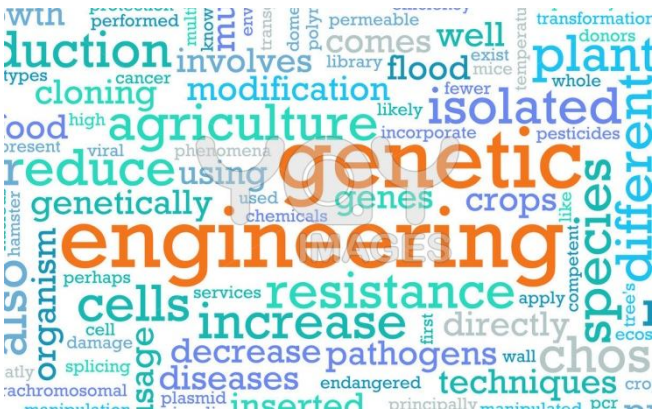
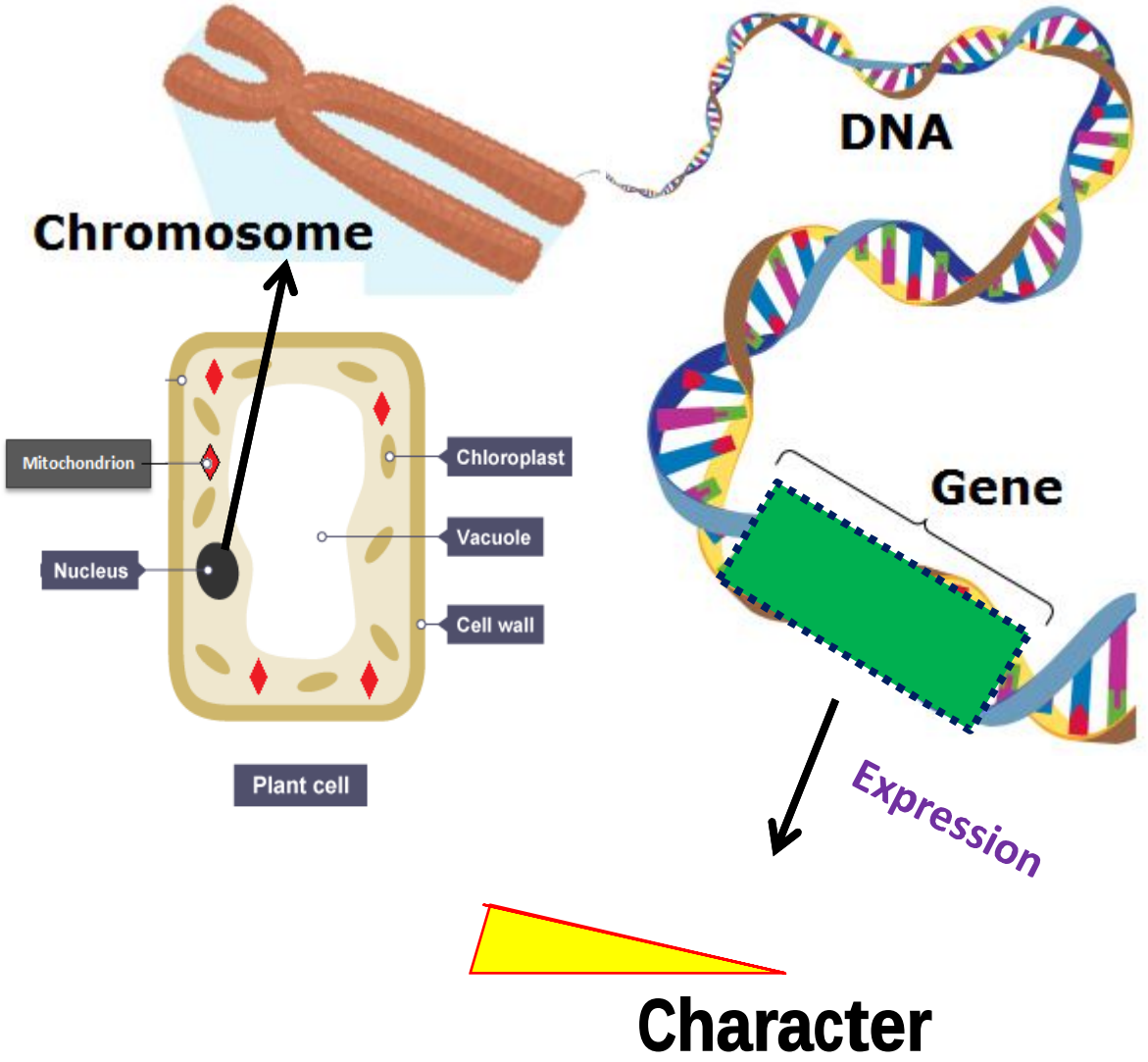
Transgenics : An Introduction



Joshitha Vijayan
IRDM Faculty Centre
RKMVU

Gene

- **Gene is a functional portion of DNA**
- **Responsible for a physical and inheritable character**



Genetic engineering (GE)

Manipulation/alteration of structure of a gene to create a desired characteristic in an organism

- **Addition/**
- **knocking out/**
- **knocking down of a gene are also done by GE**

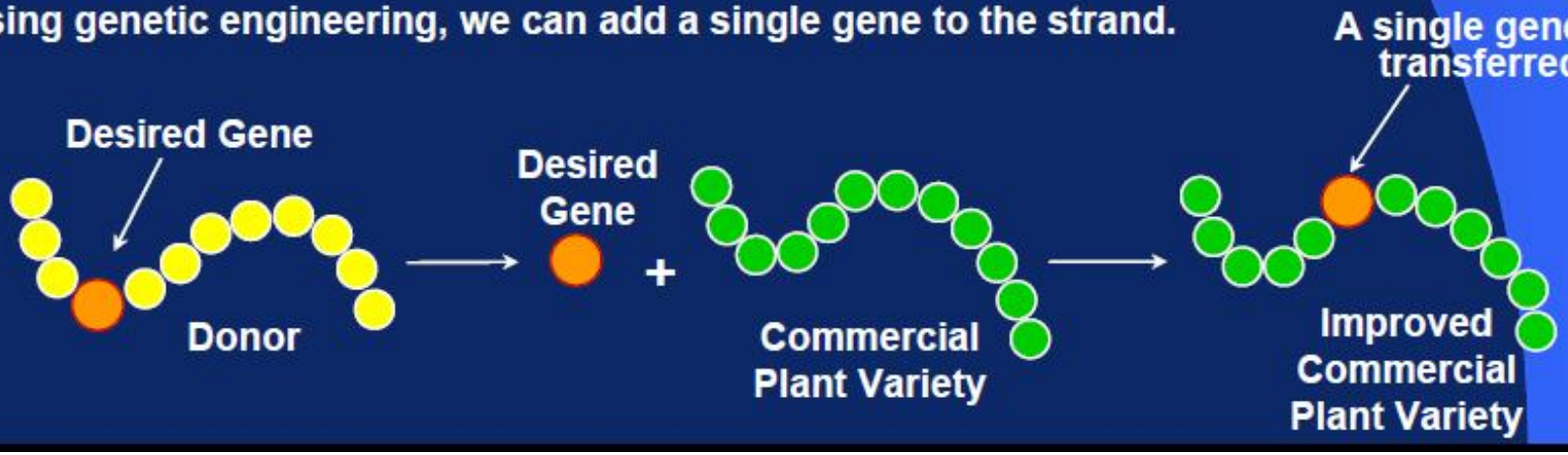
Genetic Engineering is an Extension of Traditional Plant Breeding

TRADITIONAL PLANT BREEDING

DNA is a strand of genes, much like a strand of pearls. Traditional plant breeding combines many genes at once.

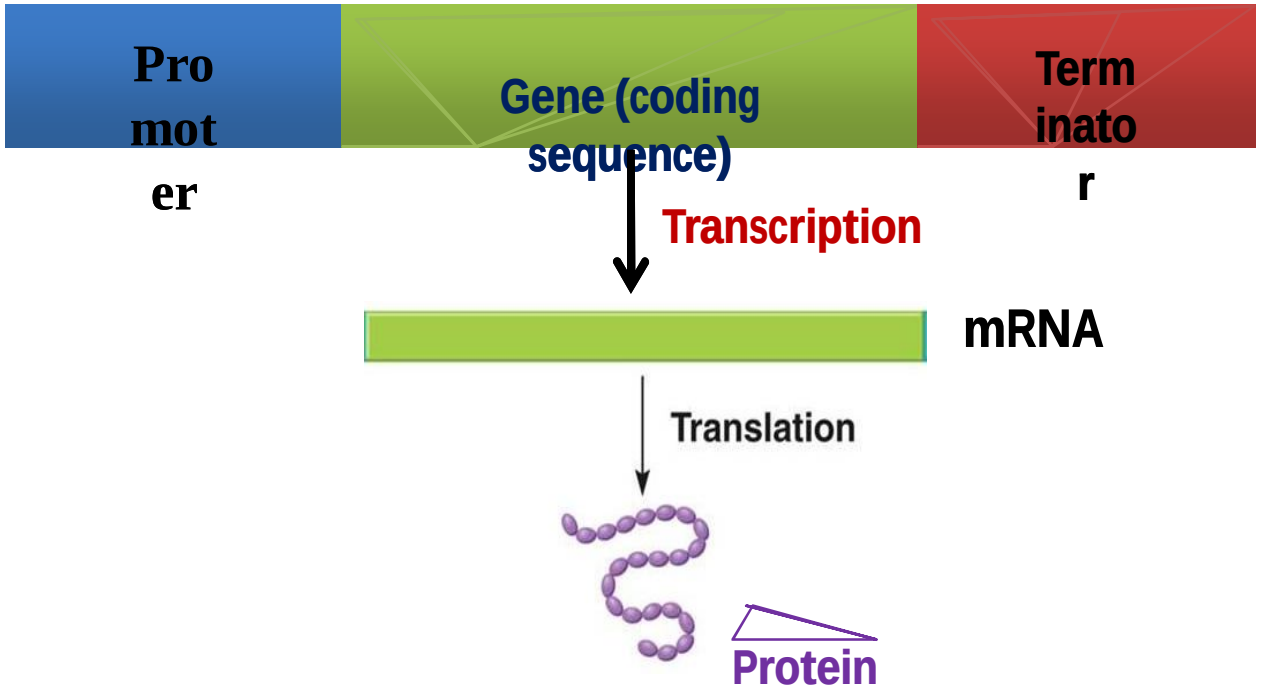
GENETIC ENGINEERING

Using genetic engineering, we can add a single gene to the strand.

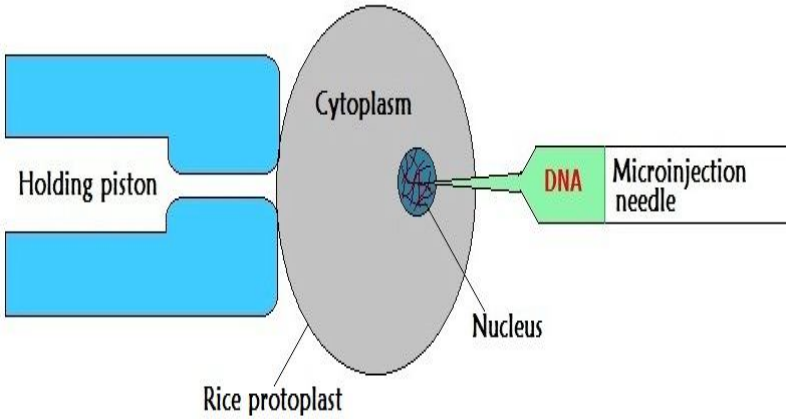


How to do? The procedure

- Gene expression cassette-

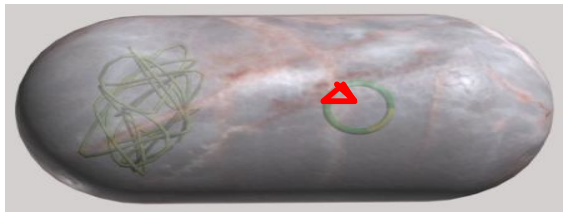


Gene transformation methods



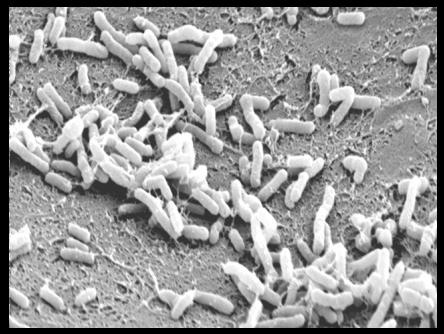
Microinjection

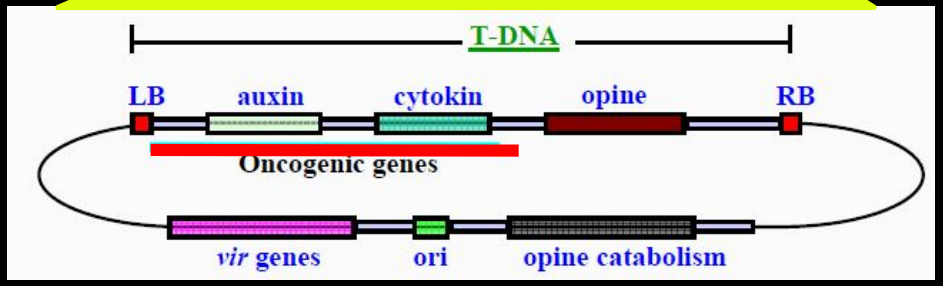
Biolistic gun

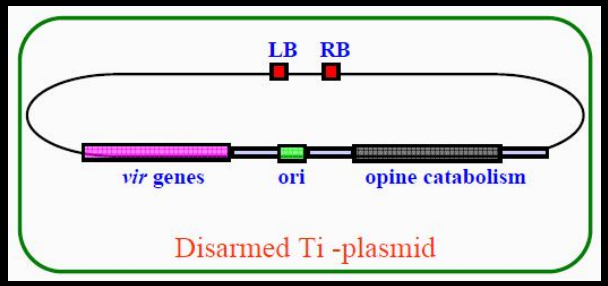


Agrobacterium

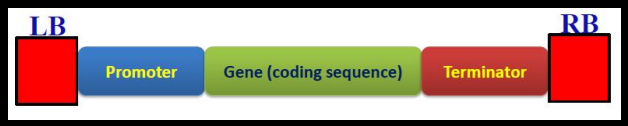
Agrobacterium: the natural engineer



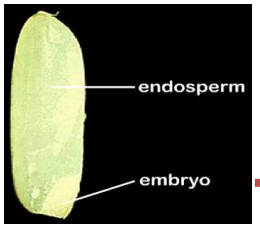


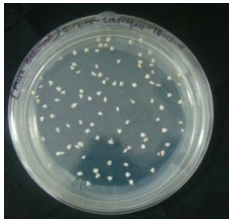


Expression cassette



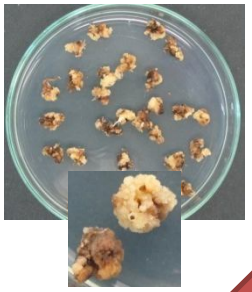
A practical example





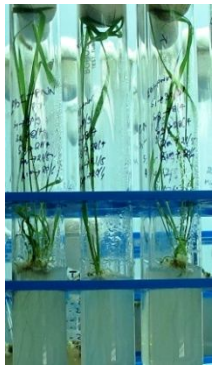
Agro + gene cassette

Incubation



Selection

Regeneration



Rooting

Genetically engineered rice plant

2. Application

Insect resistant crops (Bt-Crops)

Insertion of *cry* gene from *Bacillus thuringiensis*

Cotton

Brinjal

Corn

Potato

Herbicide tolerant crops

R

[redacted]

cterium CP4

roscopicus (for
ce)

Soybean

Canola

Disease resistance/Drought tolerance

Virus resistant papaya

Insertion of ***coat protein gene- HA 5-1*** from PRS virus

Late blight resistant potato

RB gene from *Solanum bulbocastanum*

Virus resistant Sweet pepper

Coat protein gene from cucumber mosaic virus

Drought tolerant Rice

Arabidopsis DREB1A gene

Metabolic engineering

To fight Vitamin A deficiency

Golden rice...
Daffodil *psy* gene and *Erwinia crt1* gene

Reduce acrylamide level

Knock down of PPO5 gene (low bruising) and
asparagine synthetase-1 gene (*Asn1*) (low acrylamide)

To fight Iron and phosphorus deficiency

Low phytate maize....
phy2A (Phytase)* gene from *A. niger

Blue rose

Burgundy

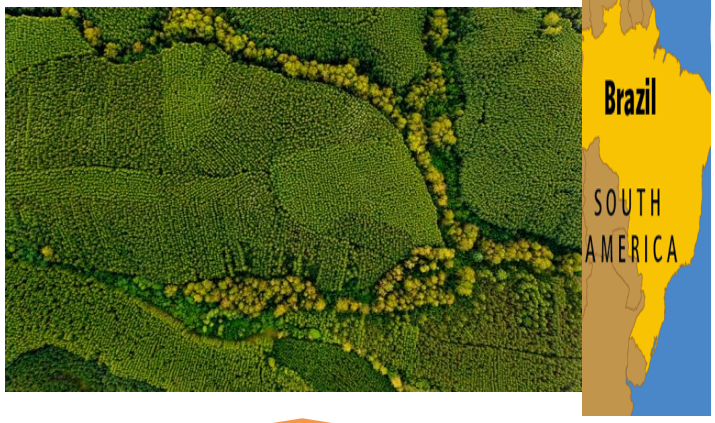
Blue

1. Rnai mediated silencing of dihydroflavonol 4-reductase (*DFR gene*) to block all other color production
2. Expression of delphinidin gene from Pansy plant (*Viola tricolor*)

Industrial application

- Pulp and paper industry

- Bt-POPLAR



- Biodies
- industr
- y

Microbes

Oil eating Bacteria (GE *Pseudomonas*)

In Medical Science

Production of—

Insulin

Hepatitis B vaccine

Tissue plasminogen activator

Human Growth

Others

GM salmon declared fit for dinner plates

Genetically modified (GM) salmon was finally approved in November for commercial sale in the US—the first GM animal to be approved

shareholder—Randal J. Kirk's Germantown, Maryland–based Intrexon—that tends to take the long view (*Nat. Biotechnol.* 33, 1017–1018,

AquAdvant mon (background) vs. non-transgenic Atlantic salmon sibling of the same age. Both

Glow-in-the-Dark Cat

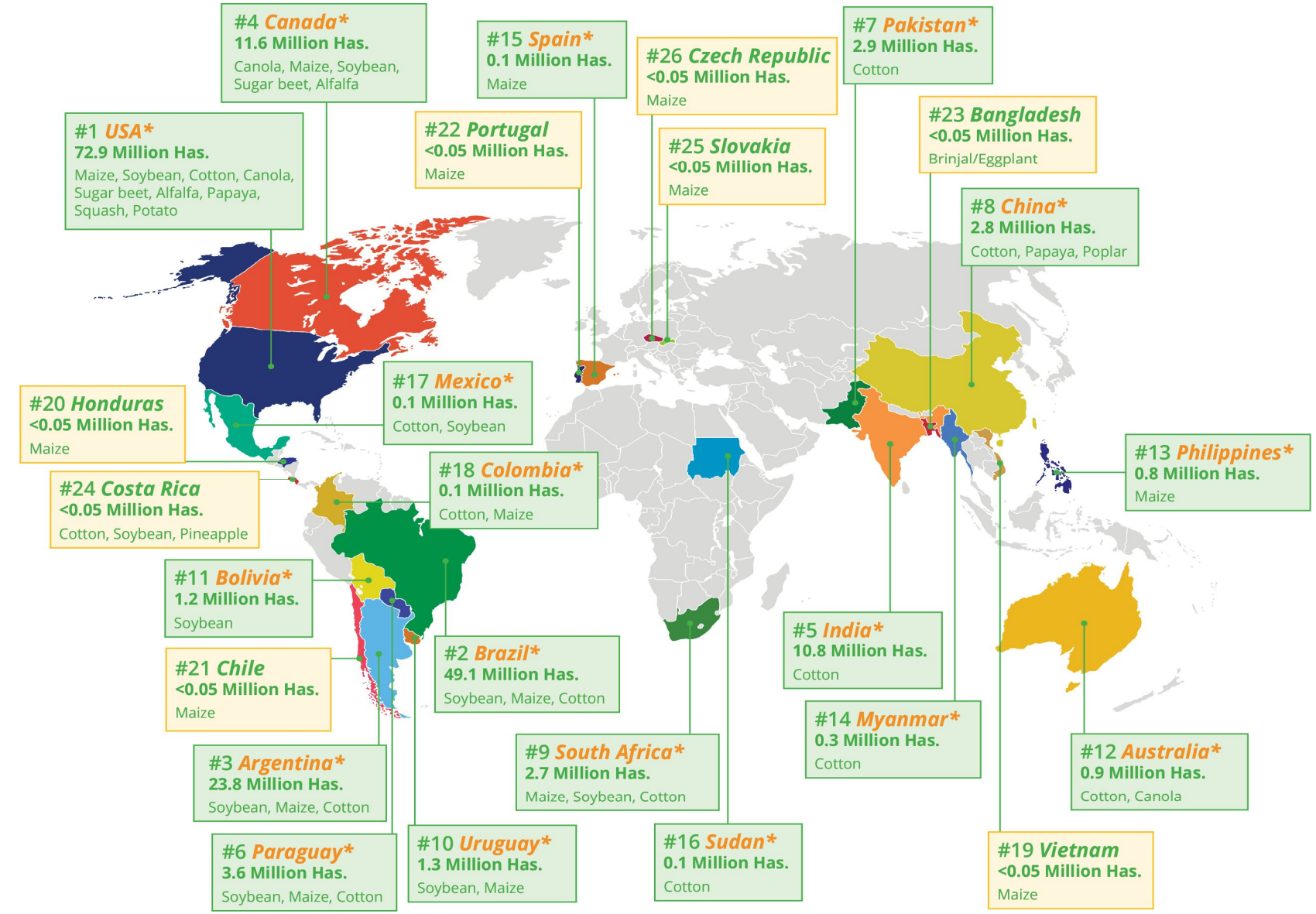
Glow Fish with fluorescent protein gene

See through frog: organ/cancer /other disease development can be studied live without dissecting the frog

Less-Flatulent Cows
(25% less production of methane)
18% global green house gass emission from livestock

Global status

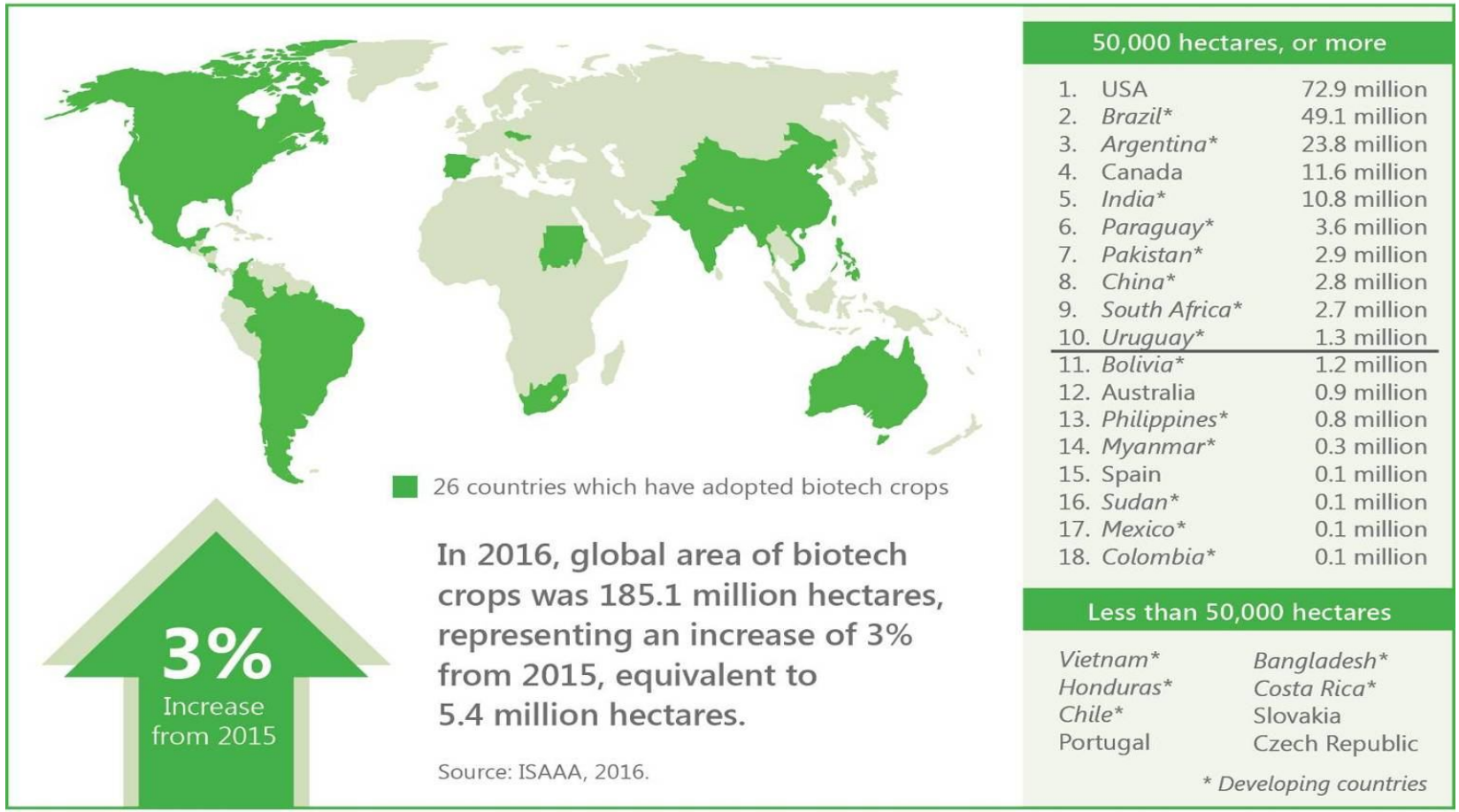
Biotech Crop Countries and Mega-Countries*, 2016



*18 biotech mega-countries growing 50,000 hectares, or more, of biotech crops.

ISAAA, 2016

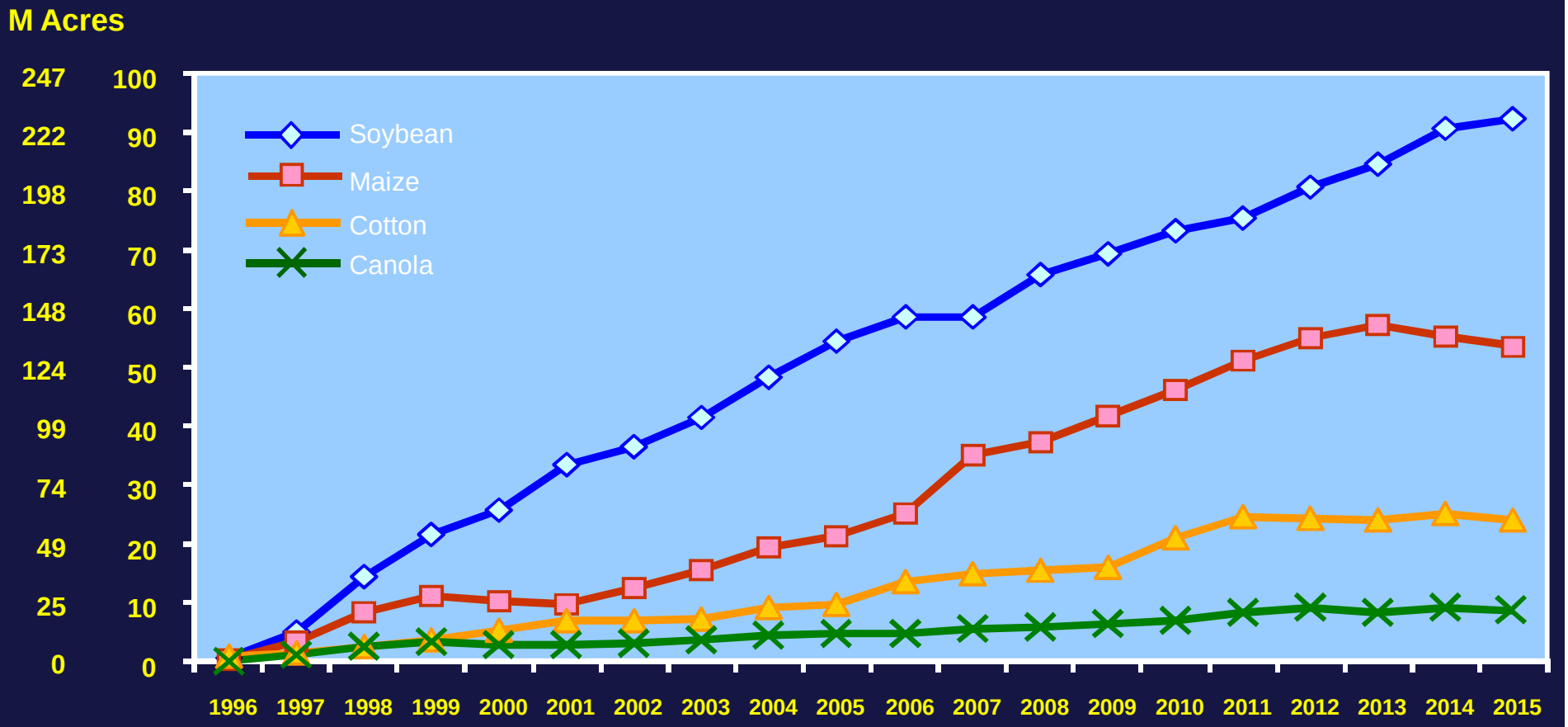
Global Area of Biotech Crops, 2016: By Country (Million Hectares)



• Top five countries: 3 Dev countries (Brazil, Argentina, and India) and 2 Industrial countries (USA and Canada) grew 91% of biotech crop

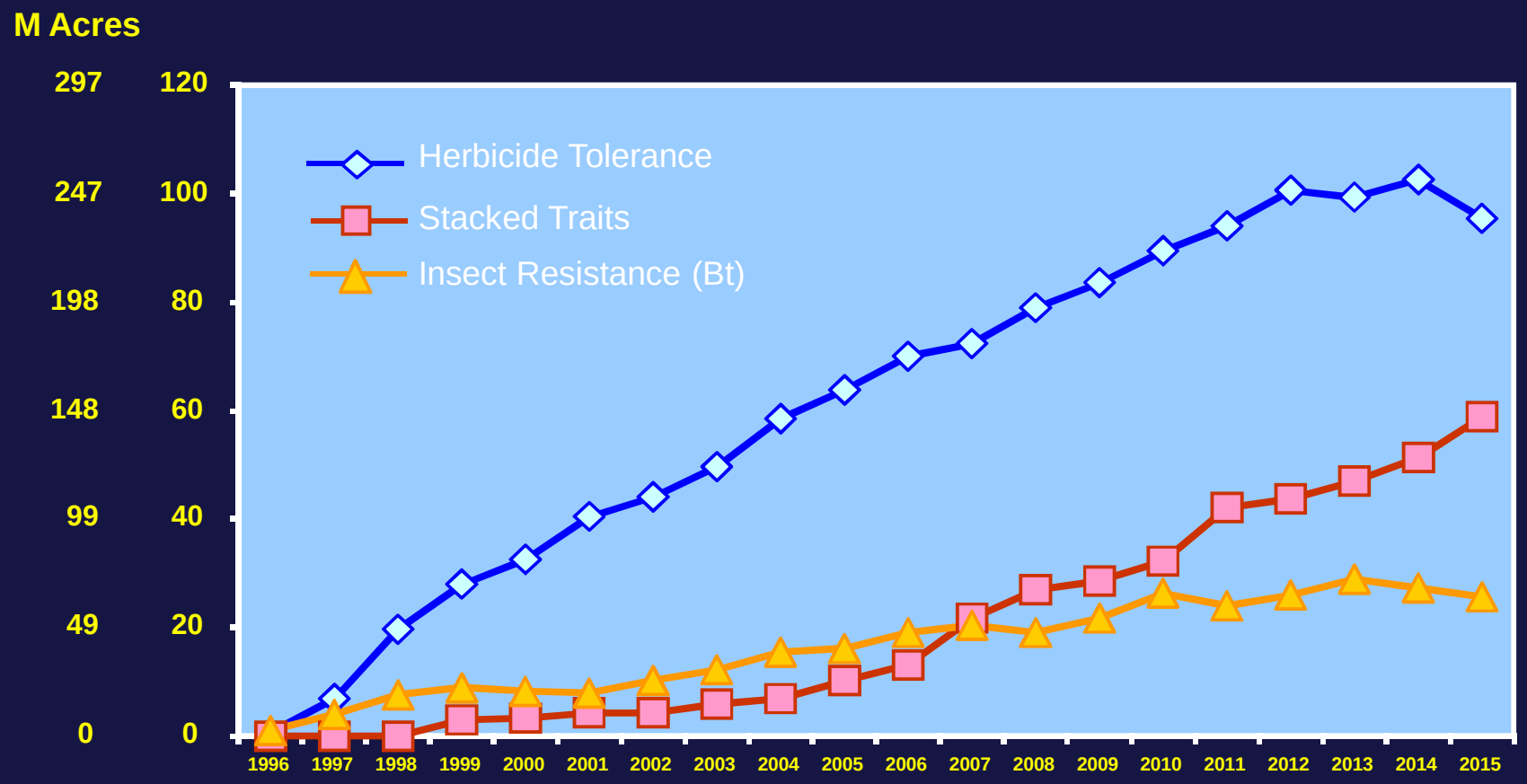
Source

Global Area of Biotech Crops, 1996 to 2015: By Crop (Million Hectares, Million Acres)



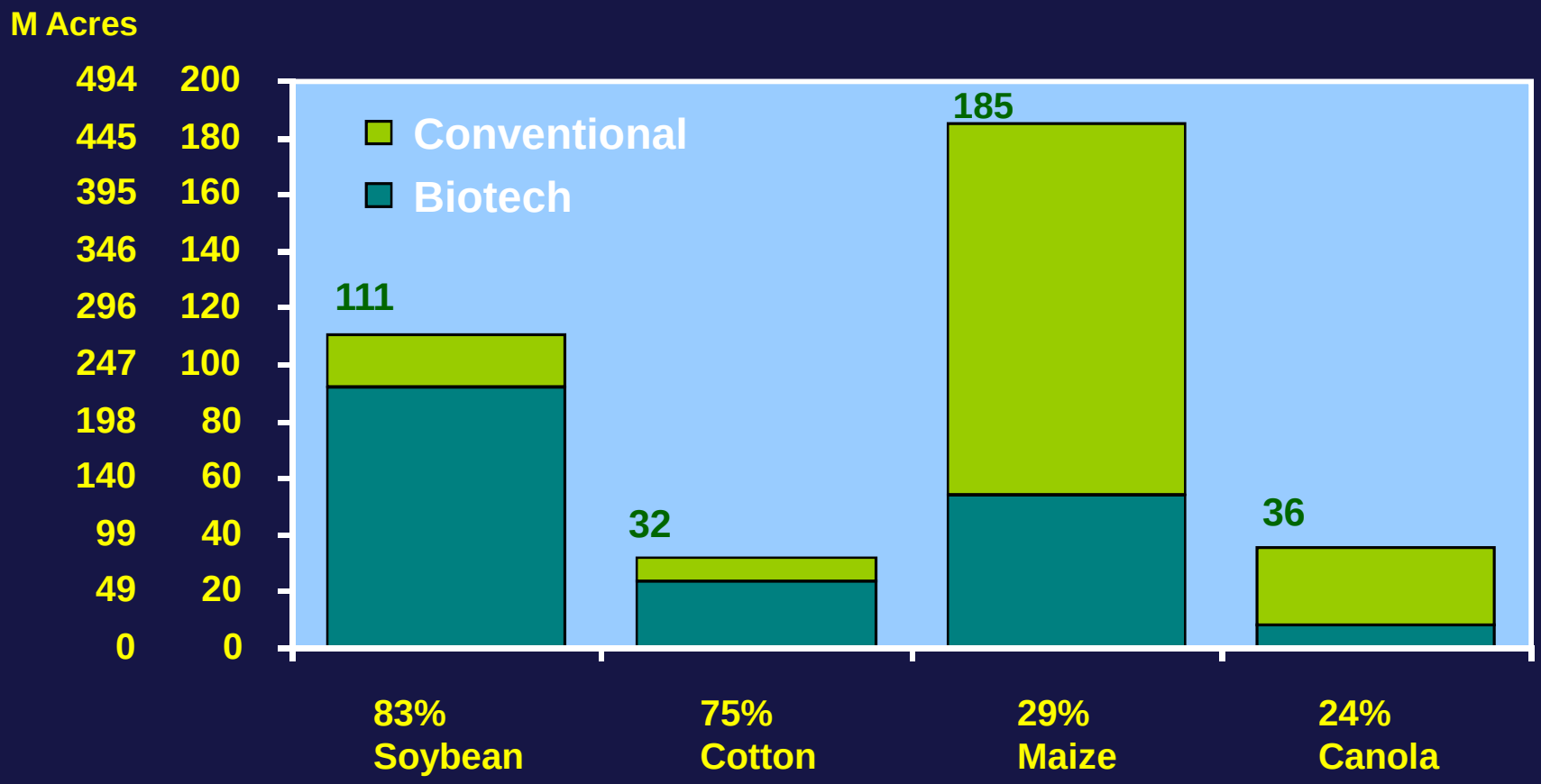
Source: Clive James, 2015

Global Area of Biotech Crops, 1996 to 2015: By Trait (Million Hectares, Million Acres)



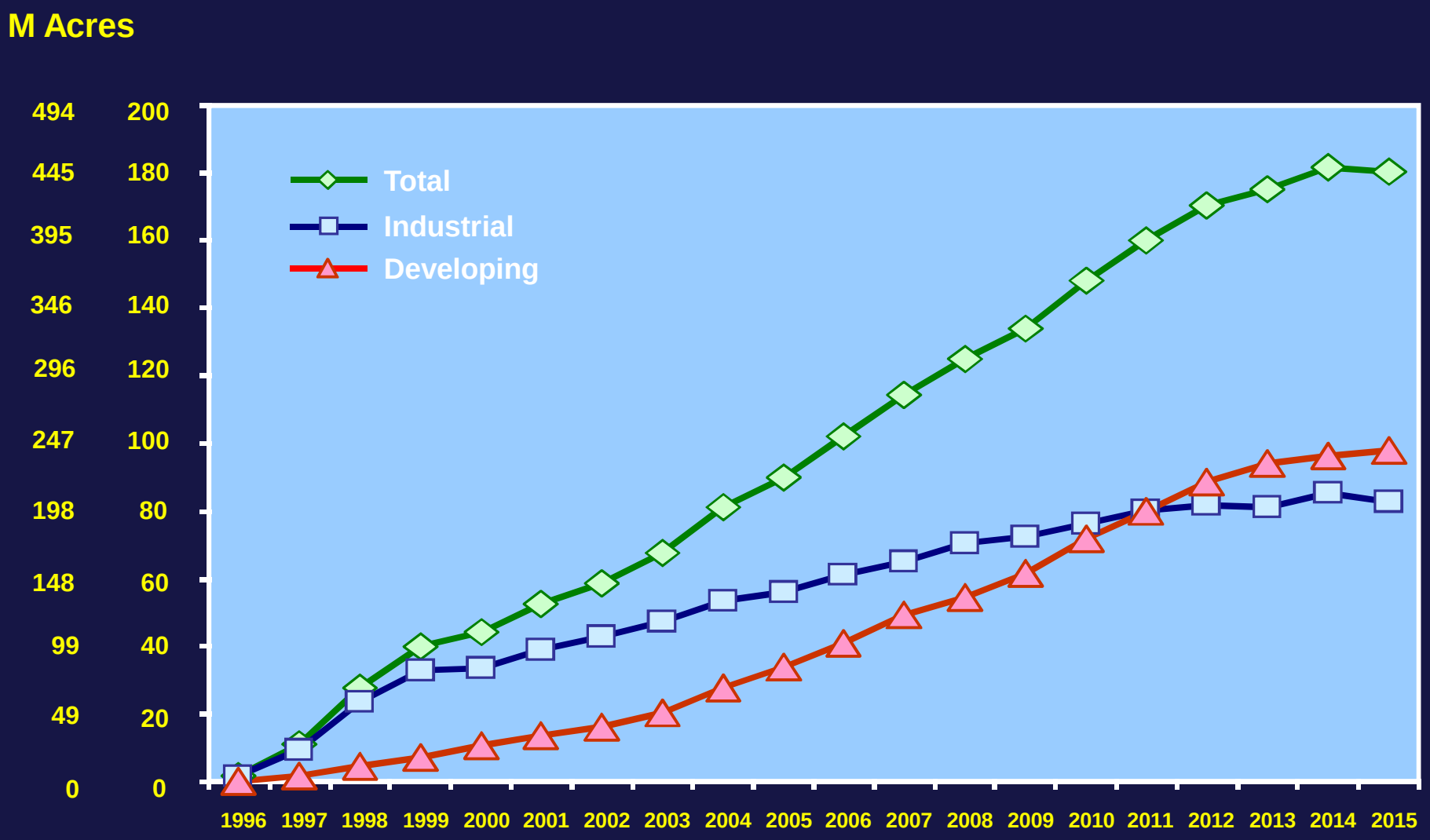
Source: Clive James, 2015

Global Adoption Rates (%) for Principal Biotech Crops (Million Hectares, Million Acres), 2015

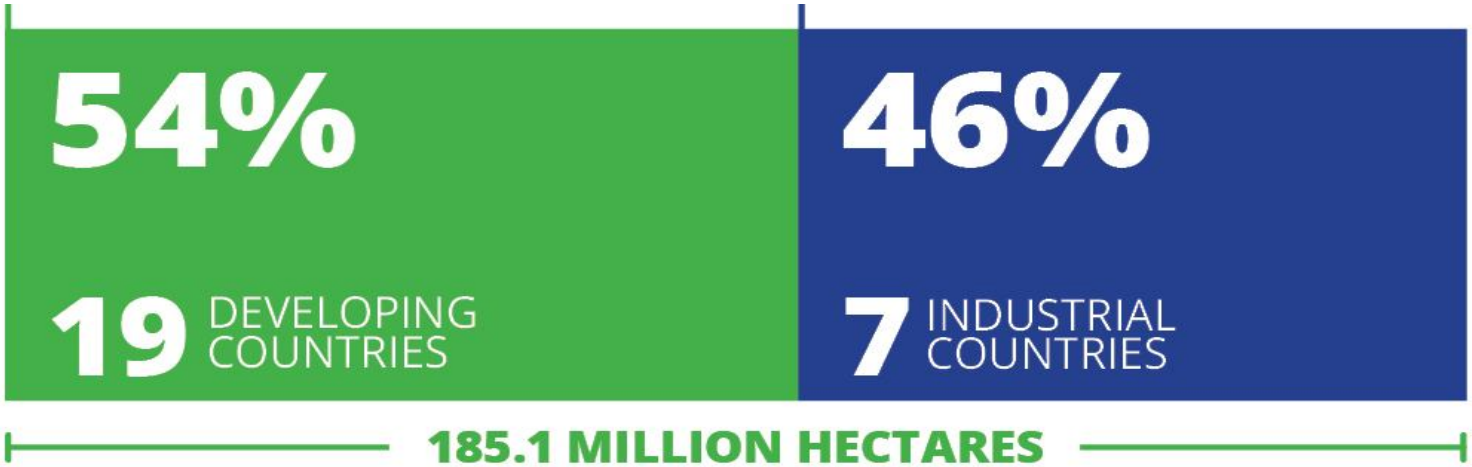


Source: Clive James, 2015
Hectarage based on FAO Data for 2013.

Global Area of Biotech Crops, 1996 to 2015: Industrial and Developing Countries (M Has, M Acres)



Source: Clive James, 2015

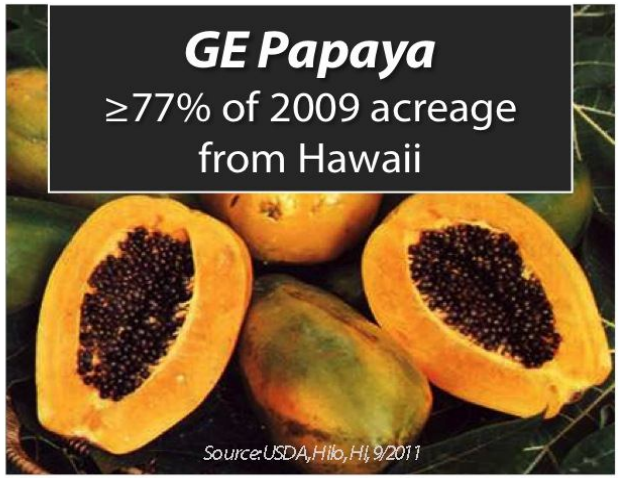


DISTRIBUTION OF BIOTECH CROPS IN DEVELOPING AND INDUSTRIAL COUNTRIES IN 2016

Source: ISAAA, 2016

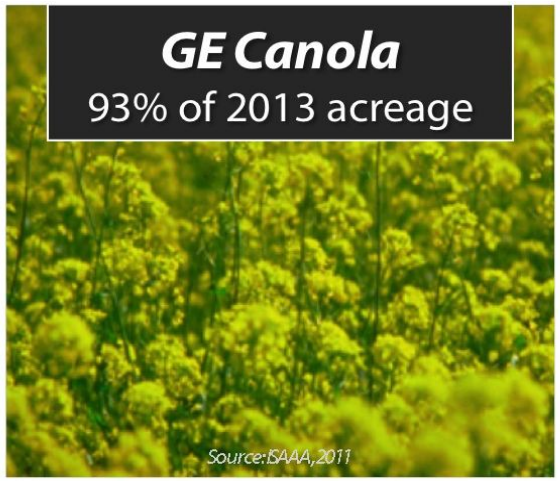
Developing countries: 99.6 million hectares
Industrial countries: 85.5 million hectares

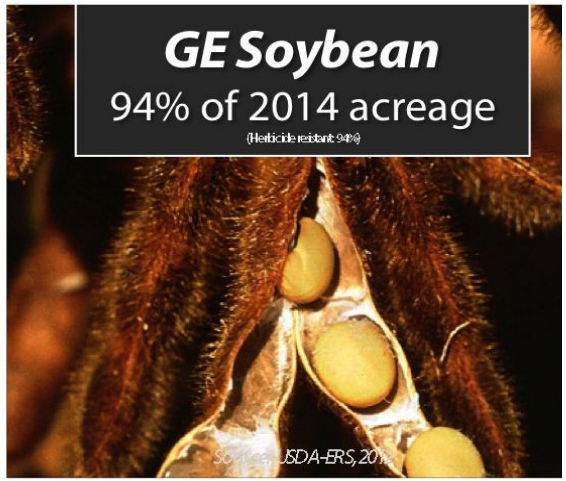
Source

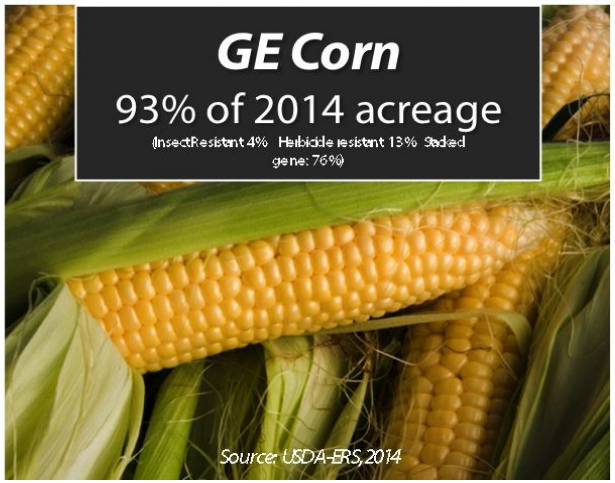

GE Papaya
≥77% of 2009 acreage
from Hawaii
Source: USDA, Hilo, HI, 9/2011

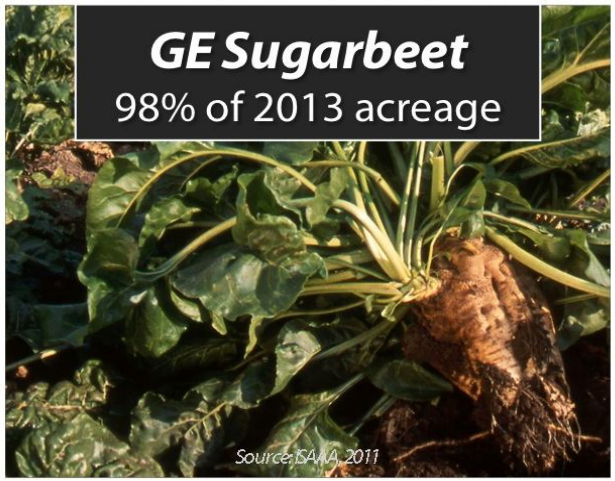

GE Squash
13% of 2006 acreage
Source: Cornell University, 2013


GE Cotton
96% of 2014 acreage
(Insect Resistant: 5% Herbicide tolerant: 12% Stacked gene: 79%
Source: USDA-ERS, 2014


GE Canola
93% of 2013 acreage
Source: ISAAA, 2011


GE Soybean
94% of 2014 acreage
(Herbicide resistant: 94%)

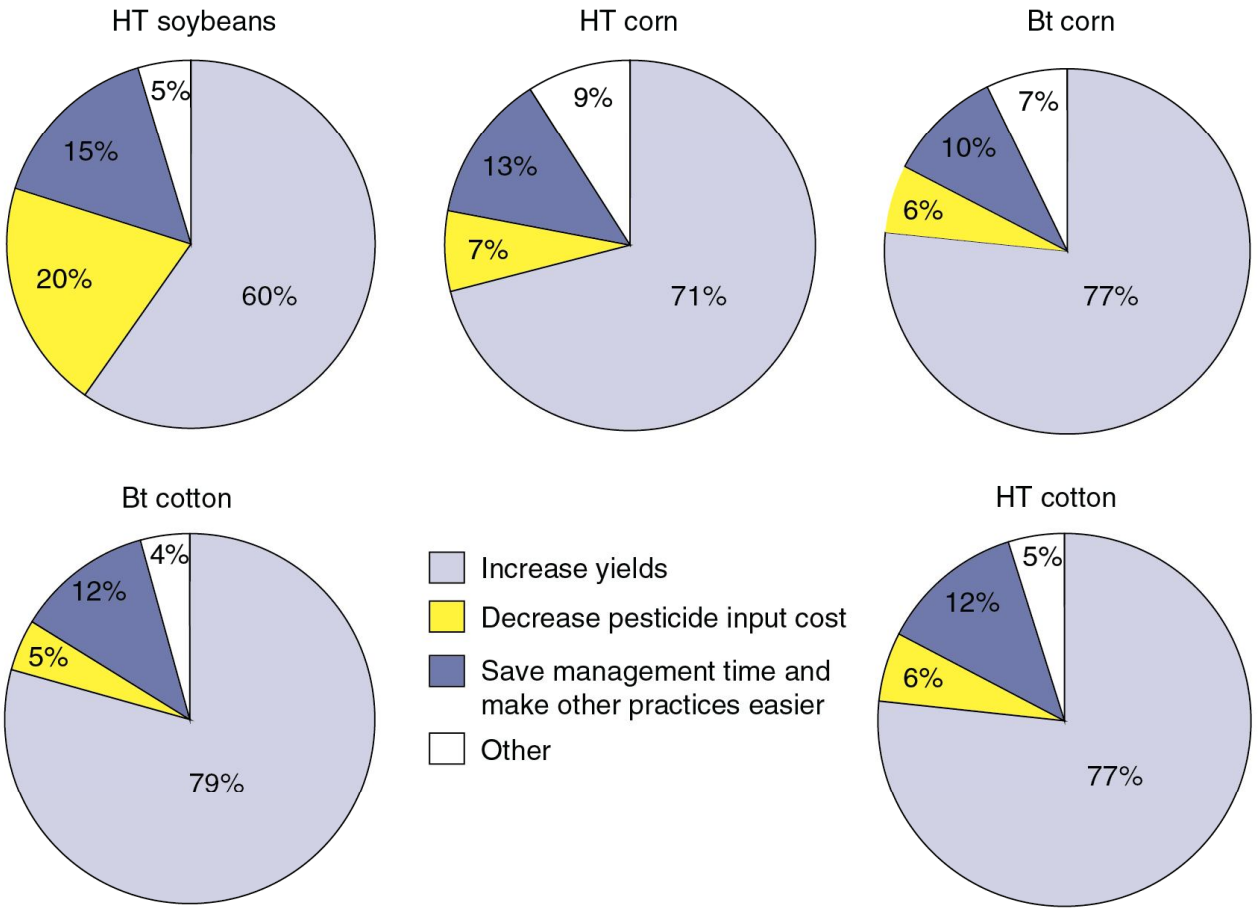

GE Corn
93% of 2014 acreage
(Insect Resistant 4% Herbicide resistant 13% Stacked
gene: 76%)
Source: USDA-ERS, 2014


GE Sugarbeet
98% of 2013 acreage
Source: ISAAA, 2011


GE Alfalfa
25% of 2014 acreage
Source: Dan Putnam, UCANR, 2014

Figure 7

Farmers' reasons for adopting genetically engineered crops



Bt crops have insect resistant traits; HT crops have herbicide tolerance traits.

Sources: USDA Economic Research Service using data from Agricultural Resource Management Survey (ARMS) Phase II surveys: 2010 for corn, 2007 for cotton, and 2006 for soybeans.

SOURCE: Fernandez-Cornejo, J., Wechsler, S., Livingston, M. and Mitchell, L. 2014. Ge
Engineered Crops in the United States. USDA Economic Research Service Report No. 162, Februa

Global Facts

***Contribution to food security, sustainability, and climate change

Economic gain-
US$ 133.3 billion

Reduction in pesticide usage
~500 million Kg

Reduced CO_2 emission by 28 billion kilograms
= 12.4 million cars taking off from the road/year

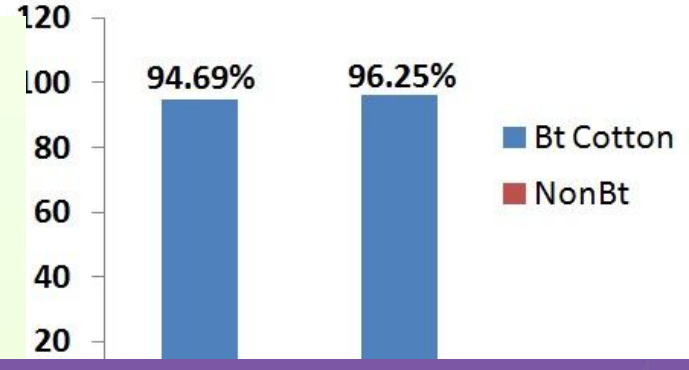
Source: Beyond Promises: Top 10 Facts about Biotech/GM Crops in 2014, ISAAA

Source: Brooks & Barfoot, GM Crops and Food, 2015

26 March 2002: A Landmark in India

India’s first transgenic crop

Success story of Bt-cotton in India



IN
NC

IN

TH

Sharp decline in insecticide use-US$160 million in 2004 US$25 million in 2010 – an % decrease, equivalent to saving of US$135 million

Increase in Cotton Yield- **24%/acre**
Profit- **50% gain**
Consumption expenditures- **18%**

Source- Kathage & Qaim, 2012, PNAS

Thank you