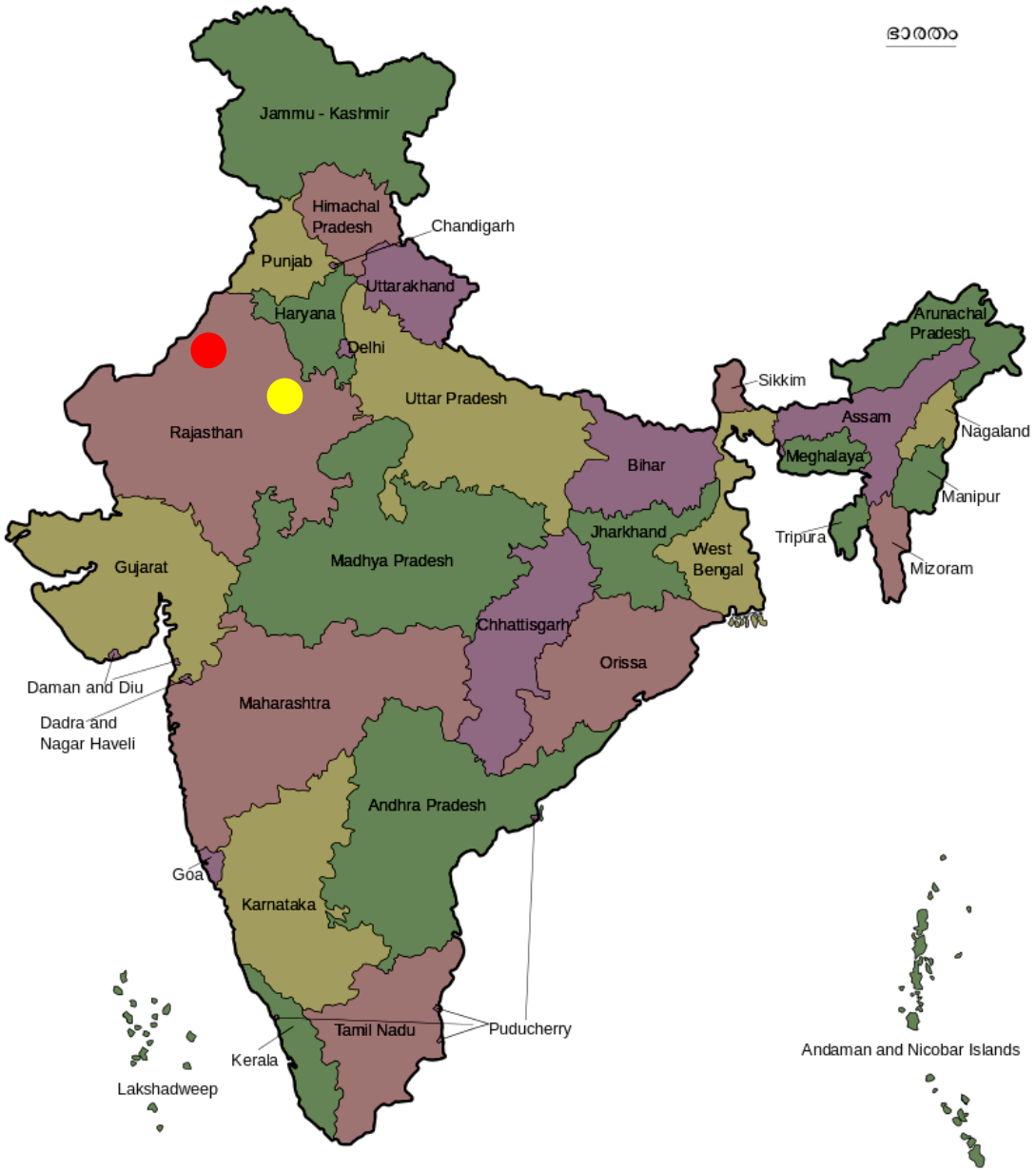

Source: http://www.irac-online.org


Cotton Leaf curl virus in Pakistan & India

# CLCuD Outbreaks

**1912, 1924 Nigeria**
**1926 Tanzania**
**1950 Sudan**

**1973, 1988, 1993, 2002**
**Pakistan S-12 SIM 70 149-F**
**1989 IARI**
**1993 Sriganganagar**
**1996 Punjab**
**2012-15 Punjab**




Kranthi, compilation

# CLCuD Strains

1. Burewala
2. Alabad
3. Kokhran
4. Multan
5. Rajasthan
6. Papaya leaf curl virus (PaLCuV)

## Whitefly resistant varieties

**LK 861, Amravathi, Kanchana, Supriya, LPS 141**

## Leaf Curl Disease resistant varieties

### Resistant Varieties

**RST9, RS875, RS810, RS2013, F1861,LH2076, H117, H1126, LRA 5166**

### Resistant hybrids

**LHH144, CSH198, CSHH238 and CSHH243**

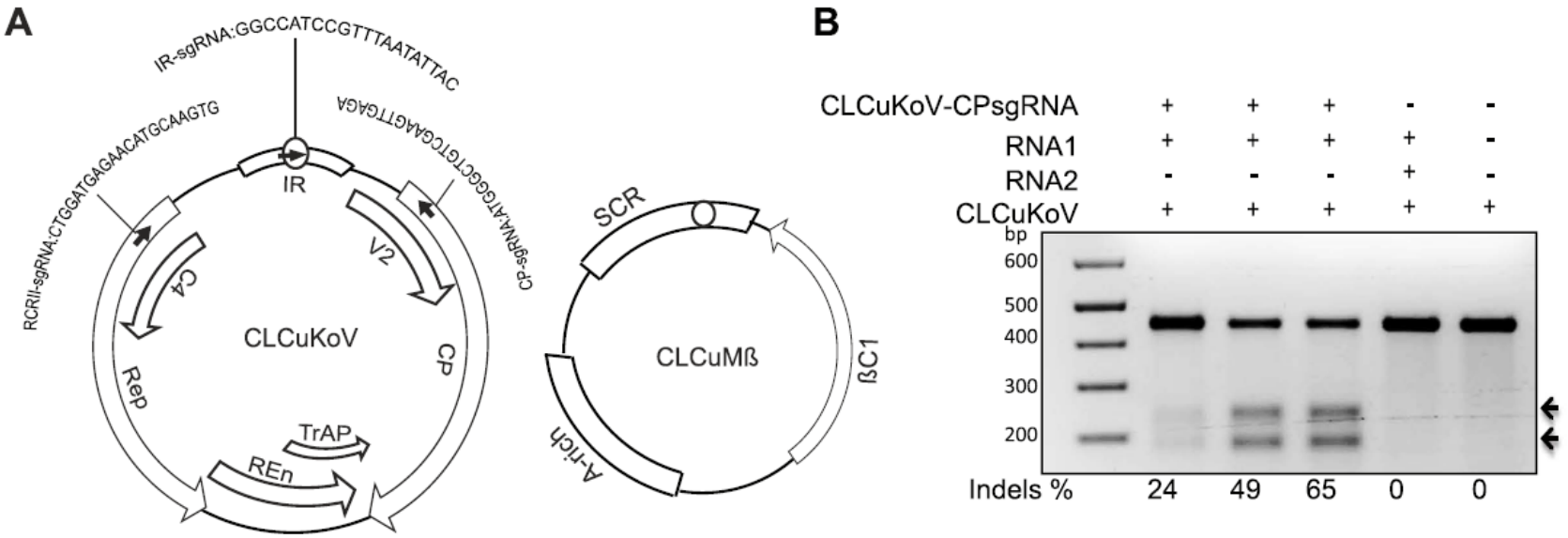
SCIENTIFIC REPORTS

OPEN

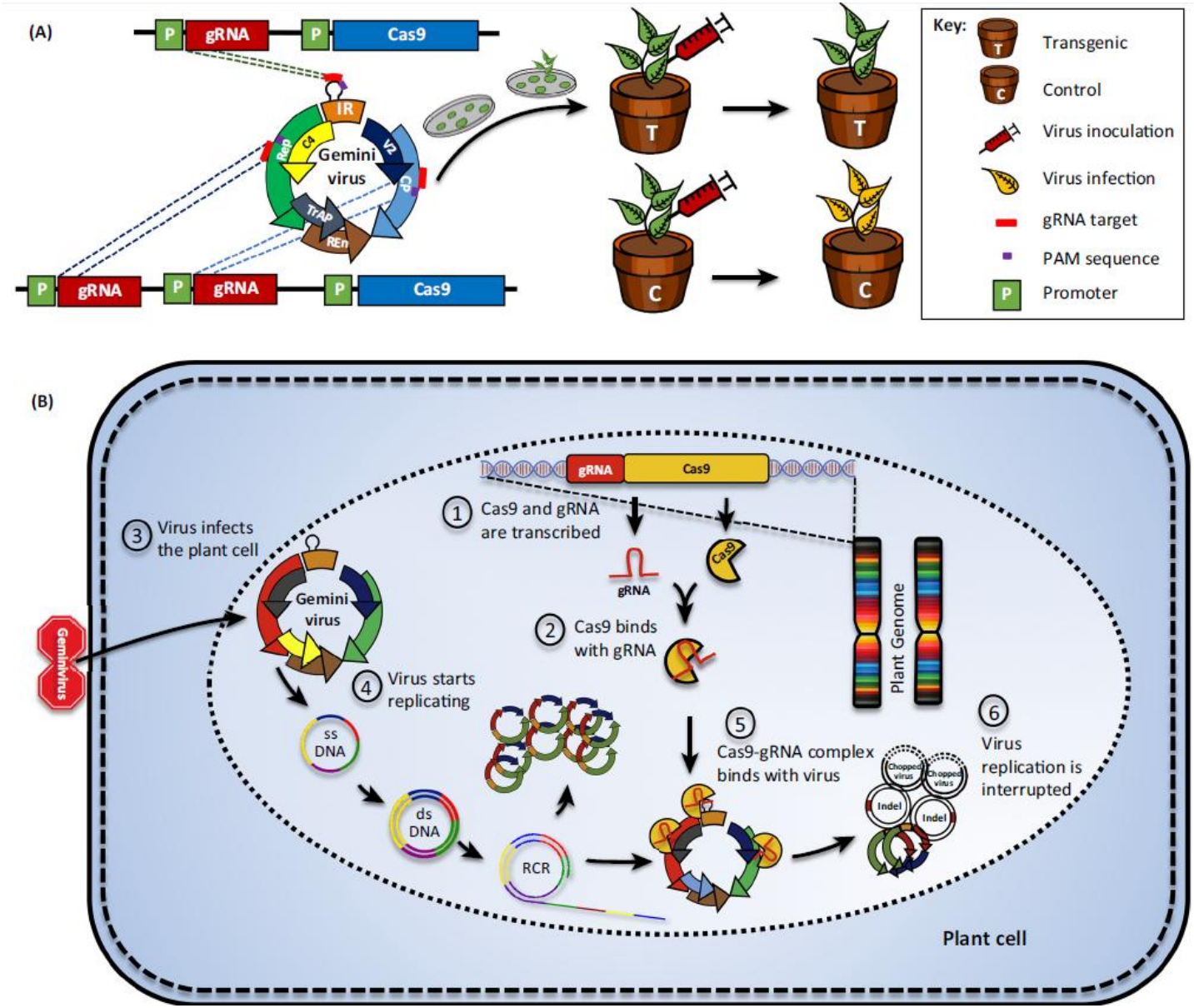
# CRISPR/Cas9-Mediated Immunity to Geminiviruses: Differential Interference and Evasion

Received: 18 March 2016

Zahir Ali, Shakila Ali, Manal Tashkandi, Syed Shan-e-Ali Zaidi & Magdy M. Mahfouz



# Resistance to leaf curl virus CRISPR-CAS9




**2016**

Trends in Plant Science

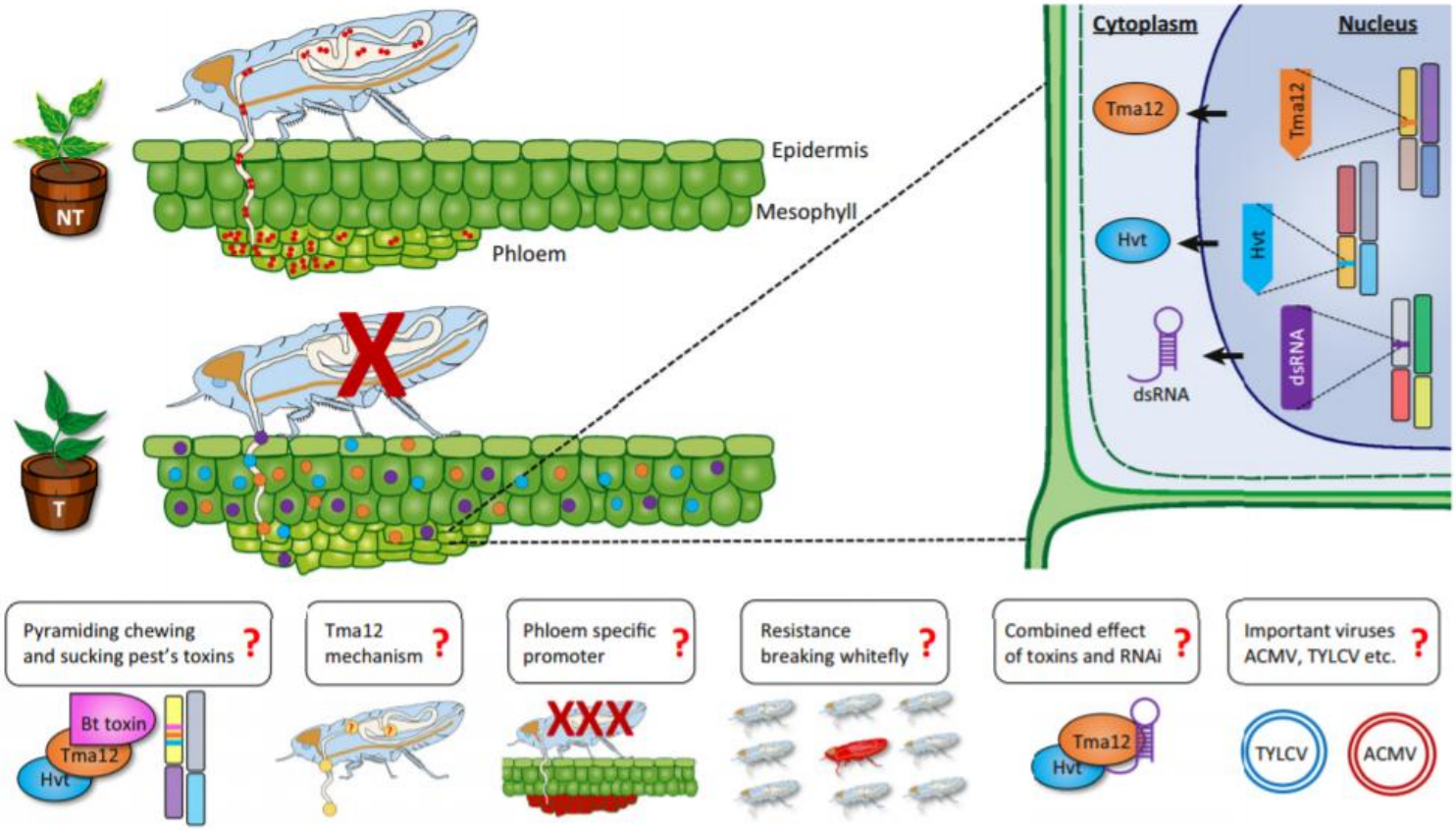
Spotlight

## Engineering Plants for Geminivirus Resistance with CRISPR/Cas9 System

Syed Shan-e-Ali Zaidi,[1,2] Shahid Mansoor,[2] Zahir Ali,[1] Manal Tashkandi,[1] and Magdy M. Mahfouz[1,*]

# Resistance to leaf curl virus

## Using RNAi, gene expression & CRISPR-CAS9




**2017**

Trends in Plant Science

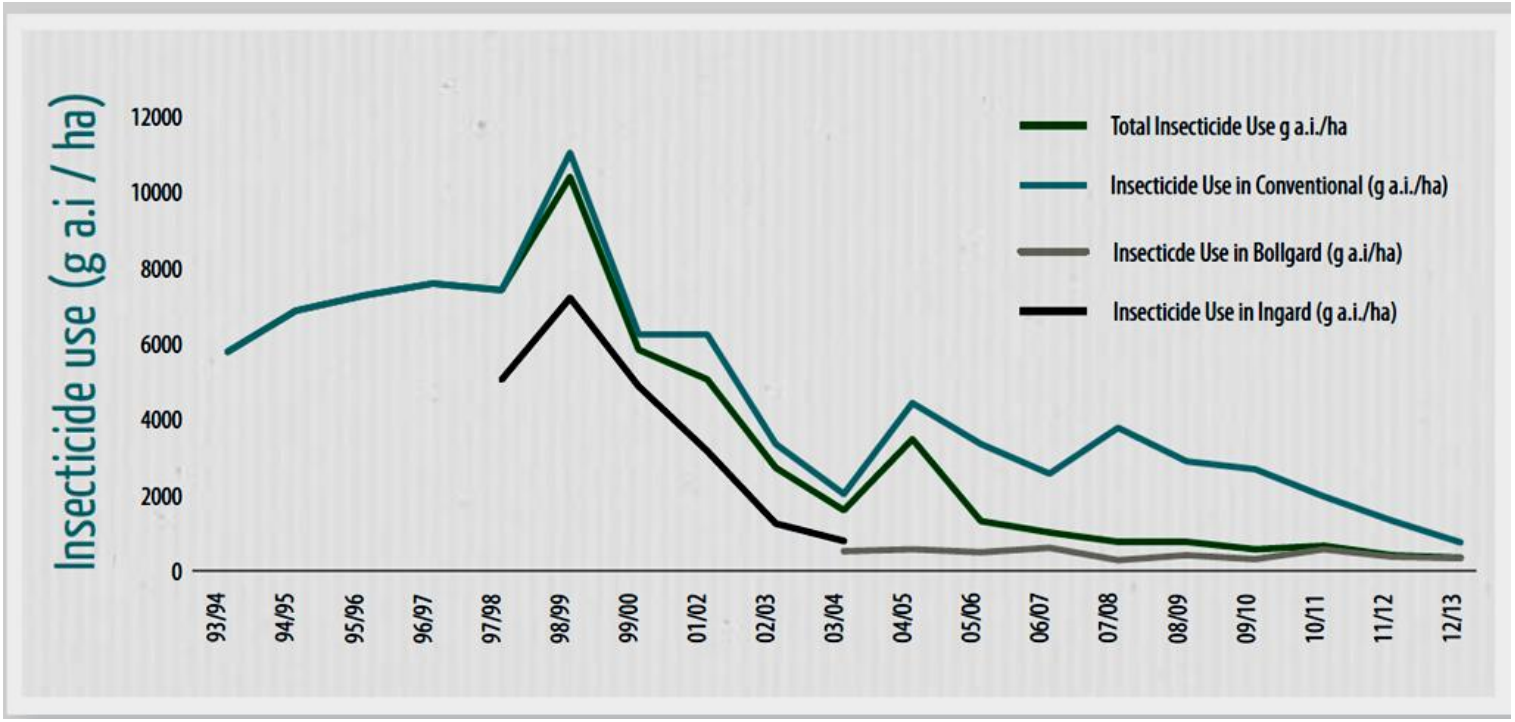
Spotlight

Engineering Dual Begomovirus-*Bemisia tabaci* Resistance in Plants

Syed Shan-e-Ali Zaidi,[1] Rob W. Briddon,[1] and Shahid Mansoor[1,*]

# Australia

## Spectacular results
## Consistent growth in yield
## Precision input management
## Insecticide applications minimum at 2-3 per season
## Great example of SCIENCE BASED MANAGEMENT




Source: CRDC. Australian Grown Cotton, Sustainability Report 2014,

# Friends in the cotton Ecosystem

Tobacco hornworm *Manduca sexta* (L) parasitized by *Cotesis congregata*.
Photograph Justin Bredlau, Virginia Commonwealth University.

# Way Forward

1. **Conservation Agriculture**
2. **Biological** -Soil nutrient and health enhancement
3. **Cropping systems:** Cereals-Legumes/pulses-Fodder
4. **Use Biotech to the best potential**

# Management




1. Available GM traits in native varieties
2. Short duration varieties
3. Early sowing
4. Judicious fertilizers
5. Conserve Natural control
6. Legume based cropping systems
7. IPM STRATEGIES

**Insects ruled the earth for 330 Million years**
**Man evolved only 1.5 Million years ago**

**We inherited this planet from insects**


Be Calm, But Prevent The Storm..
Thank You
Photograph by K. R.Kranthi