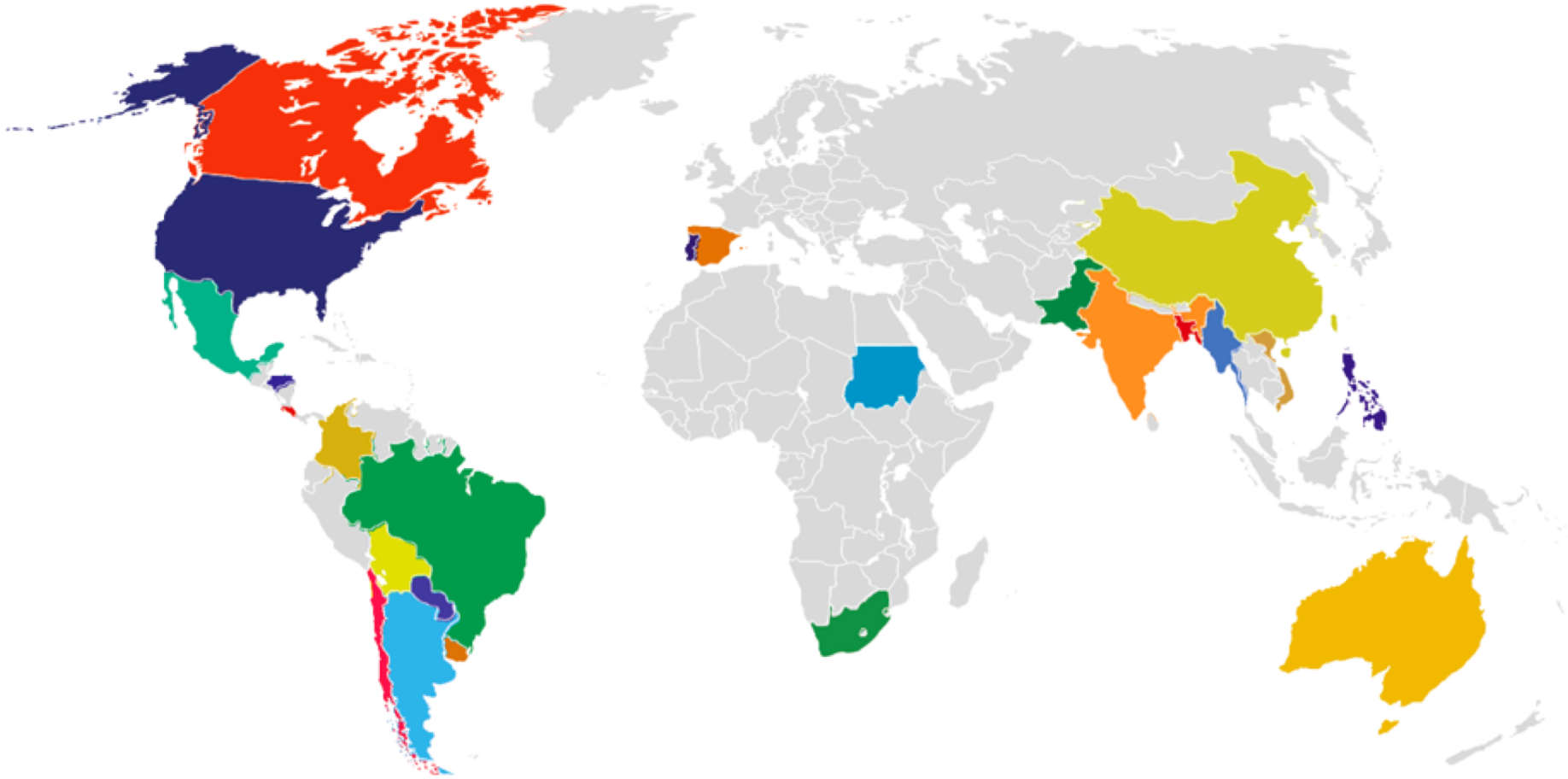
Biotech Cotton

Keshav R. Kranthi
International Cotton Advisory Committee
Washington DC

Where are Biotech Crops Grown?

189.8 m hectares

% Global share	
USA	40
Brazil	26
Argentina	12
Canada	7
India	6
Others	9



24 countries which have adopted biotech crops

Source: ISAAA, 2017

Four Major Biotech Crops

SOYBEAN

grown in 11 countries
81% of global planting

50

COTTON

grown in 15 countries
81% of global planting

13

MAIZE

grown in 17 countries
35% of global planting

31

CANOLA

grown in 4 countries
30% of global planting

5

99 % Global Share

Source: ISAAA, 2017

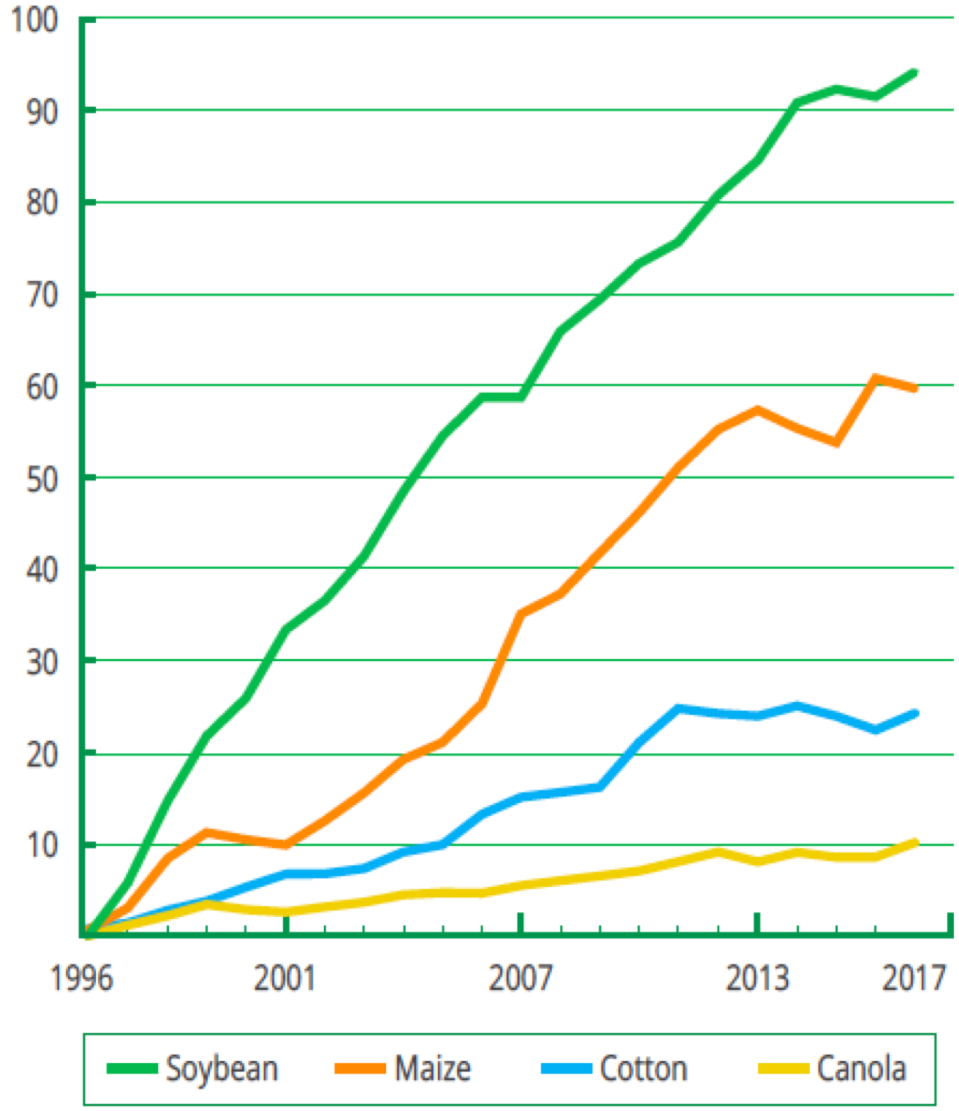


Figure 16. Global Area of Biotech Crops, 1996 to 2017: by Crop (Million Hectares)

Source: ISAAA, 2017

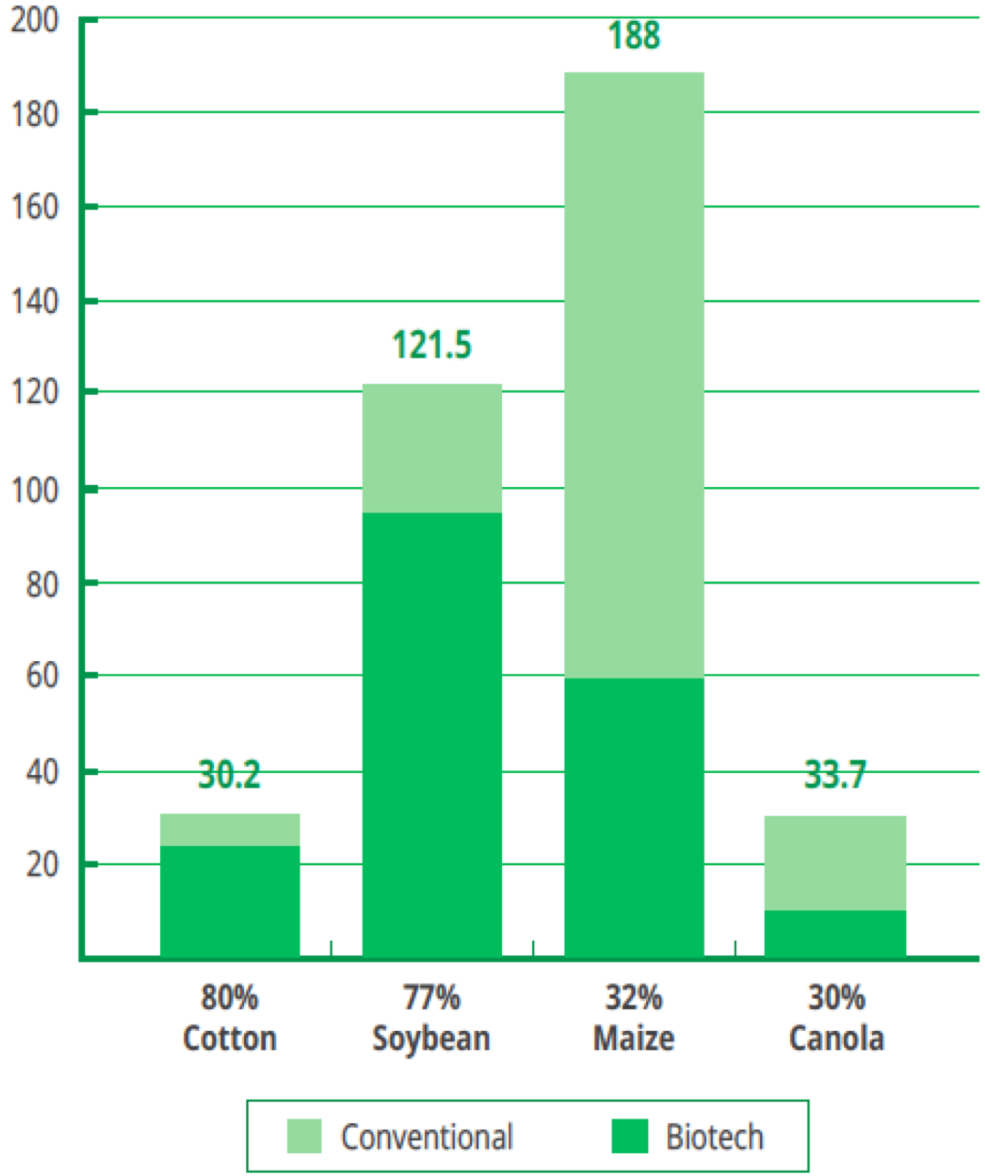


Figure 17. Global Adoption Rates (%) for Principal Biotech Crops, 2017 (Million Hectares)

Source: ISAAA, 2017

Two Major Traits

Herbicide Tolerance

Insect Resistance

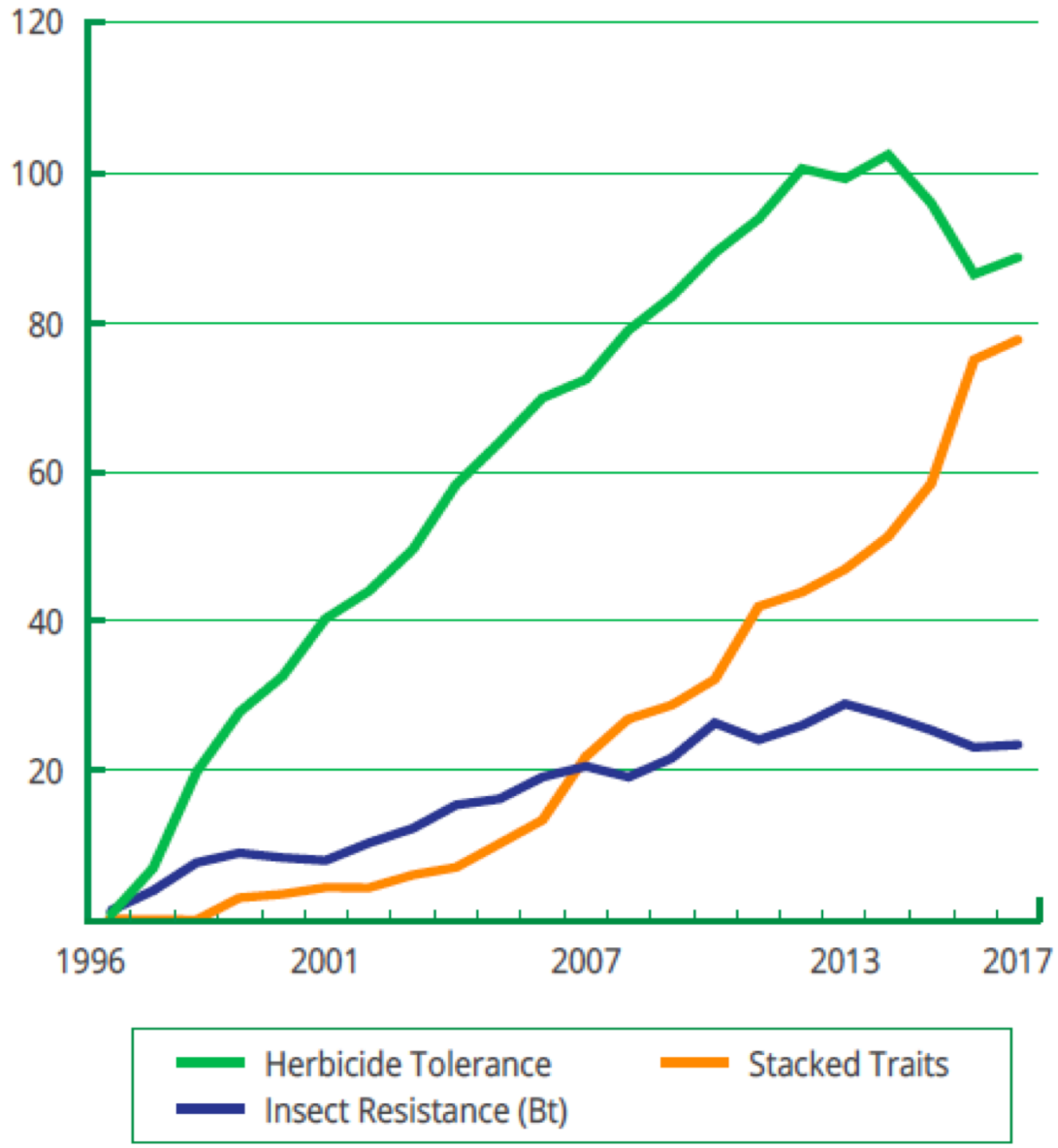


Figure 18. Global Area of Biotech Crops, 1996 to 2017: by Trait (Million Hectares)

Source: ISAAA, 2017

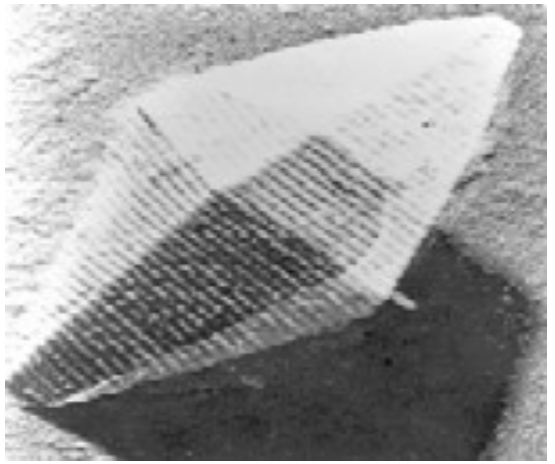
Herbicide Tolerant GM Cotton, Soybean, Maize, Rice, Canola

Bt

Bacillus thuringiensis **(Bt) is a gram positive soil bacterium that produces insecticidal proteins.**

Bt was discovered by Ishawata in 1901 in Japan & first used commercially in France in 1938.

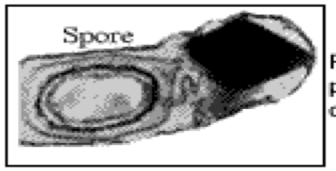
There are 67 subspecies of *B. thuringiensis*.



There are 329 Cry toxins, 17 Cyt toxins and 65 VIP toxins reported from Bt

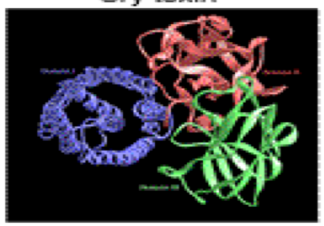
Bacillus thuringiensis

Gram-positive, spore-forming soil bacterium



Produce insecticidal crystal proteins (δ-endotoxins) during sporulation

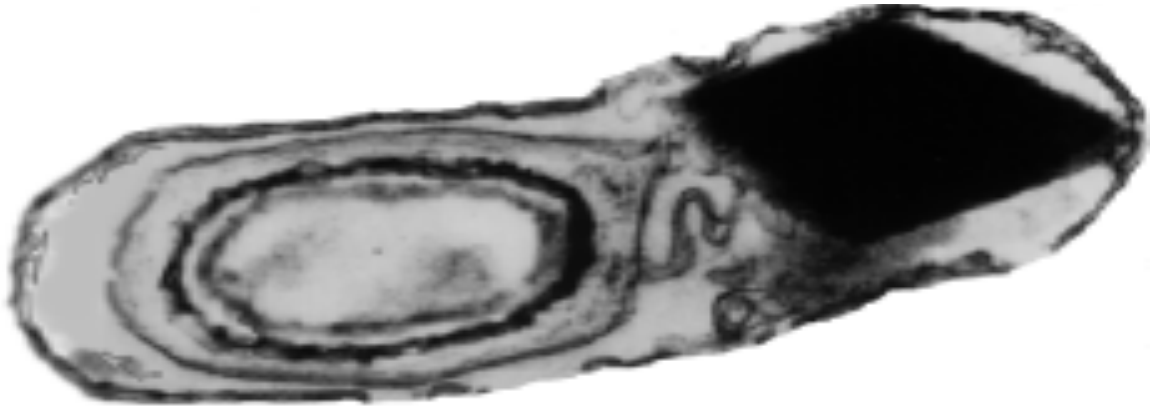
Cry toxin

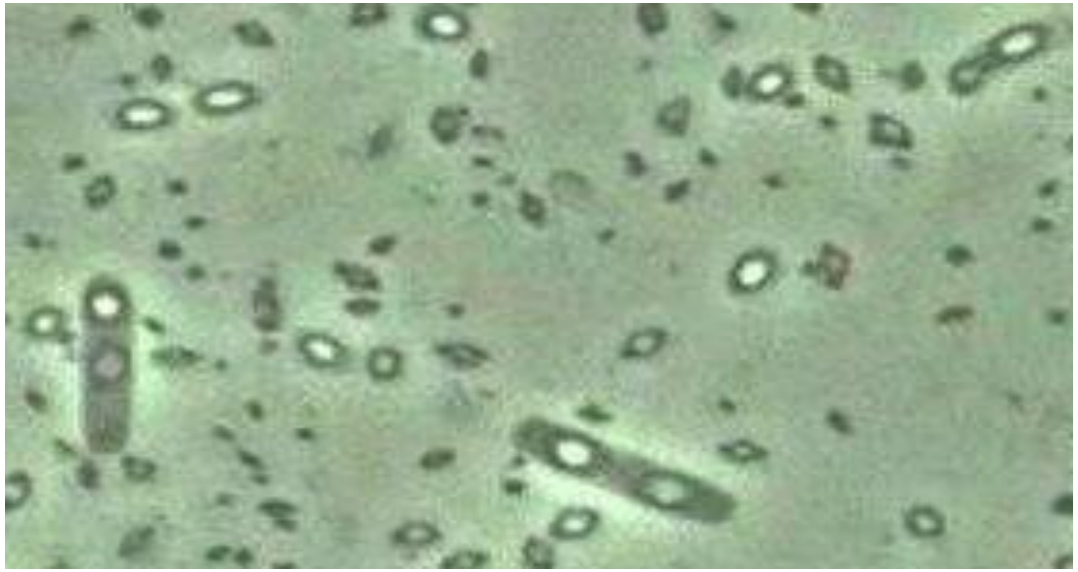


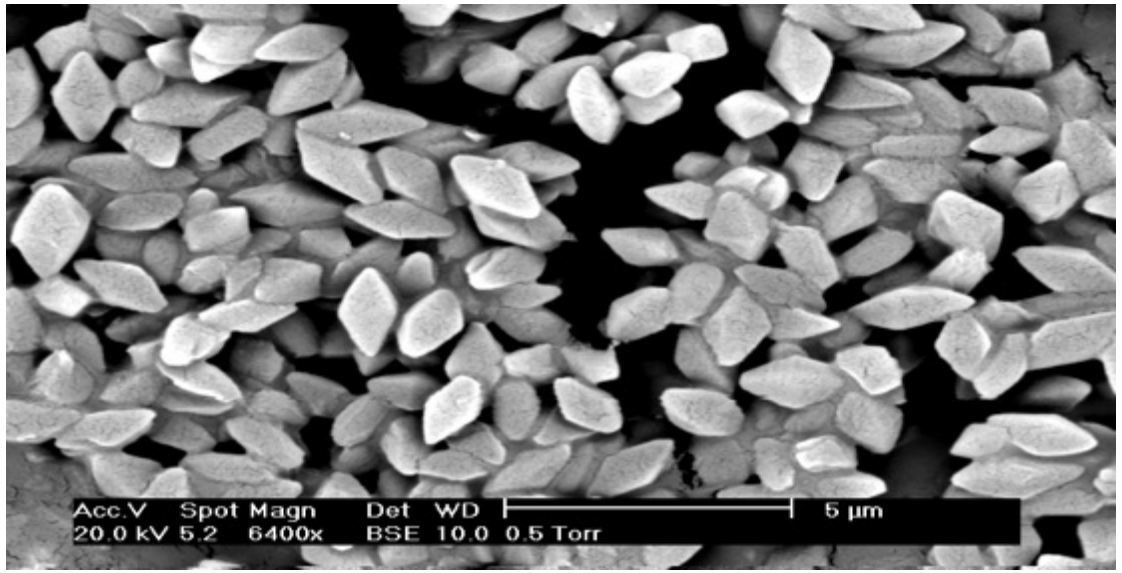
Most *Bt* strains can synthesise more than one crystal, which may be formed by different Cry toxins

Crystal Toxins				
Toxin	Number	Shape	Size	Toxicity
Cry1	173 Aa to La	Bipyramidal	130-135	Caterpillars
Cry2	51 Aa to Ai	Cuboidal	70	Caterpillars and flies
Cry3	18 Aa to Ca	Flat/irregular	74	Beetles
Cry4	14 Aa to Cc	Bipyramidal	70-133	Flies
Cry5 to Cry59	203 Aa to Aa	Multiple	33-130	Undefined
Cytolytic Toxins				
Cyt1	10 Aa to Ca	Multiple		
Cyt2	17 Aa to Ca	Multiple		
Vegetative Insecticidal Proteins				
VIP1	8 Aa to Da	Multiple		
VIP2	11 Aa to Bb	Multiple		
VIP3	47 Aa to Bb	Multiple		

Bacillus thuringiensis

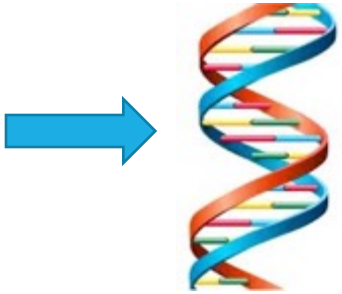




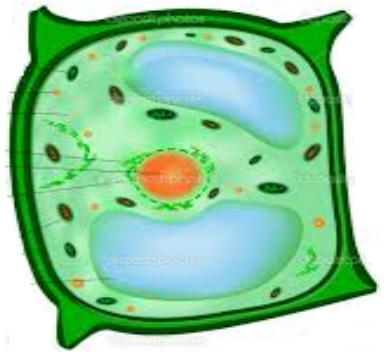


Development of Bt cotton

Bacillus thuringiensis



Bt gene

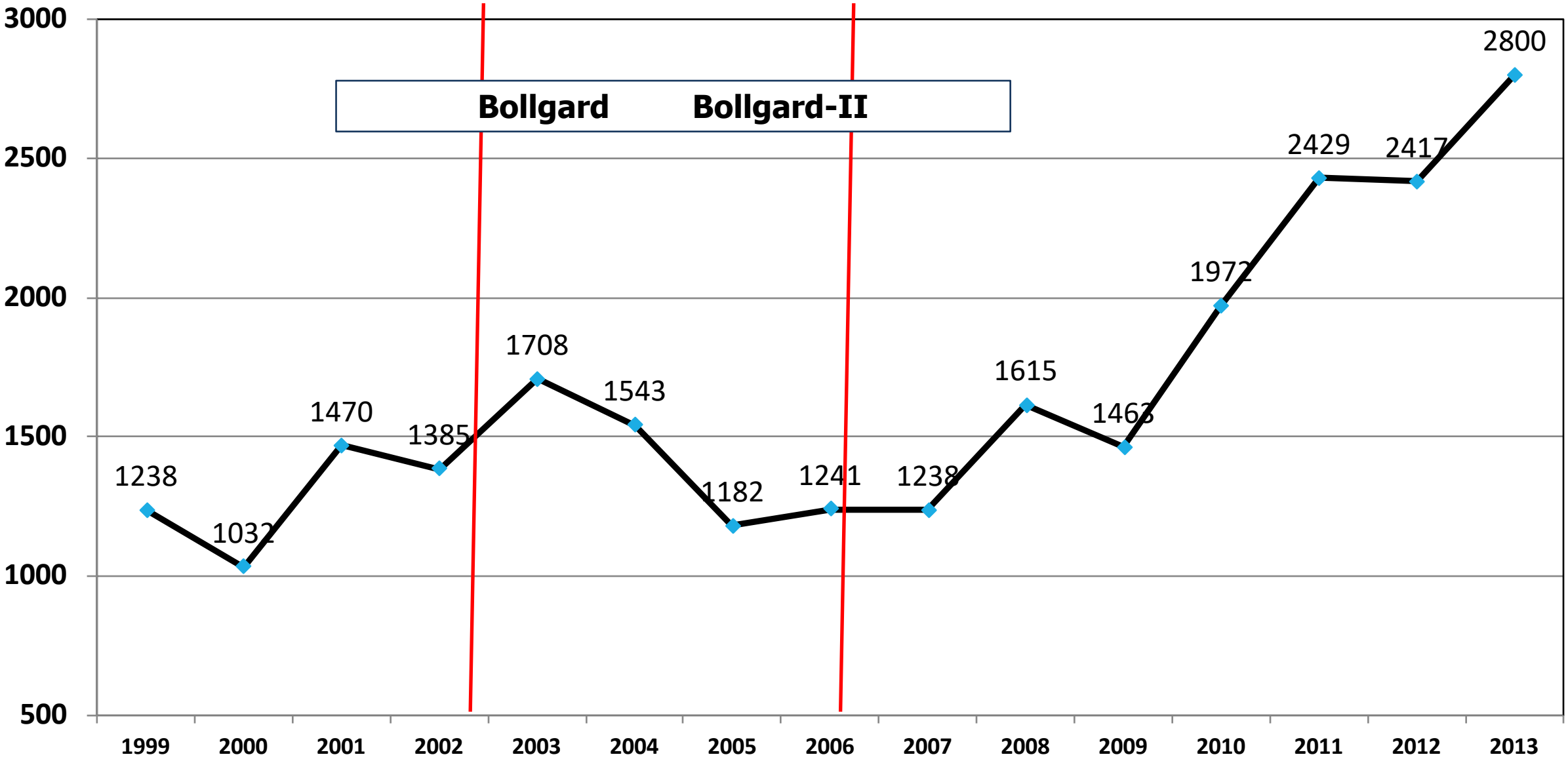


Cotton plant cell

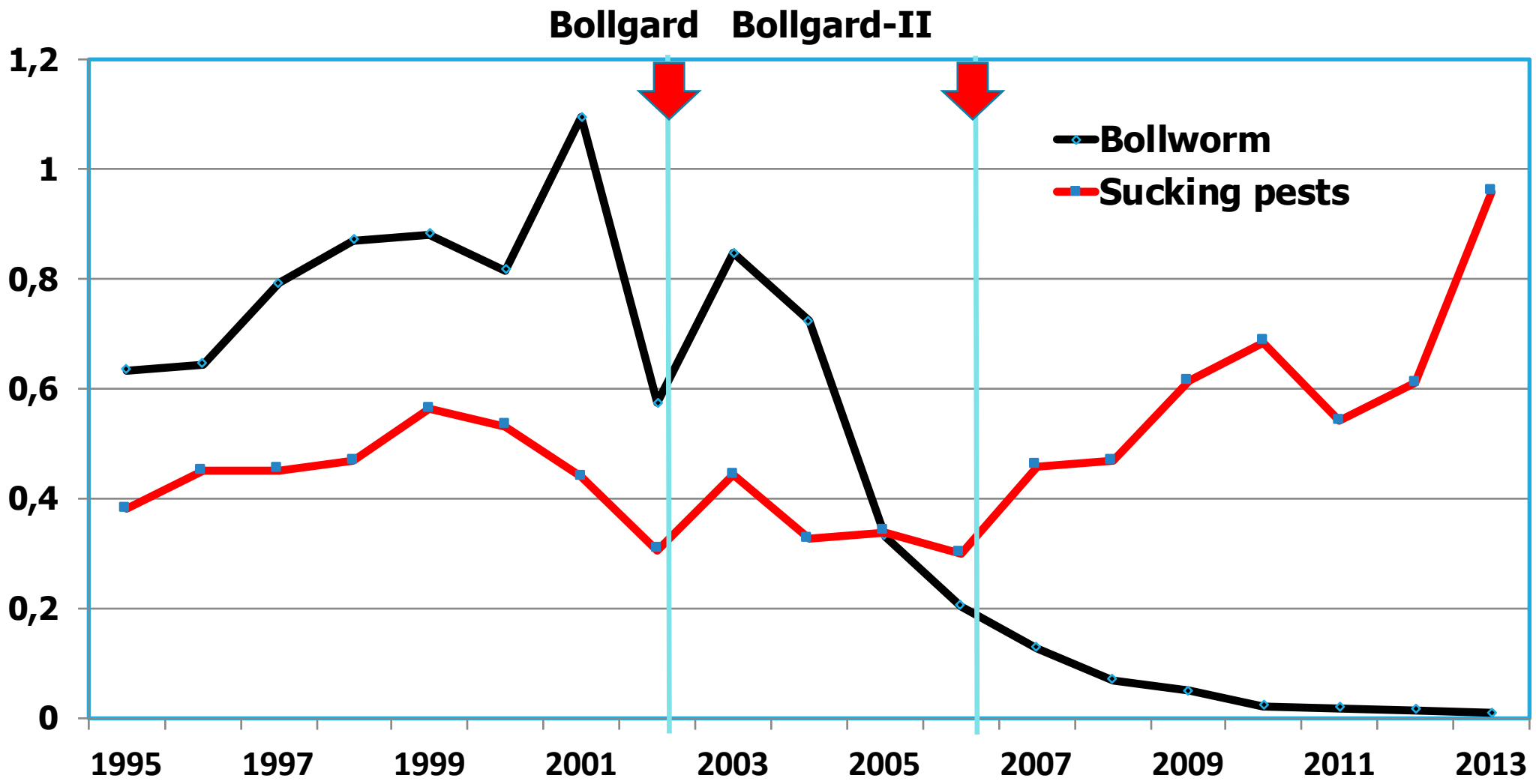
Bt Cotton

Rapid Adoption of GM Cotton

India- Insecticides Rs/ha



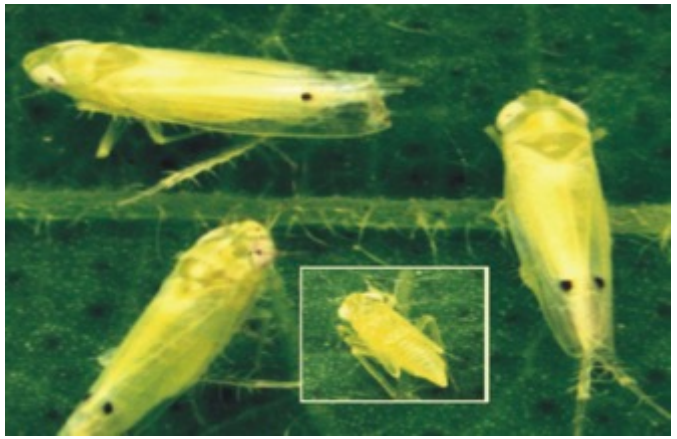
Insecticides Kg/ha



Impact of Bt hybrids

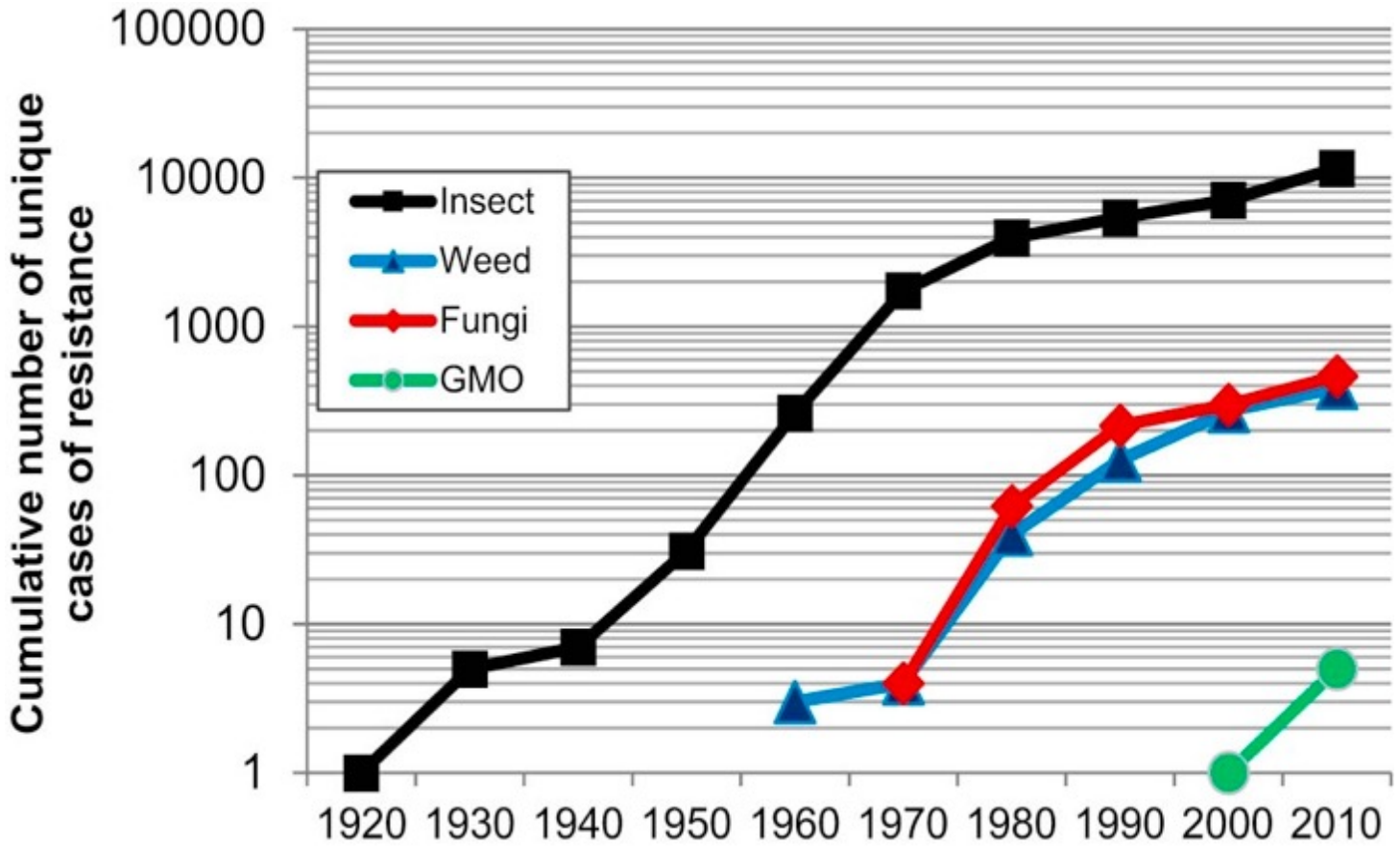
	Area in lakh ha		Yield	Hybrids	Insecticide use Mt	
Year	BG	BG-II	Kg/ha	No.	Sucking Pests	Bollworms
2001					3312	9410
2002	0.3		302	3	2110	4470
2003	0.9		399	3	2909	6599
2004	5		470	4	2735	6454
2005	10		472	20	2688	2923
2006	36	1	521	62	2374	1874
2007	59	5	554	138	3805	1201
2008	55	20	524	283	3877	652
2009	36	48	503	564	5816	500
2010	37	64	517	809	7270	249
2011	26	85	496	1128	6372	222
2012	19	93	477	1128	6872	178

Minor Pests Became Major Pests






Cases of Insect, Weed & Fungal Resistance to Pesticides and GM crops

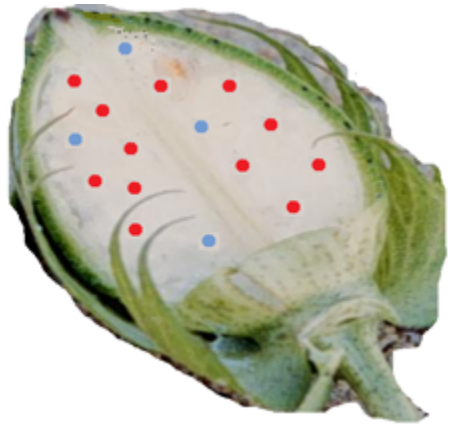


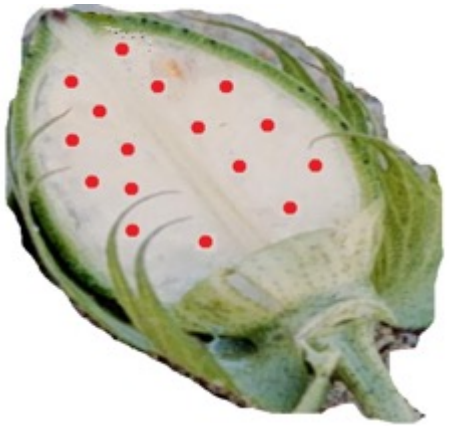
Resistance to Bt Crops

Bt transgenic crops			
Fall armyworm, ***Spodoptera frugiperda***	Bt Cry 1F **corn**	Puerto Rico	2010
Pink bollworm, ***Pectinophora gossypiella***	Bt Cry 1Ac **cotton**	India	2011
	Bt Cry1Ac+ Cry2Ab **cotton**	India	**2018**
African stem borer ***Busseola fusca***	Bt Cry 1 Ab **corn**	South Africa	2011
Western corn rootworm, ***Diabrotica virgifera***	Bt Cry 3 Bb 1 **corn**	USA	2011
Cotton Bollworm ***Helicoverpa zea***	Bt Cry 1 Ac **cotton**	USA	2010

Bolls of Bt-cotton

25% developing seeds in BG & 6.25% in BG-II do not have Bt





Only India cultivates hybrids

BG: 75% seeds have Cry1Ac in bolls on F-1 hybrid plants. 25% are non-Bt

BG-II: 93.75% seeds have Bt

56.25% seeds have Cry1Ac+Cry2Ab;

18.75% seeds have Cry1Ac;

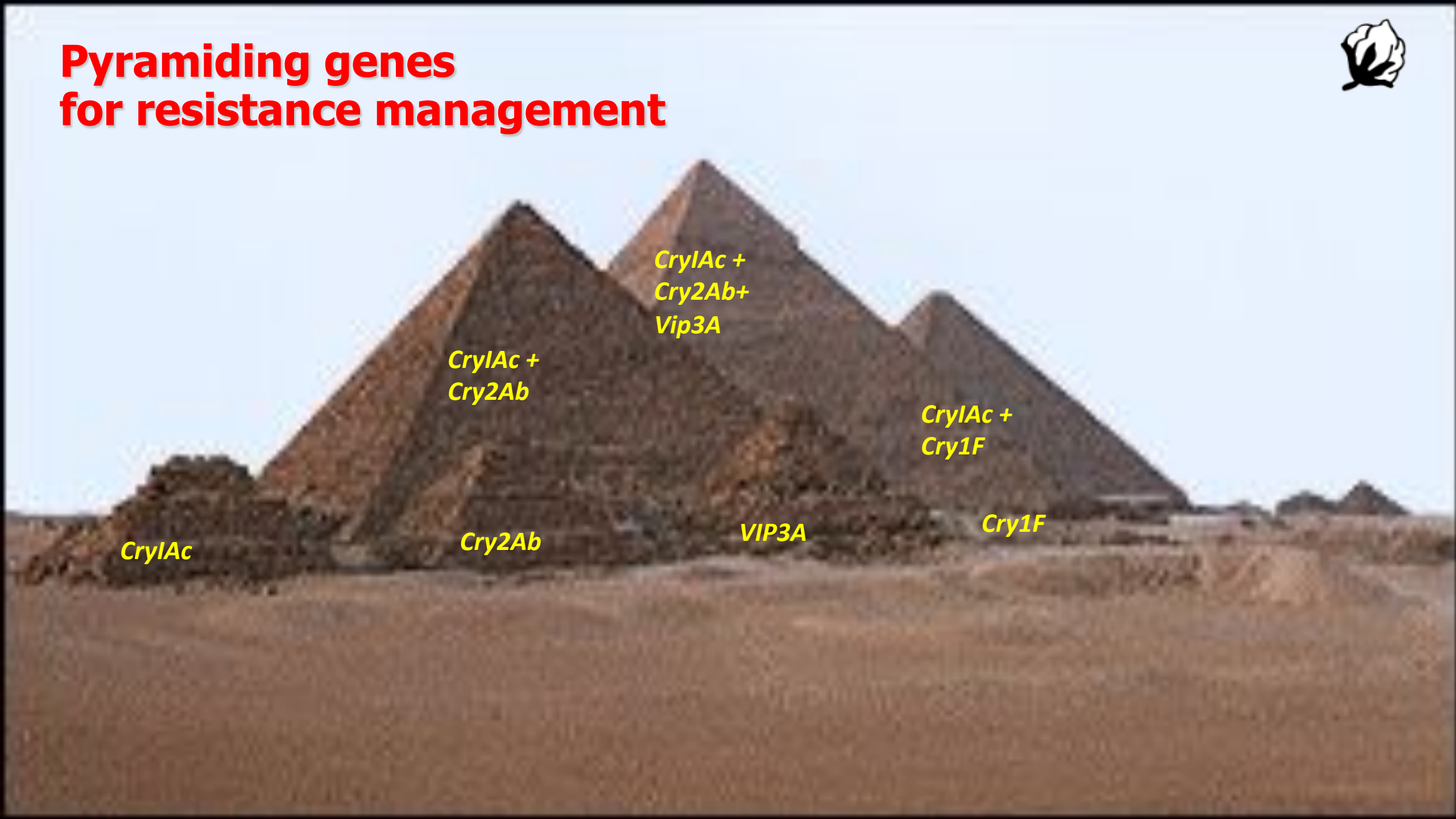
18.75% seeds have Cry2Ab and

6.25% are non-Bt

All other countries have Bt varieties

100% seeds have both Cry toxins in bolls

Pyramiding genes for resistance management



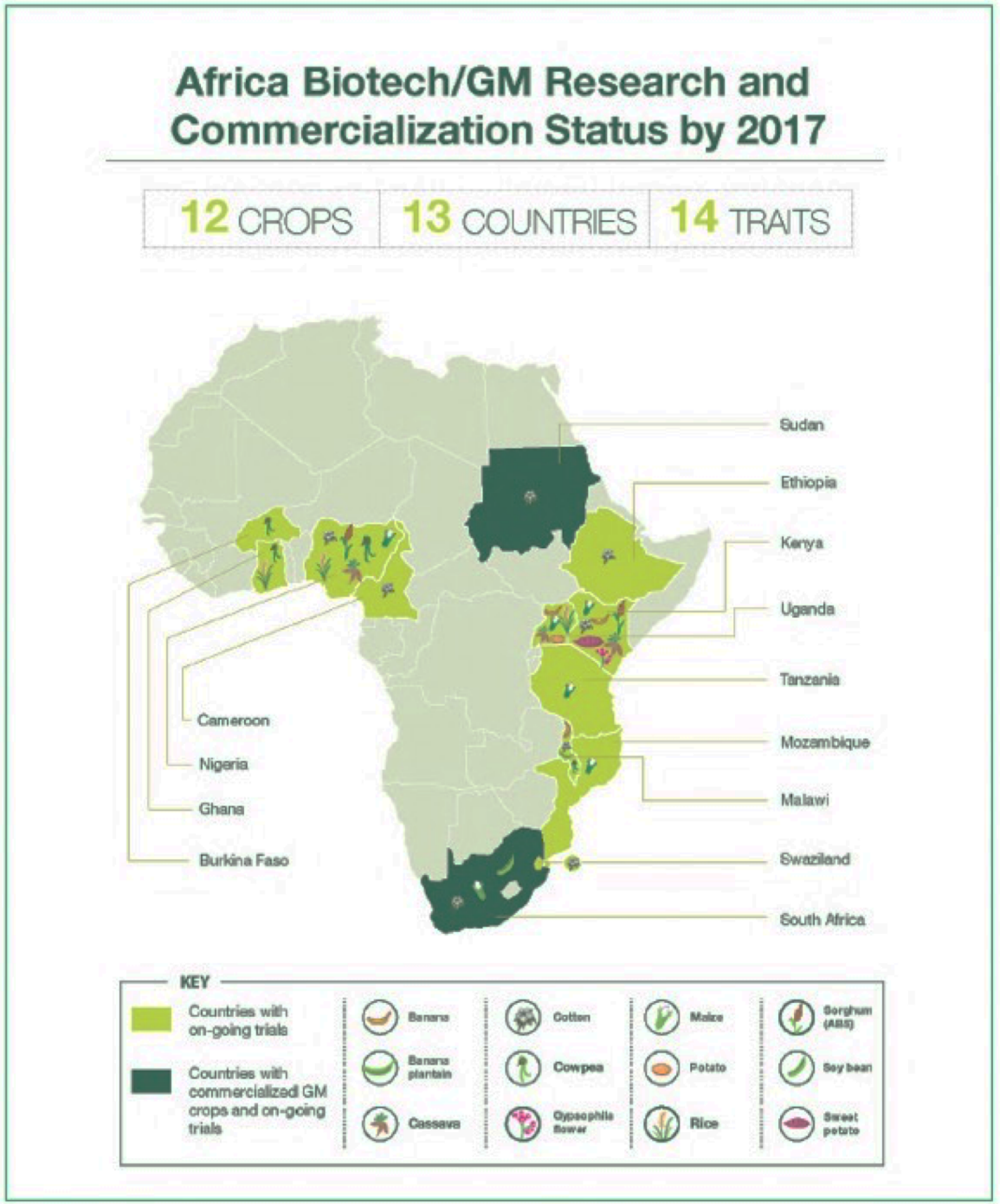
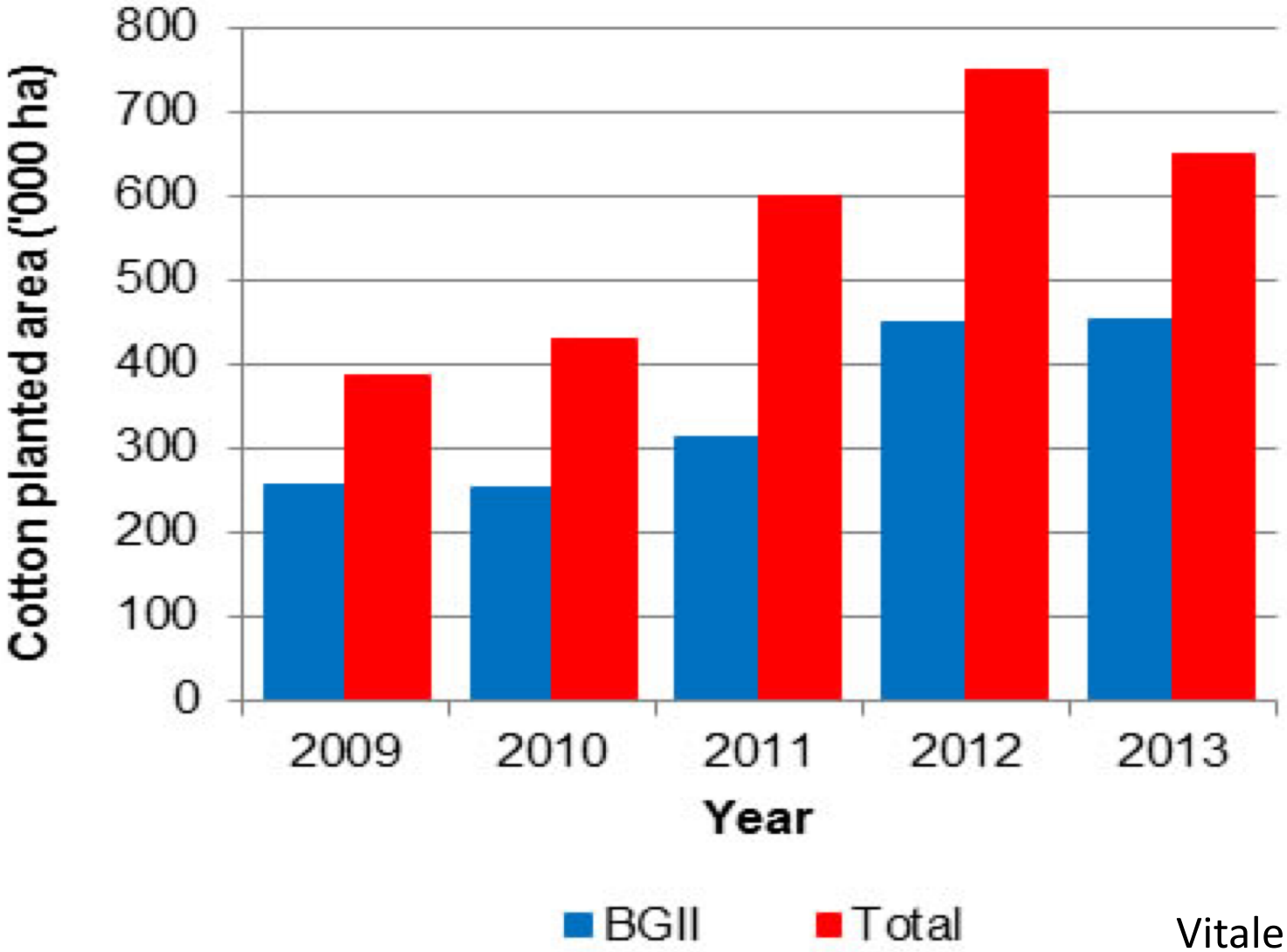


Figure 14a. Africa Biotech/GM Research and Commercialization Status in 2017

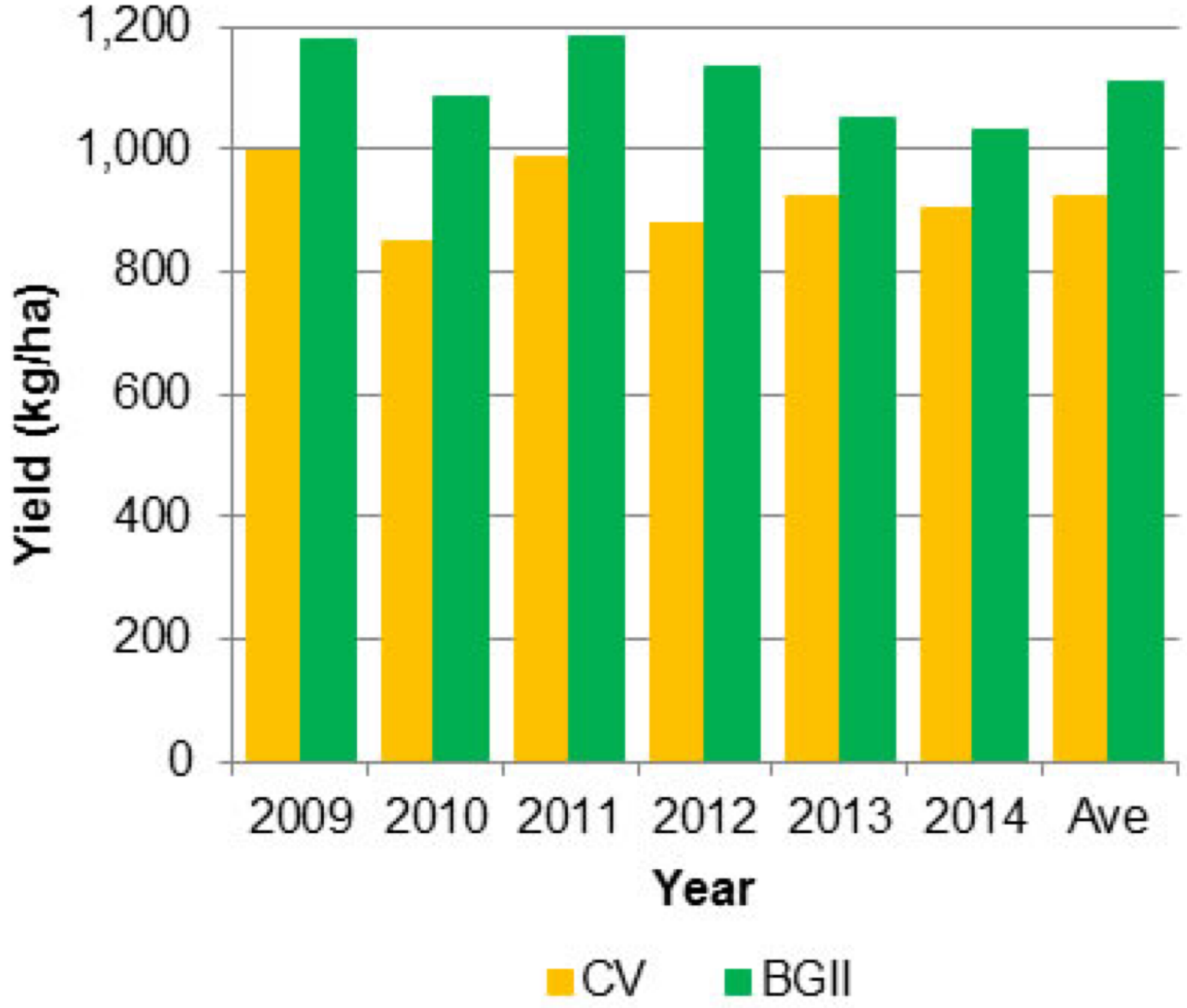
Source: ISAAA, 2017

Bt-cotton Area in Burkina Faso



Vitale et al., 2016. AgBioForum

Bt-cotton Yields in Burkina Faso

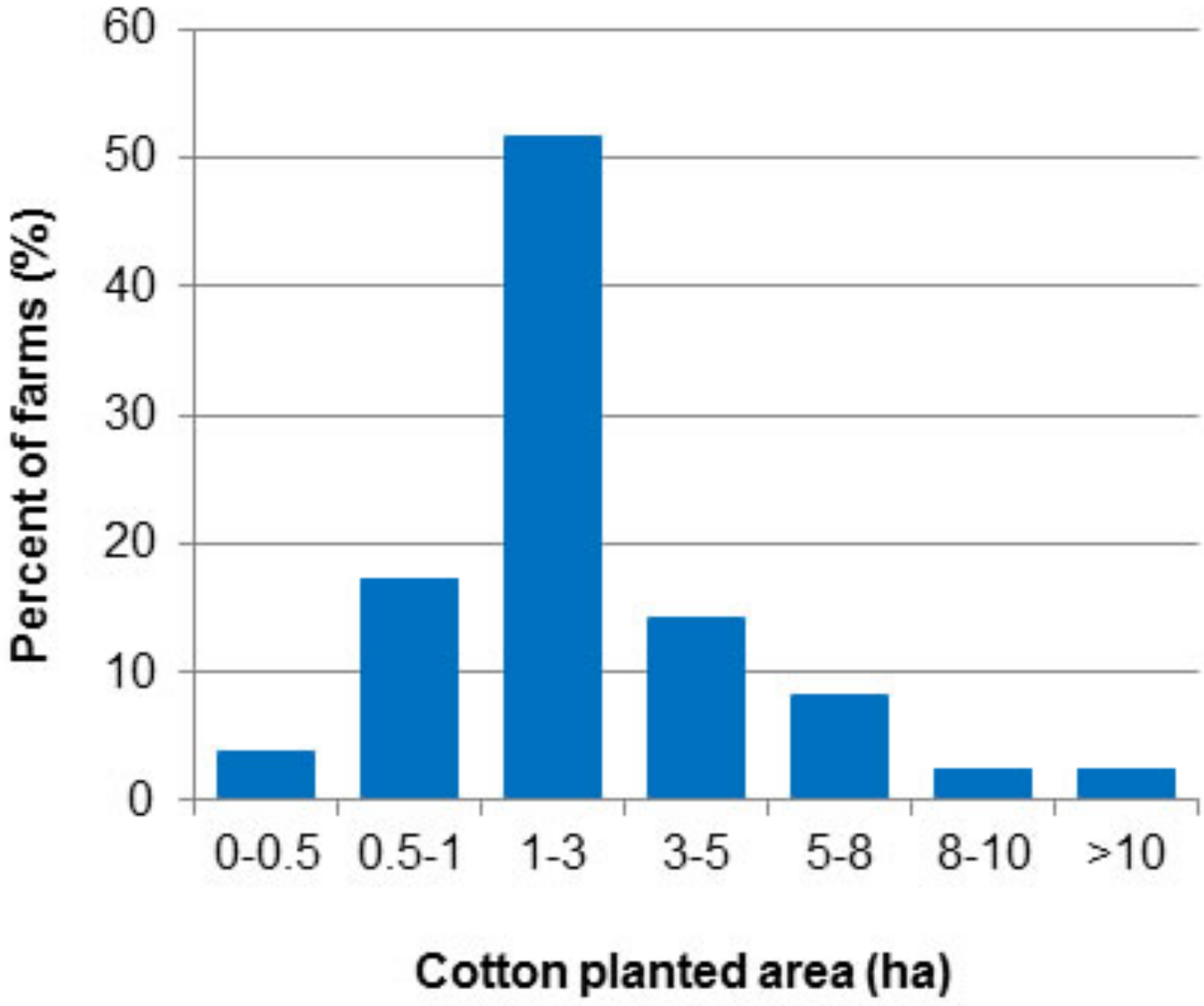


Insecticide Sprays

Conventional	5
Bt-cotton	1.5

Vitale et al., 2016. AgBioForum

Bt-cotton holdings in Burkina Faso



Vitale et al., 2016. AgBioForum

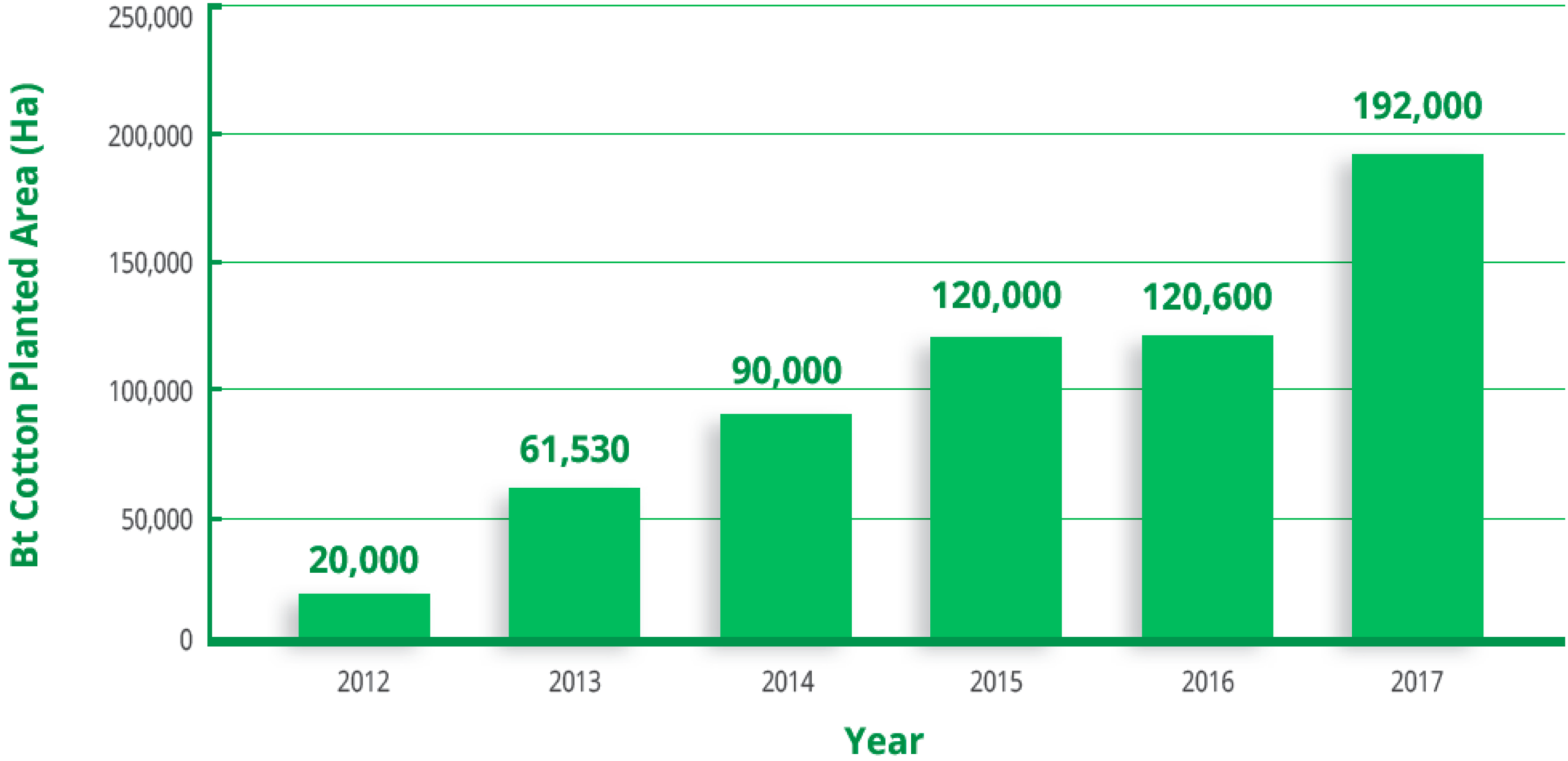


Figure 13. IR Cotton Adoption in Sudan 2012-2017

Source: ISAAA, 2017

Kenya, Ethiopia, Mozambique, Swaziland & Sudan

Cotton, Maize, Gypsophila, Cassava, Sorghum, Banana & Sweet Potato

Kenya

- **Maize** — Drought tolerance: Water Efficient Maize for Africa (WEMA)
- **Maize** — WEMA Insect resistance (Bt maize)
- **Maize** — Stacked maize event for Bt and Drought
- **Cotton** — Insect resistance
- **Gypsophila flower** — Pink Colouration of Petals
- **Cassava** — Cassava Brown Streak Disease (CBSD)
- **Cassava** — Cassava Mosaic Disease (CMD)
- **Sweet potato** — Resistance to Sweet potato virus disease
- **Banana** — Banana bacterial -Xanthomonas Wilt (BXW) resistance
- **Sorghum (ABS)** — Biofortification

Ethiopia

- **Cotton** — Insect resistance

Mozambique

- **Maize** — Stacked trait- Drought tolerance and Insect resistance (WEMA)

Sudan

- **Cotton** — Insect resistance

Swaziland

- **Cotton** — Insect resistance

Source: ISAAA, 2017

Nigeria, Tanzania & Uganda

Cotton, Cassava, Sorghum, Maize, Rice, Banana, Potato & Cowpea

Nigeria

Cowpea	Insect resistant to Maruca pest
Sorghum (ABS)	Biofortification
Rice	Nitrogen use ,Water efficiency and salt tolerant (NUWEST) Rice
Maize	Insect resistance Bt + Herbicide tolerant Ht corn
Cotton	Insect resistance
Cassava	Delayed postharvest starch deterioration

Tanzania

Maize	Drought tolerance; Stacked – Bt/DT (WEMA)

Uganda

Maize	Drought tolerance and Insect resistance stacked events (WEMA)
Banana	Banana bacterial -Xanthomonas Wilt (BXW) resistance
	Banana parasitic nematode resistance
	Biofortification
Cassava	Cassava brown streak Disease (CBSV) resistance
	Cassava Mosaic Disease
Rice	Nitrogen Use/Water Efficiency and salt tolerant
Potato	Late blight Disease resistance

Source: ISAAA, 2017

Malawi, Ghana, South Africa, Burkina Faso & Cameroon

Cotton, Maize, Soybean, Rice & Cowpea

Malawi

- **Cotton** ..... Insect resistance
- **Cowpea** ..... Insect resistance
- **Banana** ..... Bunchytop virus resistance
- **Banana plantain** ..... Bunchytop virus resistance

Ghana

- **Rice** ..... Nitrogen Use Efficiency/Water Use Efficiency and Salt Tolerance
- **Cowpea** ..... Insect resistance to maruca pest

South Africa

- **Cotton** ..... Insect resistance/Herbicide tolerance multi-stacks
- **Maize** ..... Drought tolerance and insect resistance
Insect resistance/Drought tolerant Multi-stacks
- **Soy bean** ..... Stacked trait with modified fatty acid composition

Burkina Faso

- **Cowpea** ..... Insect resistance to maruca pest

Cameroon

- **Cotton** ..... Stacked insect resistance and herbicide tolerance

Source: ISAAA, 2017

Table 32. Crop Traits under various stages of research in Africa by 2018

Crop	Country	Traits
Banana	Uganda, Malawi, Kenya	Biofortified Black sigatoka Banana bacterial-*Xanthomonas* wilt (BXW) resistance
Banana Plantain	Malawi	Bunchy top virus resistance
Cassava	Kenya, Nigeria, Uganda	Cassava mosaic Disease Cassava brown streak Disease Delayed postharvest starch deterioration
Cowpea	Burkina Faso, Ghana, Malawi, Nigeria	Maruca resistance (insect resistance)
Cotton	Ethiopia, Kenya, Nigeria, Swaziland	Insect (bollworm) resistance
Gypsophila Flower	Kenya	Pink coloration of petals
Maize	Kenya, Mozambique, Tanzania, South Africa, Uganda, Nigeria	Insect resistance (IR) Drought tolerance (DT) Stacked IR/DT
Potato	Uganda	Late blight
Rice	Burkina Faso, Ghana, Nigeria, Uganda	Nitrogen Use Efficiency Water Use Efficiency
Sorghum	Kenya, Nigeria	Biofortified
Sweet potato	Kenya	Sweet potato virus disease resistance
Soybean	South Africa	Stacked trait with modified fatty acid composition

Note: 12 Crops; 13 Countries; 14 Traits

Source: ISAAA, 2017

Biotech -Alarms

The case of Monarch Butterfly

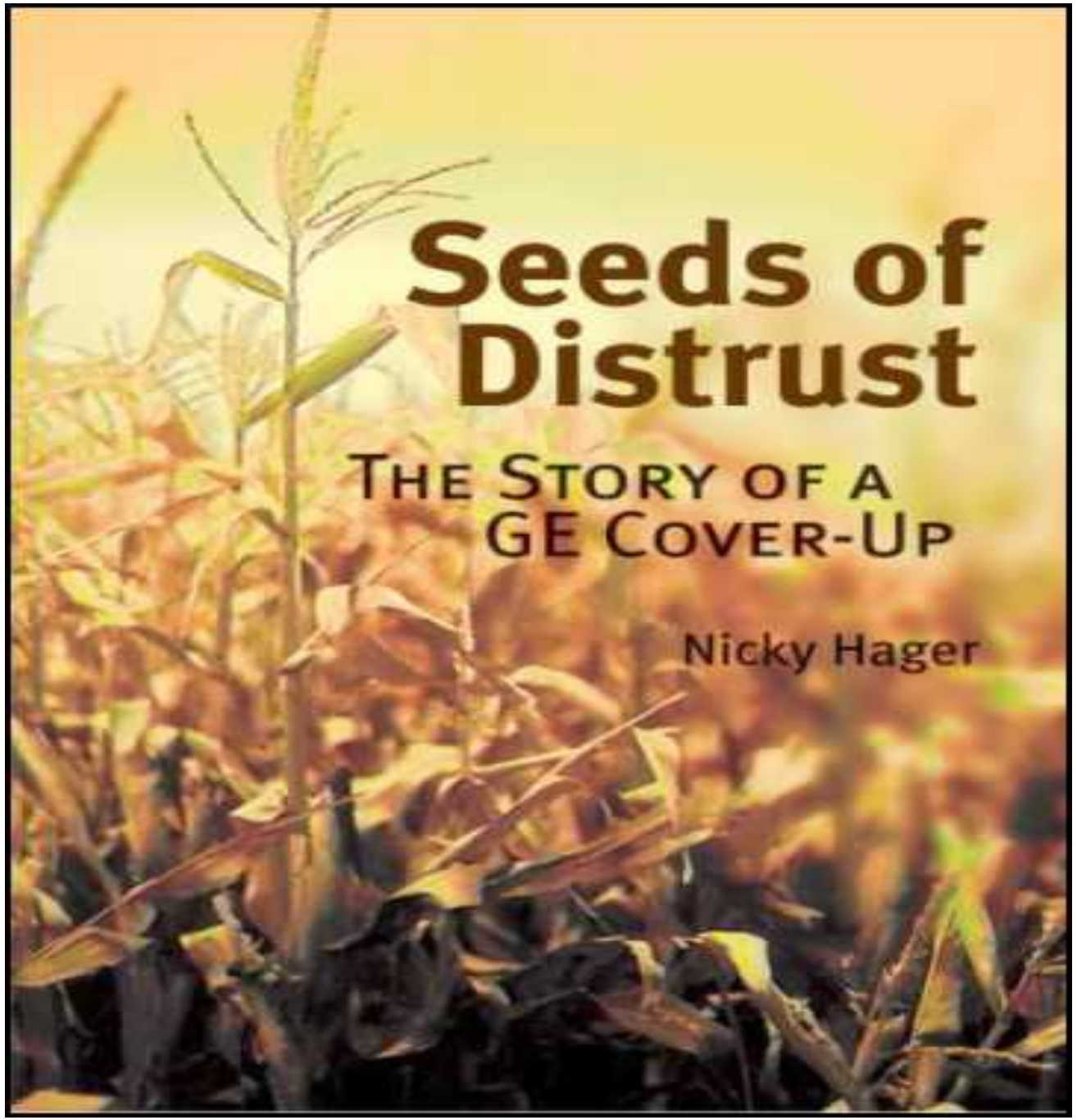
Now proven to be false alarm

Horizontal gene flow to non-target and humans from GM crops: Resistance to antibiotics?

Although the probability of transfer is low, the use of technology without antibiotic resistance genes has been encouraged by a recent FAO/WHO expert panel

Allergies

GM Soybean with Brazil nut protein and **STARLINK** Cry9C Maize were withdrawn - suspected -unsubstantiated allergy possibilities



CORNGATE SCANDAL

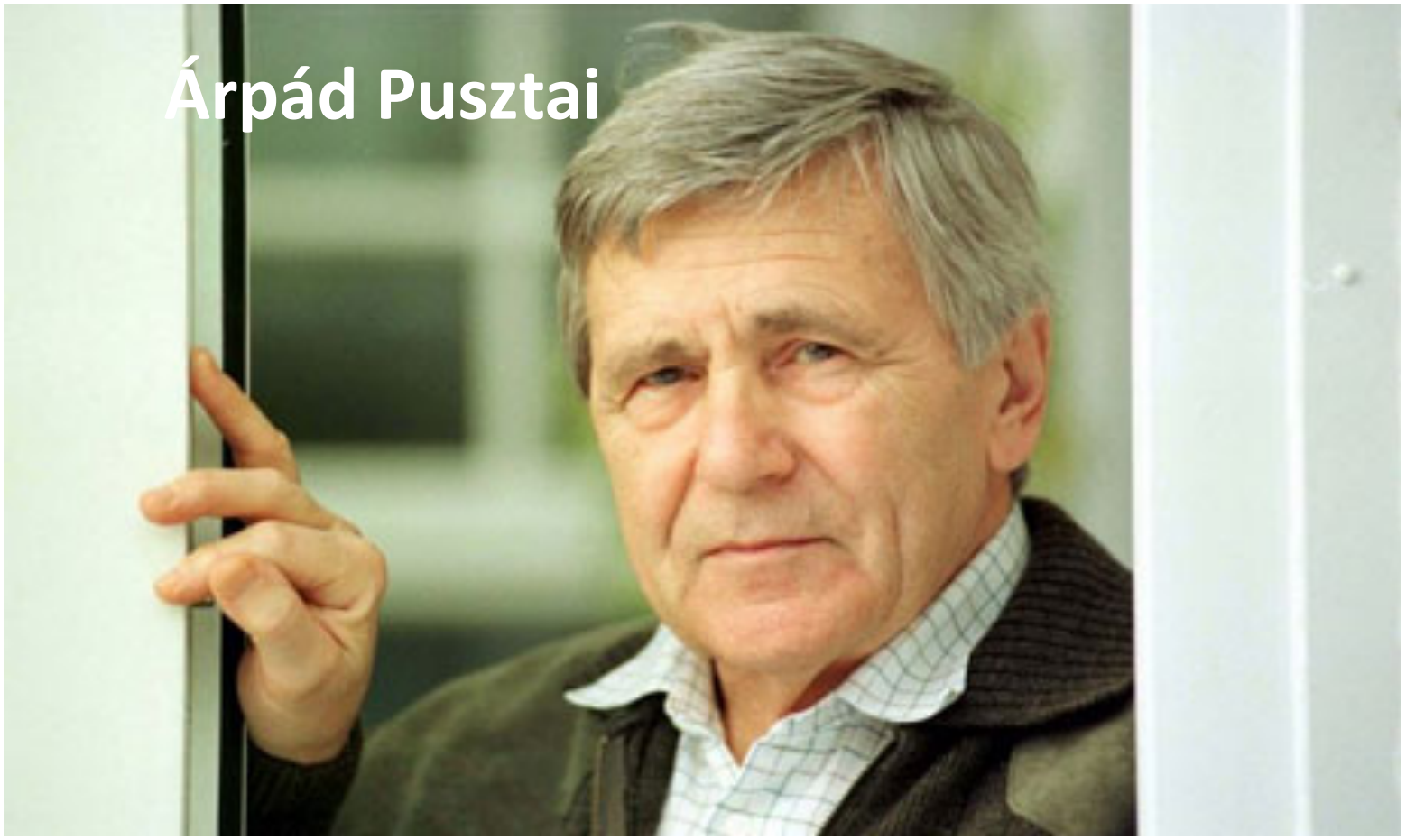
Imported corn seeds from US were reported to have GM

NEWZEALAND

2002

Gene flow from biotech crops

Does it threaten biodiversity?



“feeding on GM potatoes with snowdrop lectin genes caused damage to intestines and immune system of rats”.

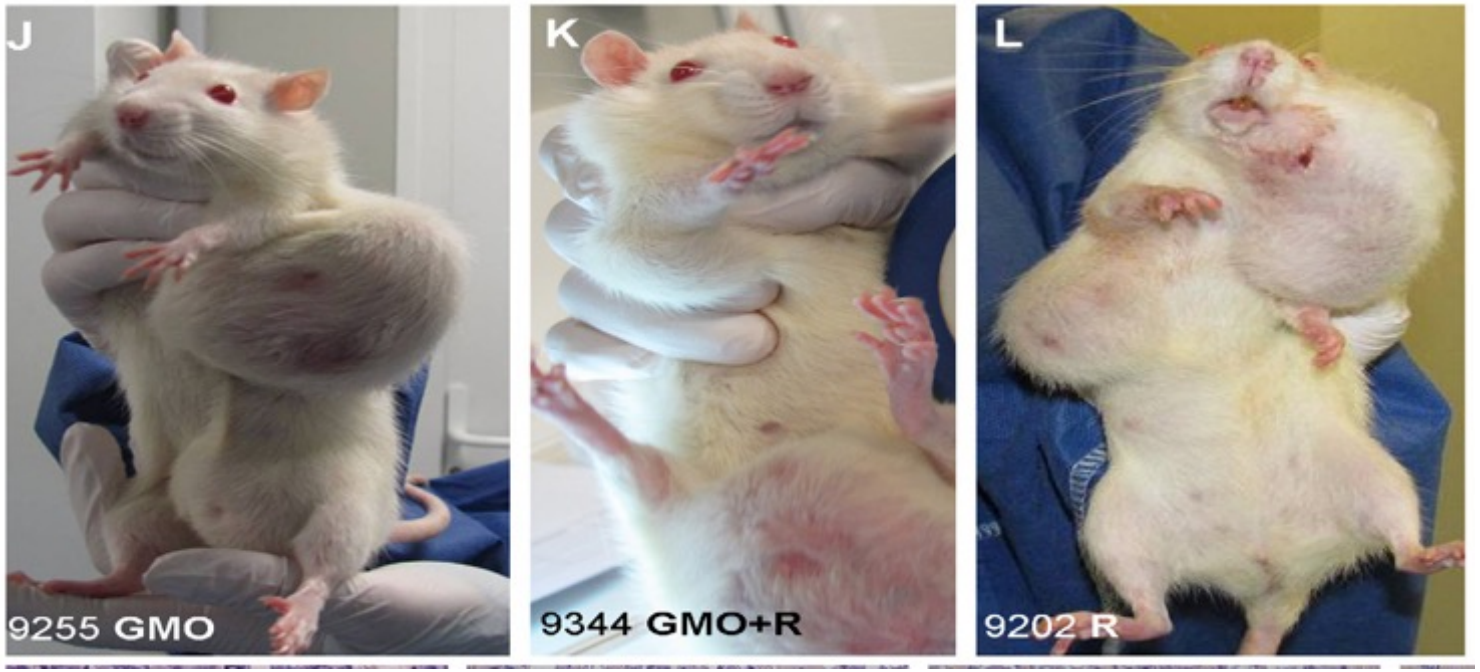
1998: "If I had the choice I would certainly not eat it,"

Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize

Gilles-Eric Séralini [a,*], Emilie Clair [a], Robin Mesnage [a], Steeve Gress [a], Nicolas Defarge [a], Manuela Malatesta [b], Didier Hennequin [c], Joël Spiroux de Vendômois [a]

[a] University of Caen, Institute of Biology, CRIIGEN and Risk Pole, MRSH-CNRS, EA 2608, Esplanade de la Paix, Caen Cedex 14032, France
[b] University of Verona, Department of Neurological, Neuropsychological, Morphological and Motor Sciences, Verona 37134, Italy
[c] University of Caen, UR ABTE, EA 4651, Bd Maréchal Juin, Caen Cedex 14032, France

Food & Chemical Toxicology, 19th September 2012



Contents lists available at ScienceDirect

Reproductive Toxicology

journal homepage: www.elsevier.com/locate/reprotox

Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Quebec, Canada

Aziz Aris[a,b,c,*], Samuel Leblanc[c]

[a] Department of Obstetrics and Gynecology, University of Sherbrooke Hospital Centre, Sherbrooke, Quebec, Canada
[b] Clinical Research Centre of Sherbrooke University Hospital Centre, Sherbrooke, Quebec, Canada
[c] Faculty of Medicine and Health Sciences, University of Sherbrooke, Sherbrooke, Quebec, Canada

Blood of thirty pregnant women (PW) and thirty-nine nonpregnant women (NPW) were studied. Serum GLYP and GLUF were detected in NPW and not detected in PW. Serum 3-MPPA and

CryAb1 toxin were detected in PW, their fetuses and NPW

Parliament –Ag Standing Committee, India

BIOSAFETY

Goat & Sheep death in South India
30% more alkaloids in Bt Brinjal
Liver & testicle weights increased in lambs fed on Bt cotton seed
GM crops should be free of antibiotic resistance markers

ARE GM CROPS SUSTAINABLE?

Pink bollworm has developed resistance

No such similar instances from any other part of India or any part of the world during the past **10-18 years** of Bt cotton cultivation.

Cotton seed cake is being fed to animals in the **US, Australia and China over the past 17-18 years** and in India over the past 10 years, without any reported adverse effects.

Thus the reports **lack scientific credence**

REVIEW

Genetically modified plants and human health

J R Soc Med 2008: **101**: 290–298. DOI 10.1258/jrsm.2008.070372

Key et al (2008) reviewed GM food biosafety and state that

"*Foods derived from GM crops have been consumed by hundreds of millions of people across the world for more than 15 years, with no reported ill effects (or legal cases related to human health) despite many of the consumers coming from that most litigious of countries, the USA. There is little documented evidence that GM crops are potentially toxic*"

Bt Cotton has an Excellent Bio-safety Profile

Oil was tested to be free of *Bt* genes and Bt proteins

Seed cake is being fed to animals in India for 10 years

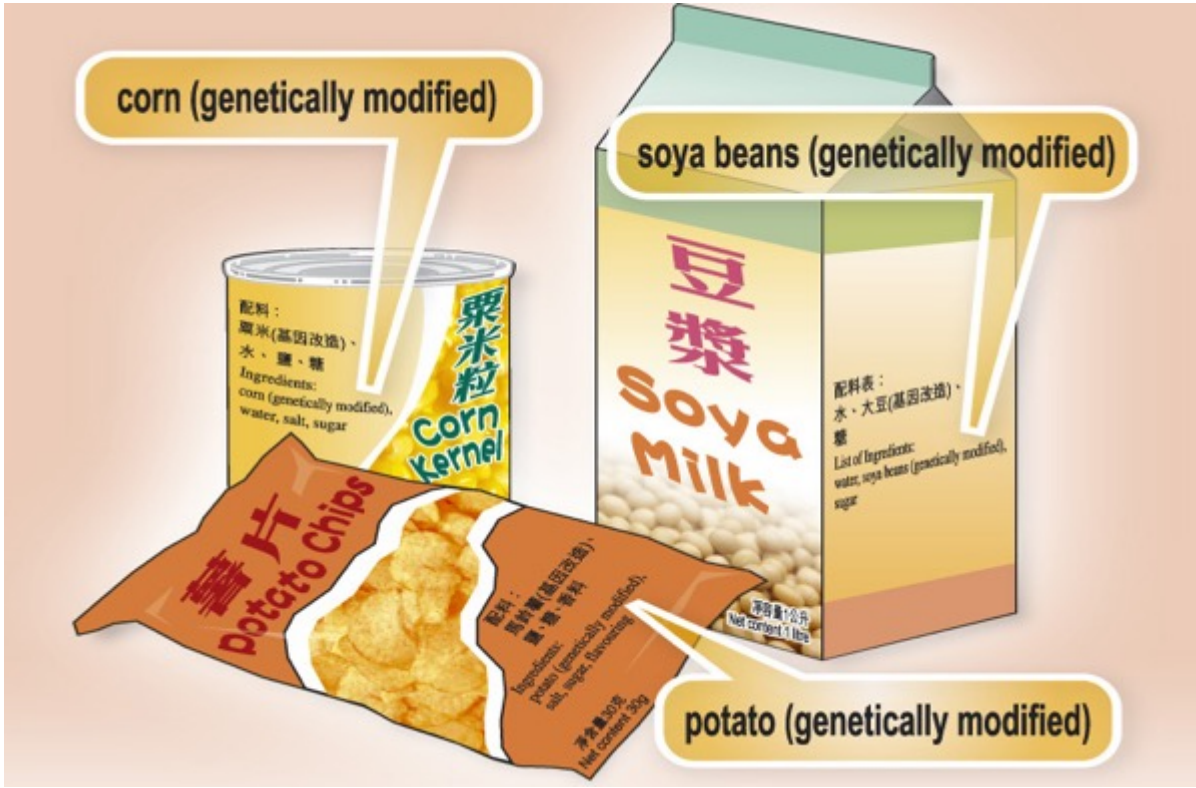
No adverse effects on soil microbes/health

No adverse effects on beneficial insects or organisms

Yields have become sustainable

GM Labeling made mandatory

>40 Countries (European Union, Australia, China, India, Japan and Russia) adopted labeling of GM products

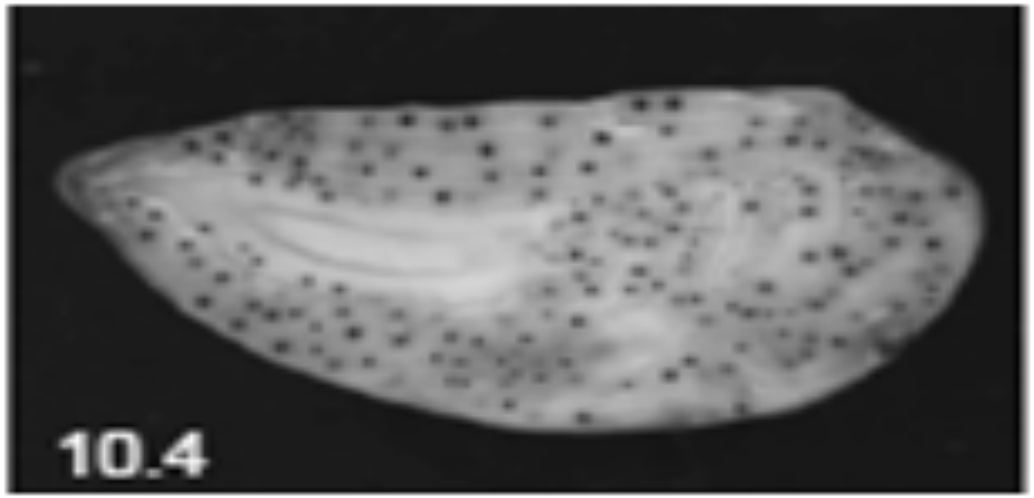


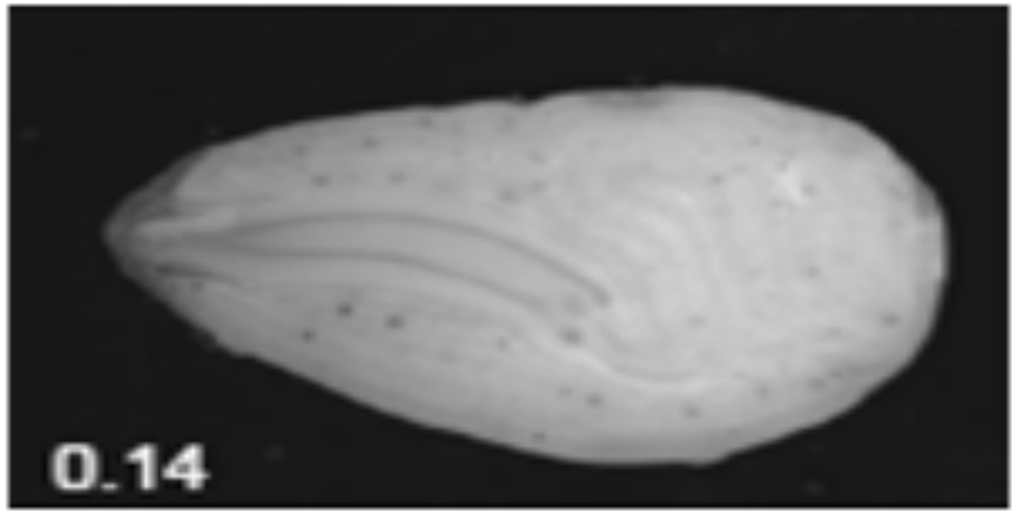
nature biotechnology Volume 25 NOVEMBER 2007

Silencing a cotton bollworm P450 monooxygenase gene by plant-mediated RNAi impairs larval tolerance of gossypol

Gossypol Reduction in seeds

Dr Kirthi Rathore, Texas 2006





Thank You