

GMOs

2024 Master Gardener Volunteer Training

March 9, 2024

Cornell Cooperative Extension
Orange County



Overview

- **What is a GMO?**
- **Why do we genetically engineer plants?**
- **How do we genetically engineer plants?**
- **Current GMO Crops**
- **Problems with GMOs**
- **Benefits of GMOs**
- **Controversy**
- **To Eat or Not to Eat?**



What is a GMO?

Genetically

Modified

Organism

What is a GMO?

Genetically
Modified
Organism



What is a GMO?

Genetically
Modified
Organism

THE EVOLUTION OF MAIZE



What is a GMO?

Genetically

Modified

Organism

=

Genetically

Engineered

**Why do we genetically engineer
agricultural crops?**

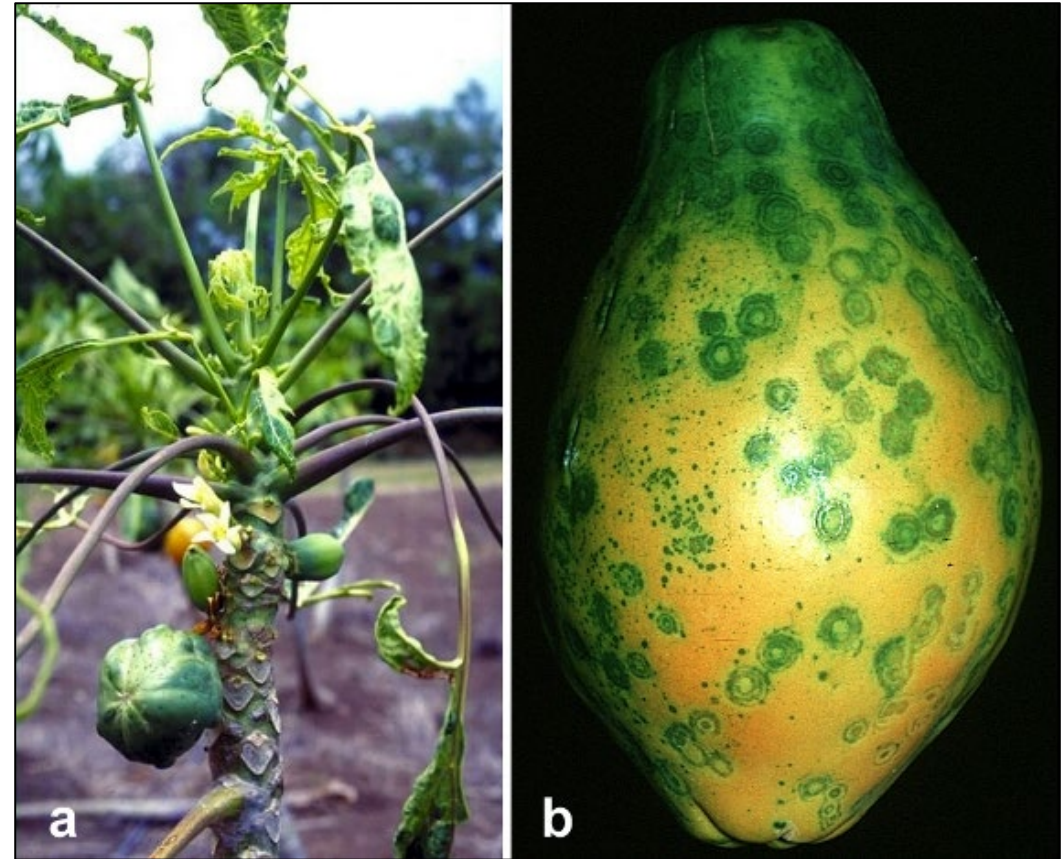


Why do we genetically engineer agricultural crops?

- **Disease Resistance**
- **Pest Resistance**
- **Herbicide Tolerance**

Why do we genetically engineer agricultural crops?

- **Disease Resistance**
 - Papaya Ringspot Virus

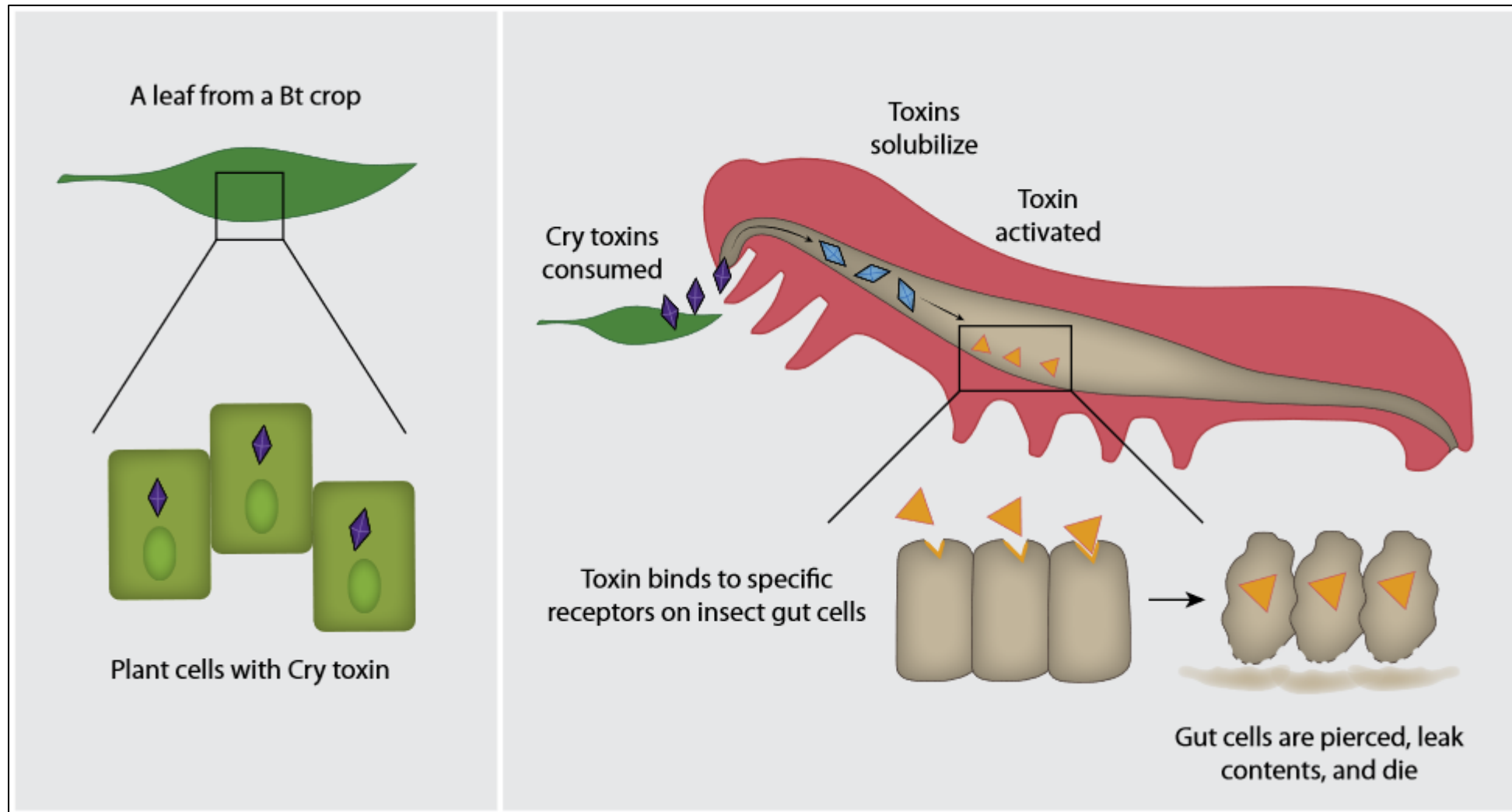


Why do we genetically engineer agricultural crops?

- Disease Resistance
- **Pest Resistance**
 - Bt Corn

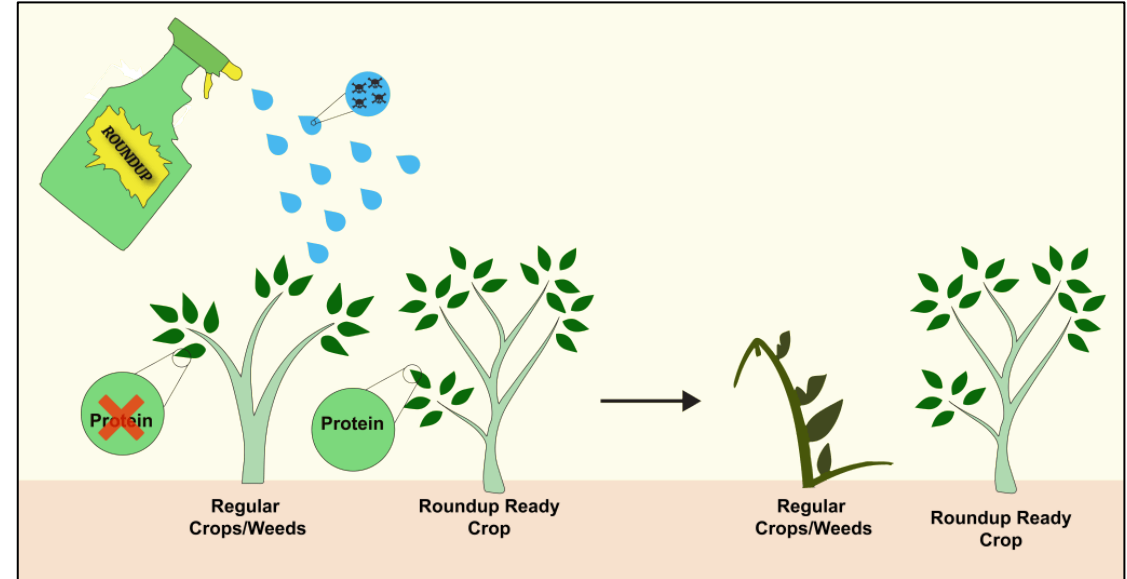


What is *Bacillus thuringiensis* (Bt)?



Why do we genetically engineer agricultural crops?

- Disease resistance
- Pest Resistance
- **Herbicide Tolerance**
 - Glyphosate -Tolerant Soy

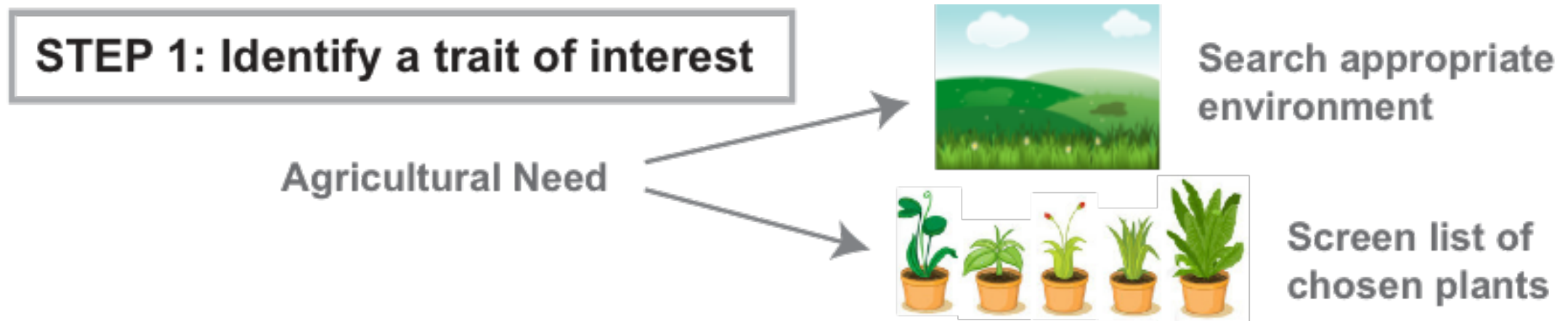


Why do we genetically engineer agricultural crops?

- Disease Resistance**
- Pest Resistance**
- Herbicide Tolerance**

**How do we genetically engineer
agricultural crops?**

How do we genetically engineer agricultural crops?



How are organisms genetically engineer agricultural crops?

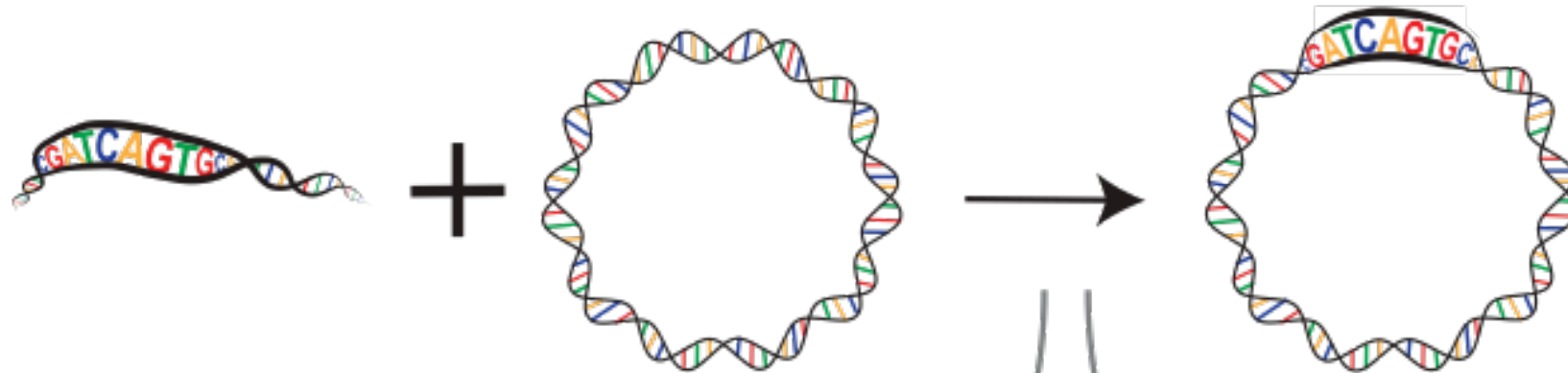
STEP 2: Isolate the genetic trait of interest

Comparative analysis of genomes to identify trait

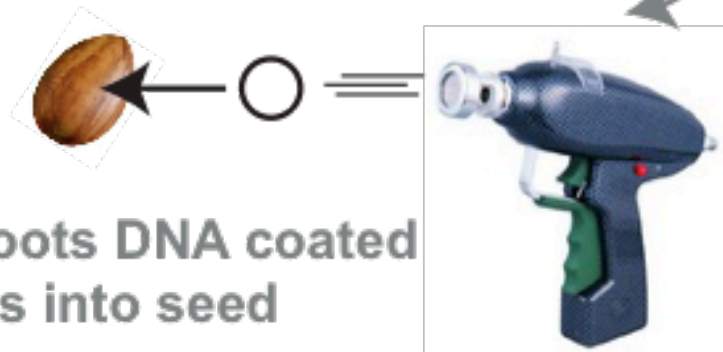


How are organisms genetically engineer agricultural crops?

STEP 3: Inset the desired trait into the new genome



Genetic trait is cut and pasted into a plasmid using enzymes



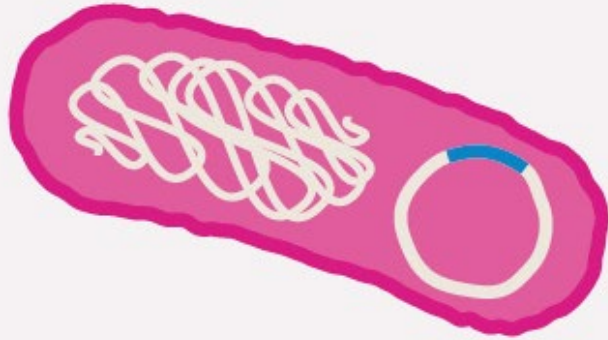
Gene Gun shoots DNA coated metal particles into seed



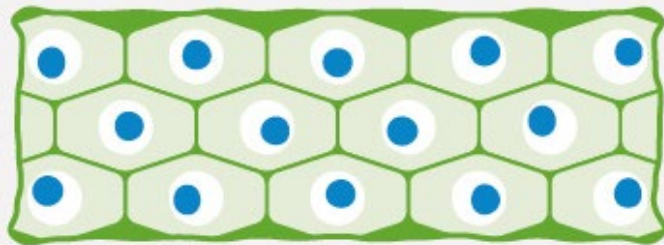
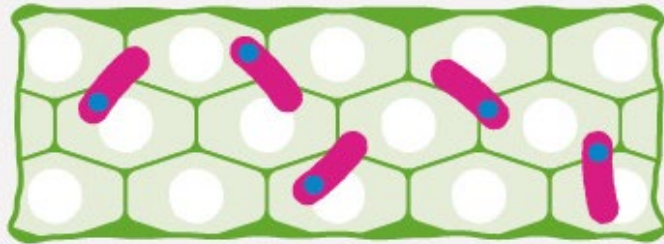
Plasmid inserted into bacteria that then infects cells

Agrobacterium tumefaciens method

Bacterium carrying desired genes

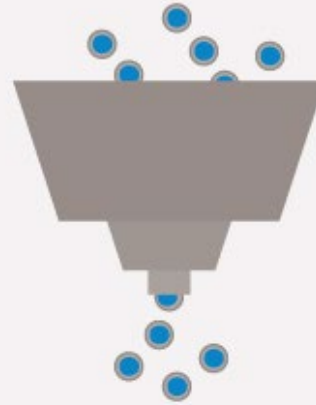


Agrobacterium grown with plant pieces

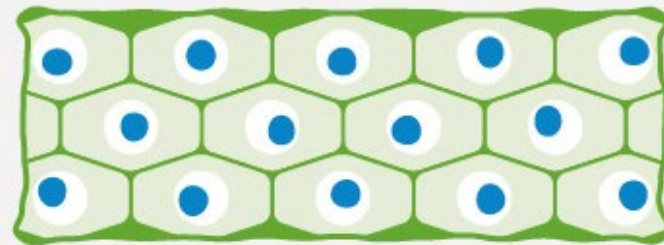
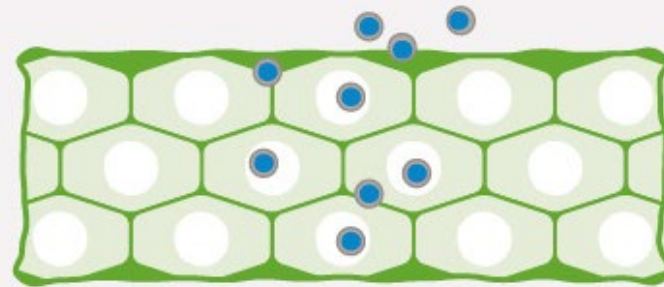


Particle gun method

Metal particles coated with DNA encoding desired genes



Bombardment of plant pieces with particles



How do we genetically engineer agricultural crops?

STEP 4: Growing the GMO



Carefully controlled growth chambers are monitored to ensure that the new GMO grows and replicates. Ultimate growth conditions are determined at this stage.



Current GMO Crops

Current GMO Crops

- **Alfalfa**
- **Apples**
- **Canola**
- **Cotton**
- **Field Corn**
- **Papaya**
- **Petunia**
- **Pineapple**
- **Potato**
- **Soybean**
- **Sugar Beet**
- **Summer Squash**
- **Sweet Corn**
- **Tomato**

Current GMO Crops

• Alfalfa

- ***Trait:*** Herbicide Tolerance, Ease of Digestion
- ***Introduced:*** 2005
- ***Source of Inserted Trait:*** Bacteria
- ***Use:*** Animal Feed
- ***% of Harvest:*** 15%

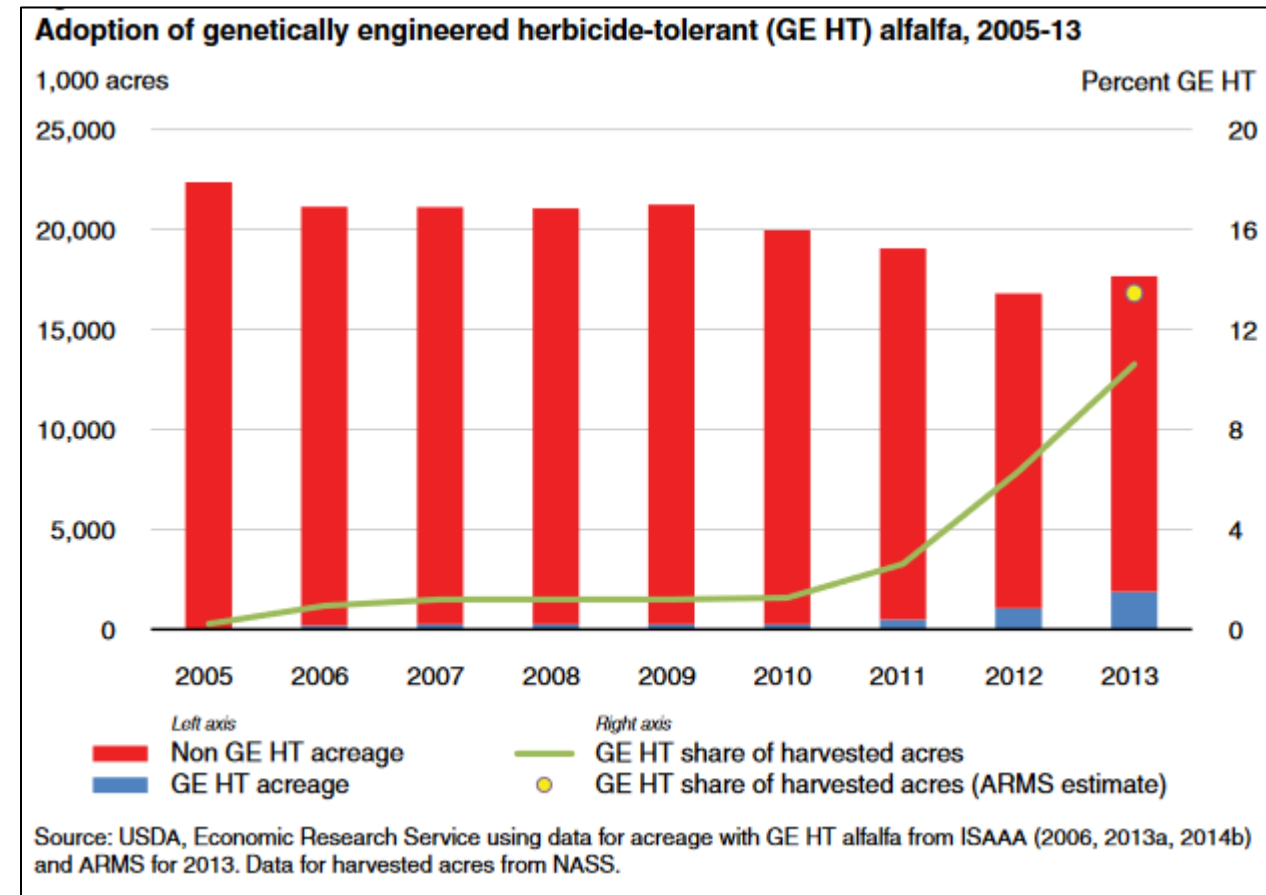


Current GMO Crops

• Alfalfa

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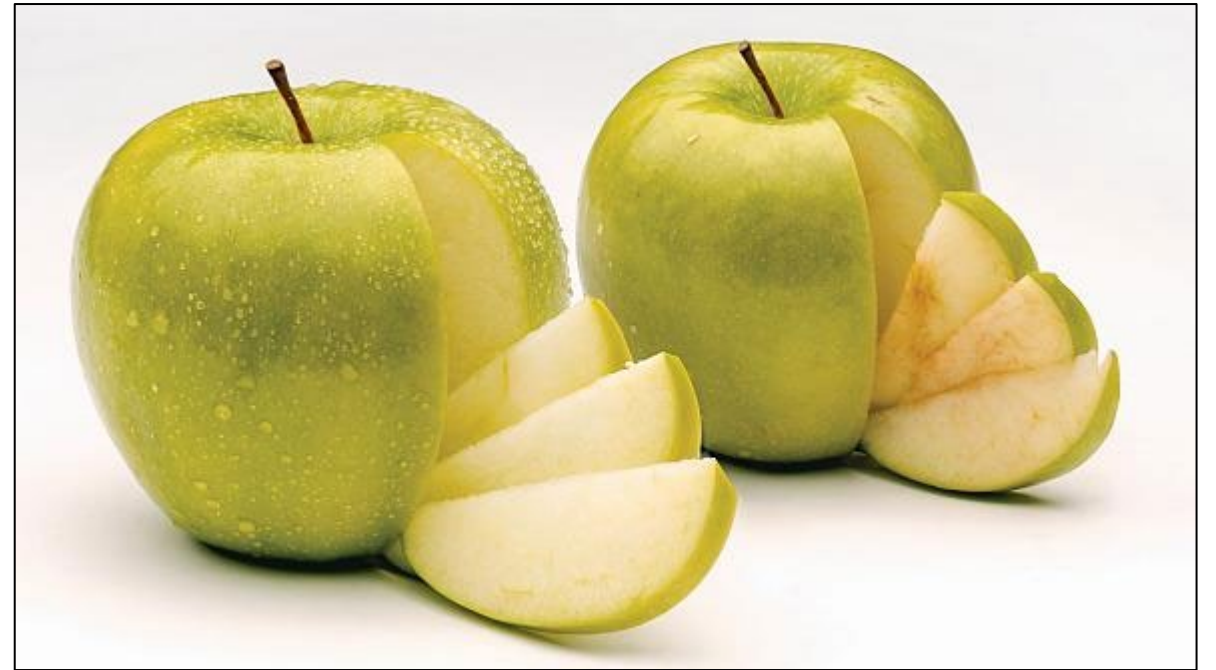
<https://www.ers.usda.gov/webdocs/publications/81176/eib-163.pdf?v=0>



Current GMO Crops

• Apples

- ***Trait:*** Anti-Browning
- ***Introduced:*** 2015
- ***Source of Inserted Trait:***
Other species of apple
- ***Variety:*** Artic
- ***% of Harvest:*** ~ 0.08%



Current GMO Crops

• Canola

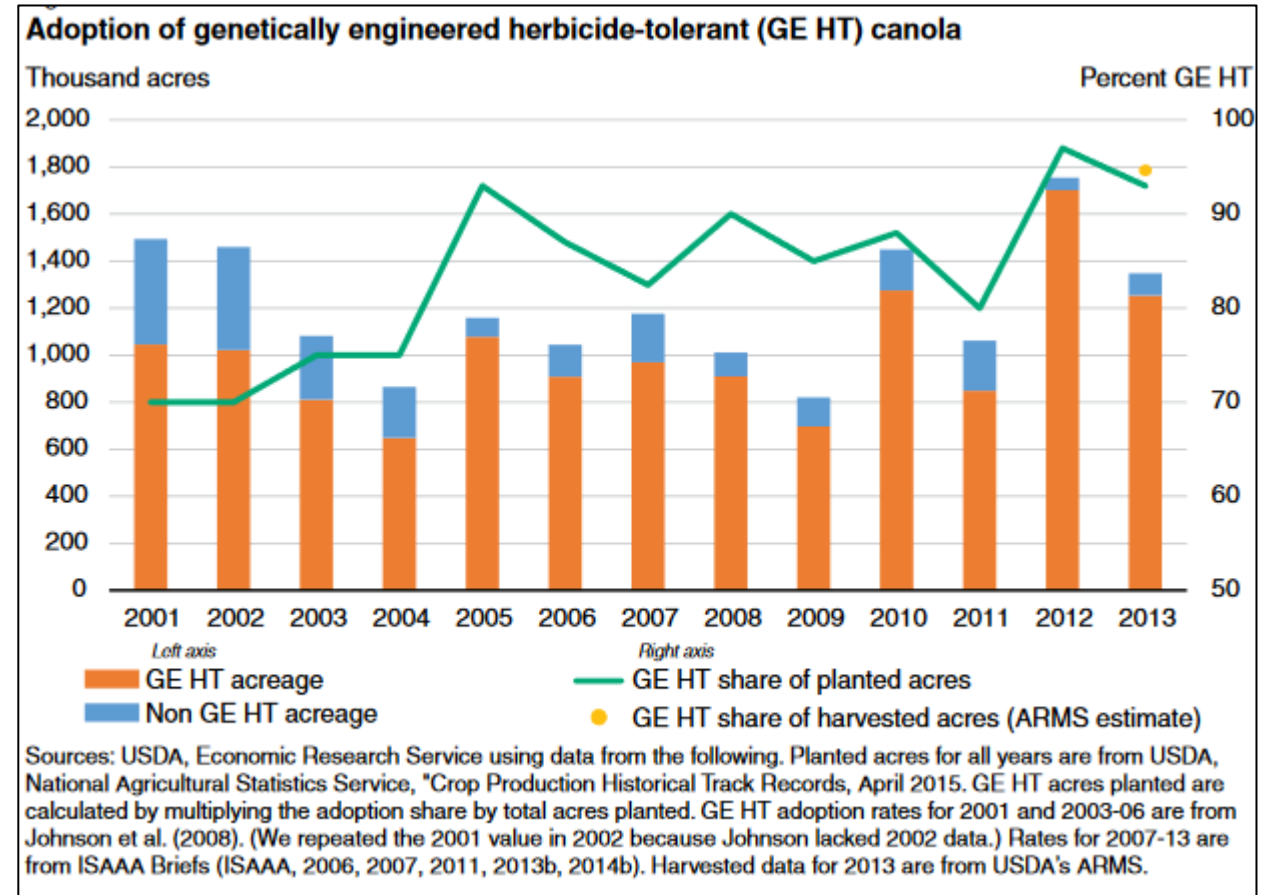
- ***Trait:*** Herbicide Tolerance
- ***Introduced:*** 1998
- ***Source of Inserted Trait:***
Bacteria
- ***Uses:*** Animal Feed,
Cooking Oil
- ***% of Harvest:*** 95%



Current GMO Crops

• Canola

- **Trait:** Herbicide Tolerance
- **Introduced:** 1998
- **Source of Inserted Trait:** Bacteria
- **Uses:** Animal Feed, Cooking Oil



Current GMO Crops

• Cotton

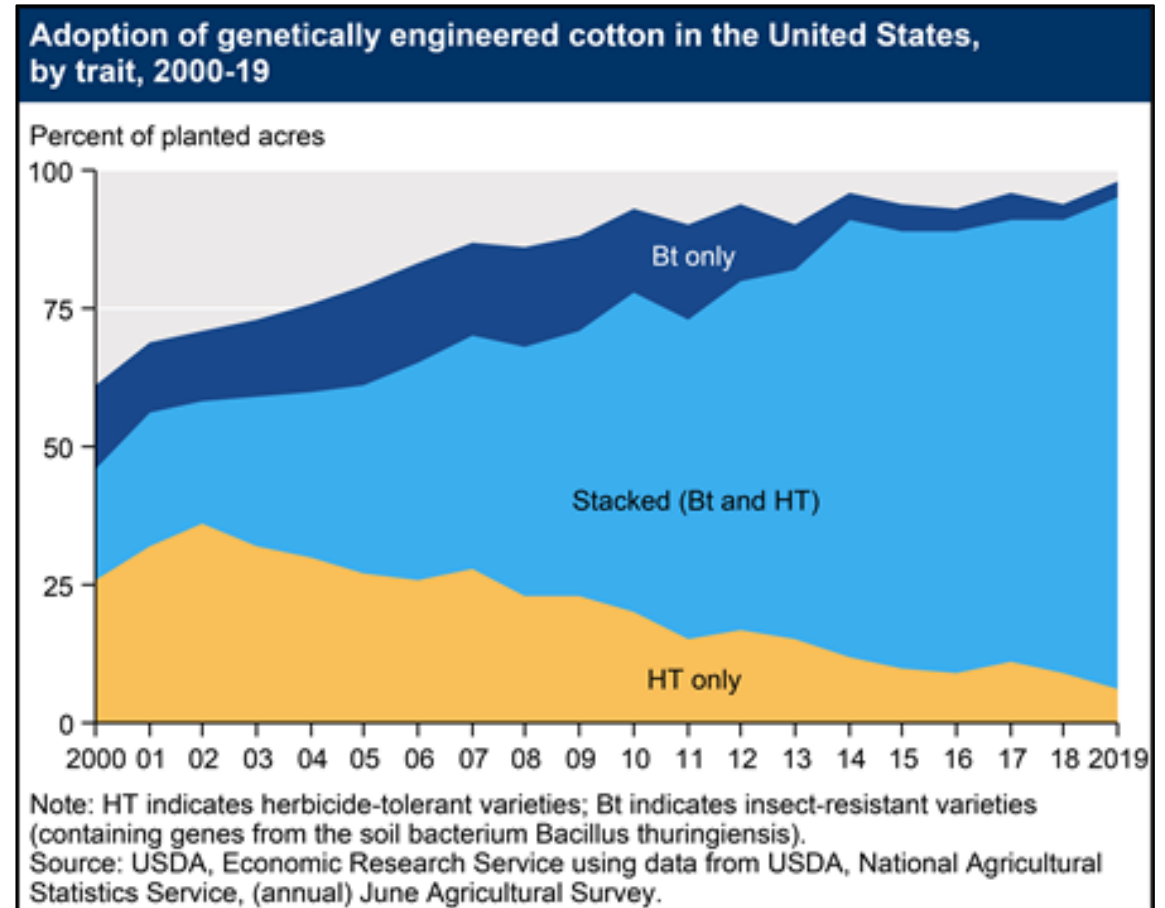
- ***Trait:*** Herbicide Tolerance
Insect Resistance
- ***Introduced:*** 1995
- ***Source of Inserted Trait:***
Bacteria
- ***Uses:*** Animal Feed
Cottonseed Oil
Fiber
- ***% of Harvest:*** >95%



Current GMO Crops

• Cotton

- **Trait:** Herbicide Tolerance
Insect Resistance
- **Introduced:** 1995
- **Source of Inserted Trait:**
Bacteria
- **Uses:** Animal Feed
Cottonseed Oil
Fiber



Current GMO Crops

• Field Corn

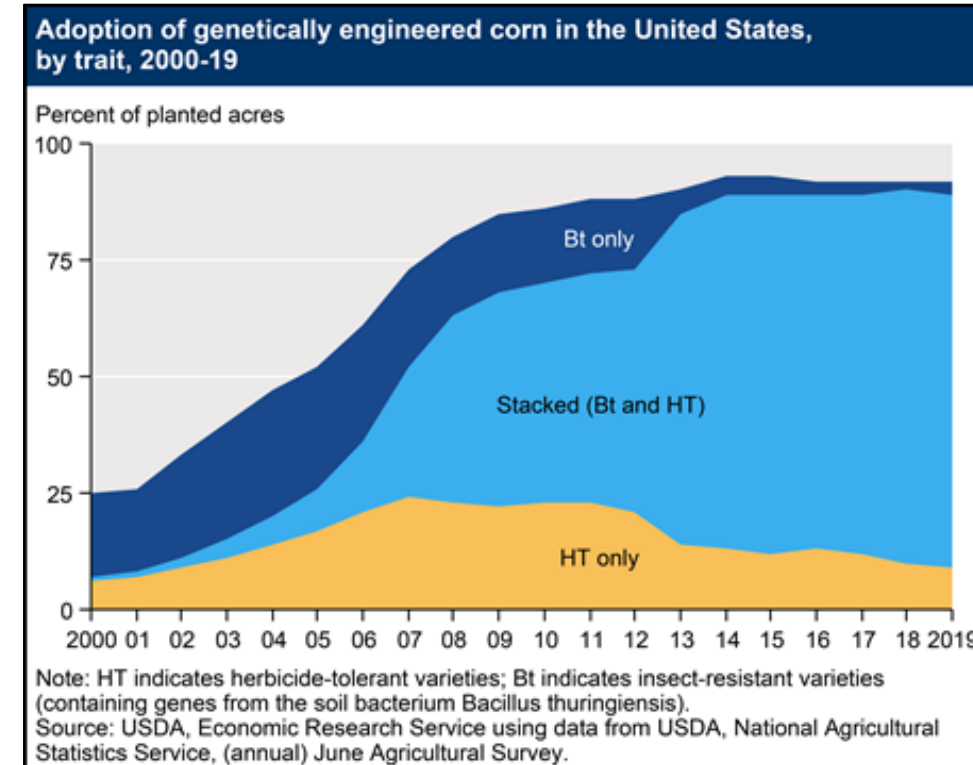
- **Trait:** Herbicide Tolerance
Insect Resistance
- **Introduced:** 1996
- **Source of Inserted Trait:**
Bacteria
- **Uses:** Alcohol Animal Feed
Corn Oil Corn Starch
Corn Syrup Ethanol
Sweeteners Industrial Uses
- **% of Harvest:** 90%



Current GMO Crops

• Field Corn

- **Trait:** Herbicide Tolerance
Insect Resistance
- **Introduced:** 1996
- **Source of Inserted Trait:**
Bacteria
- **Uses:** Alcohol Animal Feed
Corn Oil Corn Starch
Corn Syrup Ethanol
Sweeteners Industrial Uses

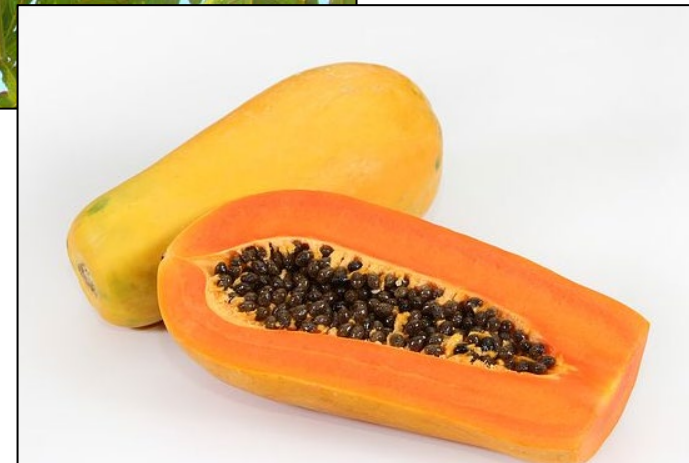


<https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx>

Current GMO Crops

• Papaya

- ***Trait:*** Disease Resistance
- ***Introduced:*** 1998
- ***Source of Inserted Trait:***
Virus
- ***Uses:*** Fresh Fruit
Juice
- ***Variety:*** Rainbow
- ***% of Harvest:*** 90%



Current GMO Crops

• PinkGlow Pineapple

- **Trait:** increased lycopene
 - Rose colored flesh
 - Sweeter
- **Introduced:** 2020
- **Source of Inserted Trait:**
 - other pineapples
 - tangerines
- **Uses:** Fresh Fruit



Current GMO Crops

• Potato

- ***Trait:*** Resist Bruising & Blackspot
Contain less Asparagine
Disease Resistance
- ***Introduced:*** 2014, 2017
- ***Source of Inserted Trait:***
Other Potatoes
RNA interference (RNAi)
- ***Uses:*** Food (White Russet)
- ***% of Harvest:*** < 0.01 %



Current GMO Crops

• Soybeans

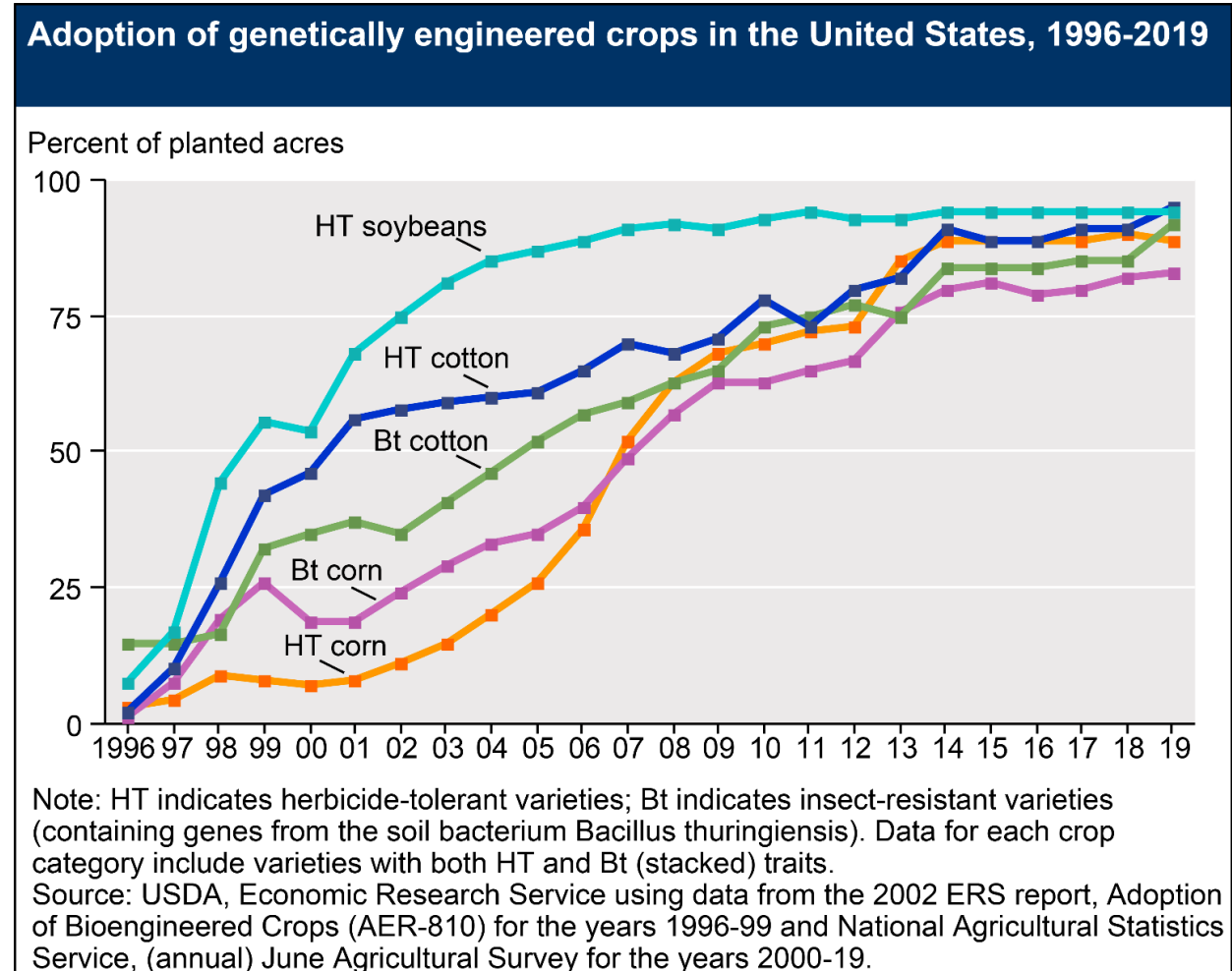
- ***Trait:*** Herbicide Tolerance
- ***Introduced:*** 1995
- ***Source of Inserted Trait:***
Bacteria
- ***Uses:*** Animal Feed
Biodiesel
Food
Industrial Uses
Vegetable Oil
- ***% of Harvest:*** 95%



Current GMO Crops

• Soybeans

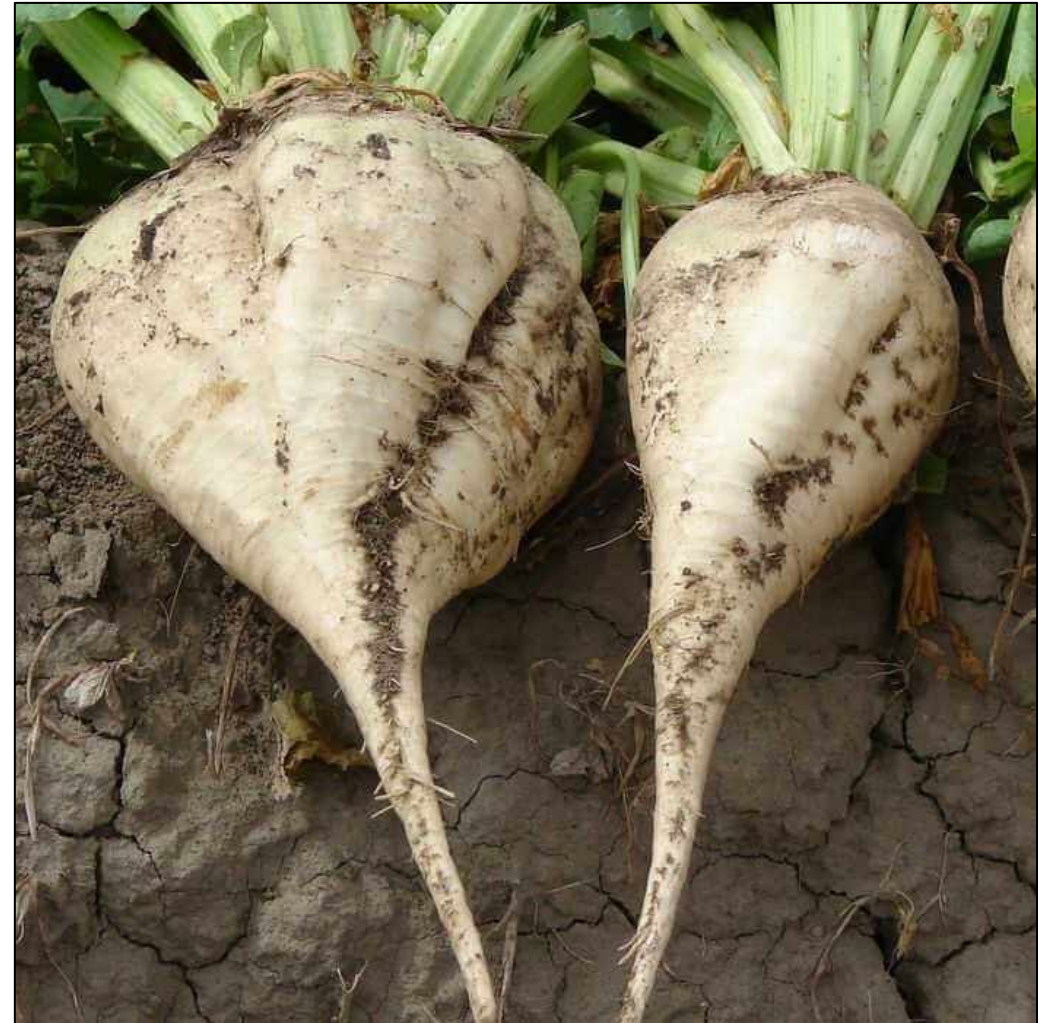
- **Trait:** Herbicide Tolerance
- **Introduced:** 1995
- **Source of Inserted Trait:** Bacteria
- **Uses:** Animal Feed
Biodiesel
Food
Industrial Uses
Vegetable Oil



Current GMO Crops

• Sugar Beets

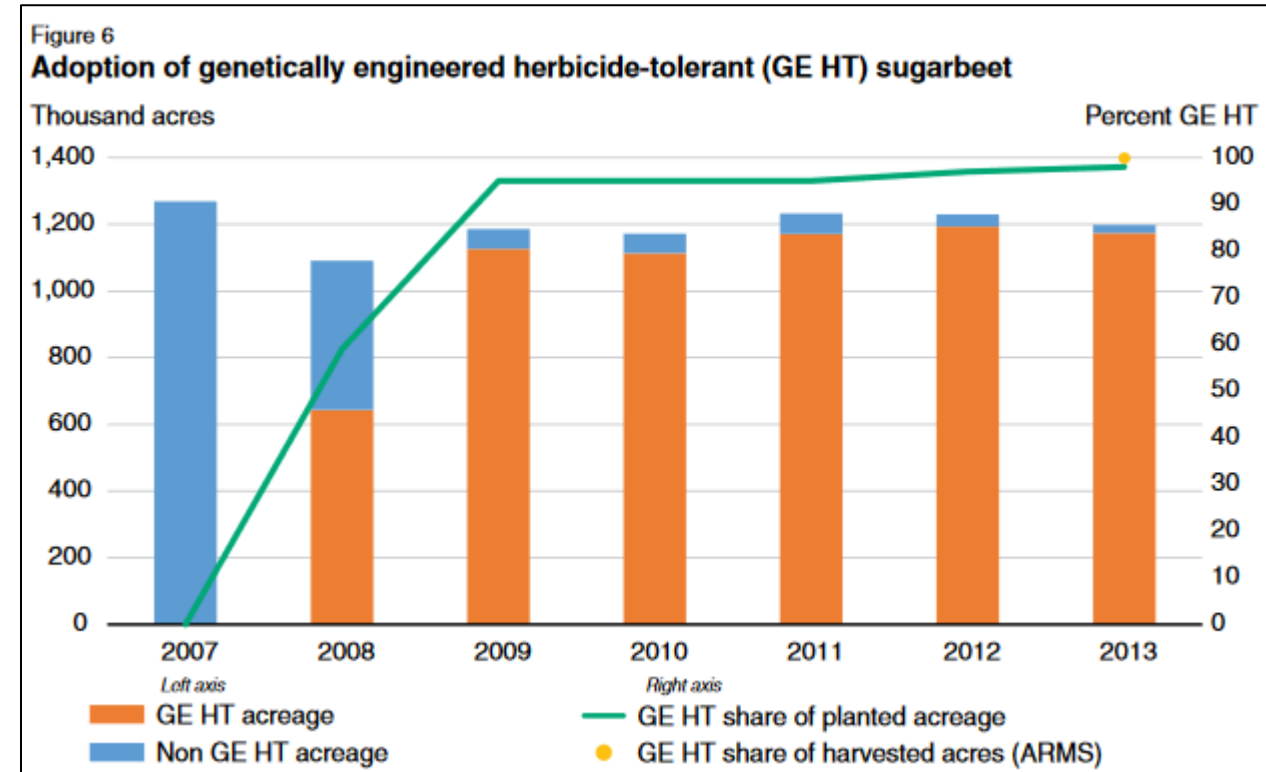
- ***Trait:*** Herbicide Tolerance
- ***Introduced:*** 2007
- ***Source of Inserted Trait:***
Bacteria
- ***Uses:*** Animal Feed
Sugar
- ***% of Harvest:*** ~ 100%



Current GMO Crops

• Sugar Beets

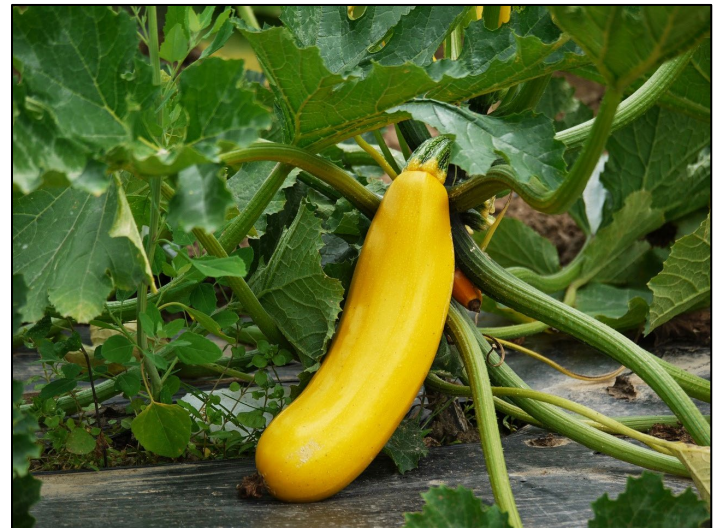
- **Trait:** Herbicide Tolerance
- **Introduced:** 2007
- **Source of Inserted Trait:** Bacteria
- **Uses:** Animal Feed
Sugar



Current GMO Crops

• Summer Squash

- ***Trait:*** Disease Resistant
- ***Introduced:*** 1995
- ***Source of Inserted Trait:***
Viruses
- ***Uses:*** Food
- ***% of Harvest:*** ~15%



Current GMO Crops

- **Sweet Corn**

- ***Trait:*** Herbicide Tolerance
Insect Resistance
- ***Introduced:*** 2011
- ***Source of Inserted Trait:***
Bacteria
- ***Uses:*** Food
- ***% of Harvest:*** ~ 10%





Brand New Commercially Available GMO Crops

Brand New Commercially Available GMO Crops

The Purple Tomato: antioxidants, color, taste

The purple color reflects the increased antioxidant content and presents a beautiful color and contrast on the plate, with a deep tomato taste.

LEARN MORE

Seeds: The Purple Tomato (10 seeds)
\$20.00



US Regulatory Path Completed: USDA Sept 2022 & FDA June 2023. [See press release here.](#)



Brand New Commercially Available GMO Crops



light.bio

Firefly Petunia

The only plant you see
when lights go off

Experience organic light from living flowers. Their subtle glow offers a backdrop for meditation, reflection, or simply a moment of tranquility.

Whether as a thoughtful gift or a unique addition to gatherings, the Firefly Petunia is sure to ignite feelings of wonder and amazement.

Limited stock.

Shipments begin in Spring 2024

Pre-order for \$29



Current GMO Crops

- **Alfalfa**
- **Apples**
- **Canola**
- **Cotton**
- **Field Corn**
- **Papaya**
- **Petunia**
- **Pineapple**
- **Potato**
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- **Sugar Beet**
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- **Sweet Corn**
- **Tomato**

Current GMO Crops



Pineapple



Corn



Soy



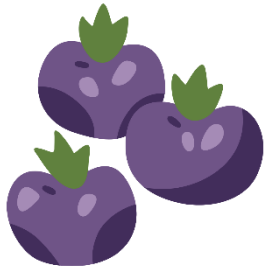
Cotton



Alfalfa



Sugar Beets



Tomato



Canola



Papaya



Apples



Potatoes



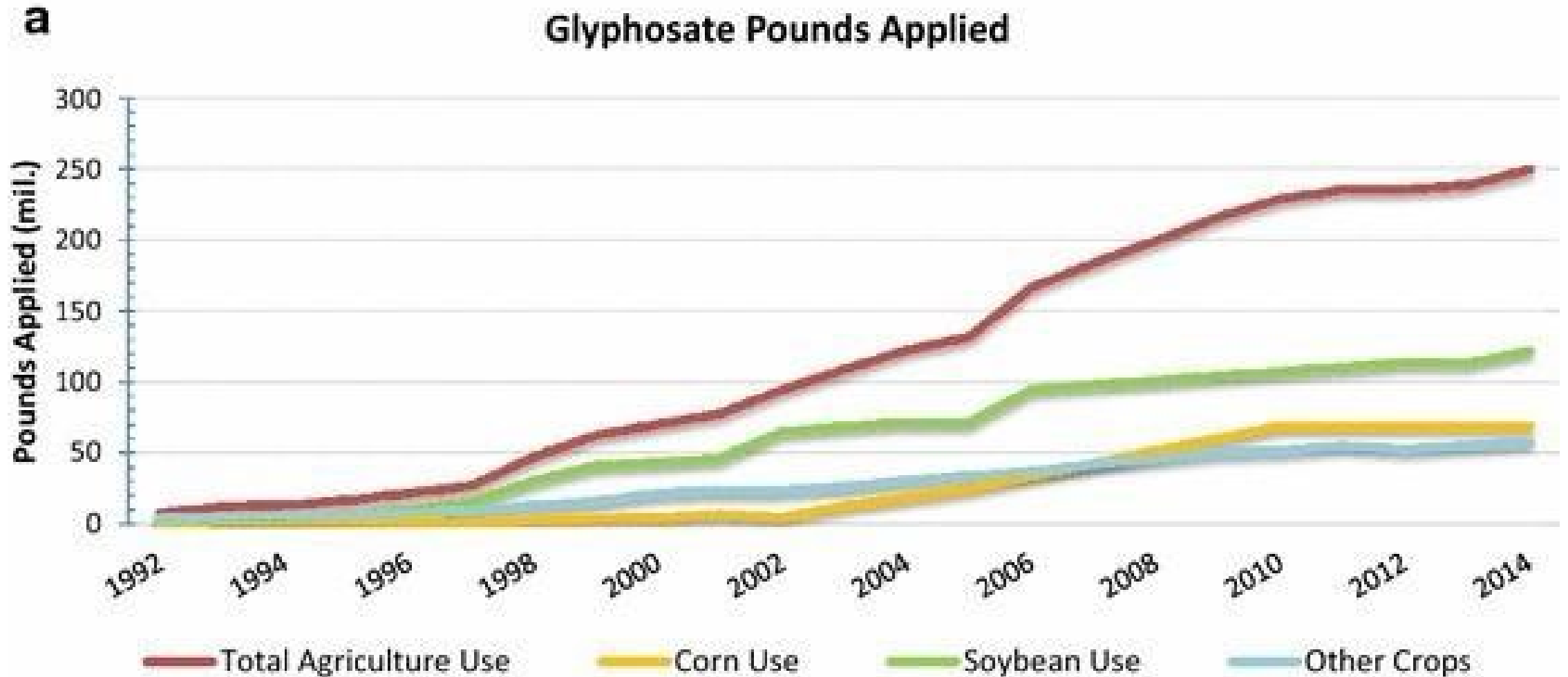
Squash

Problems with GMOs

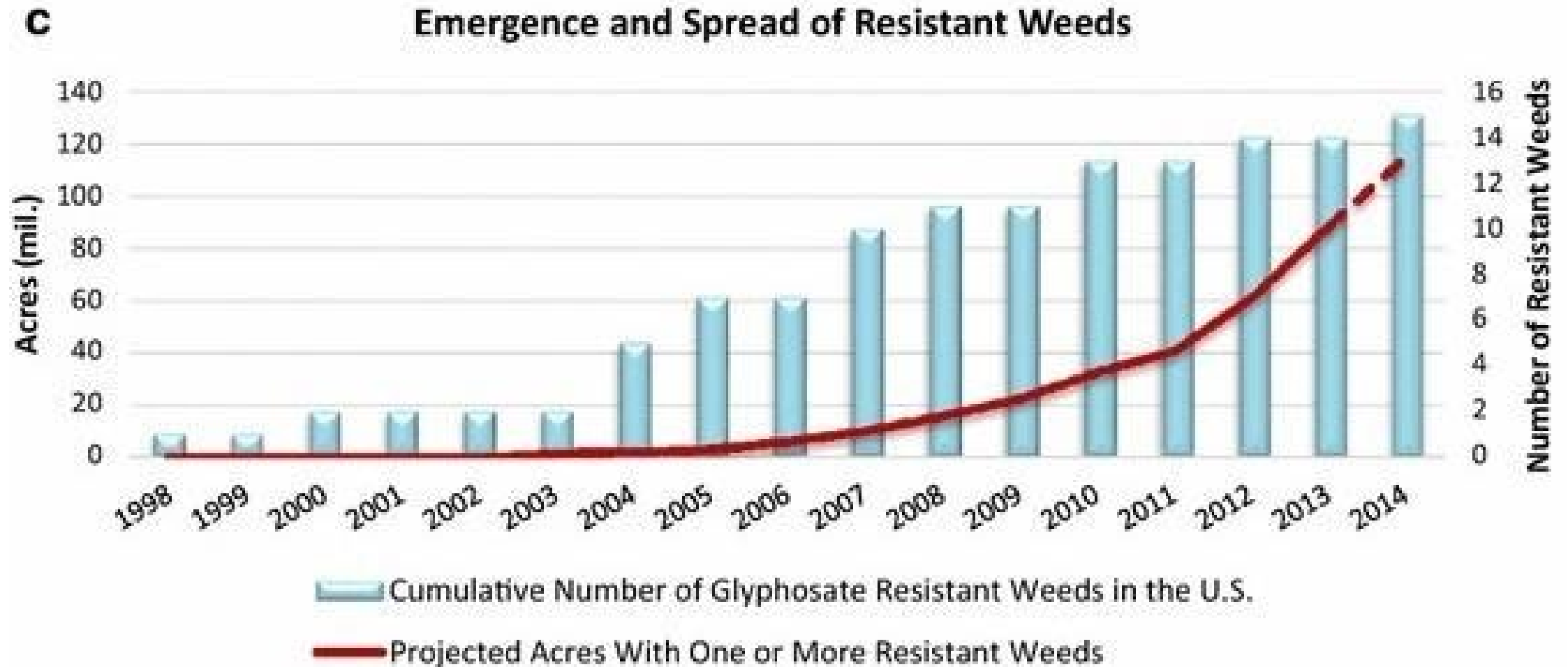
Problems with GMOs

- **Herbicide Resistance**
- **Pest Resistance**
- **Disease Resistance?**

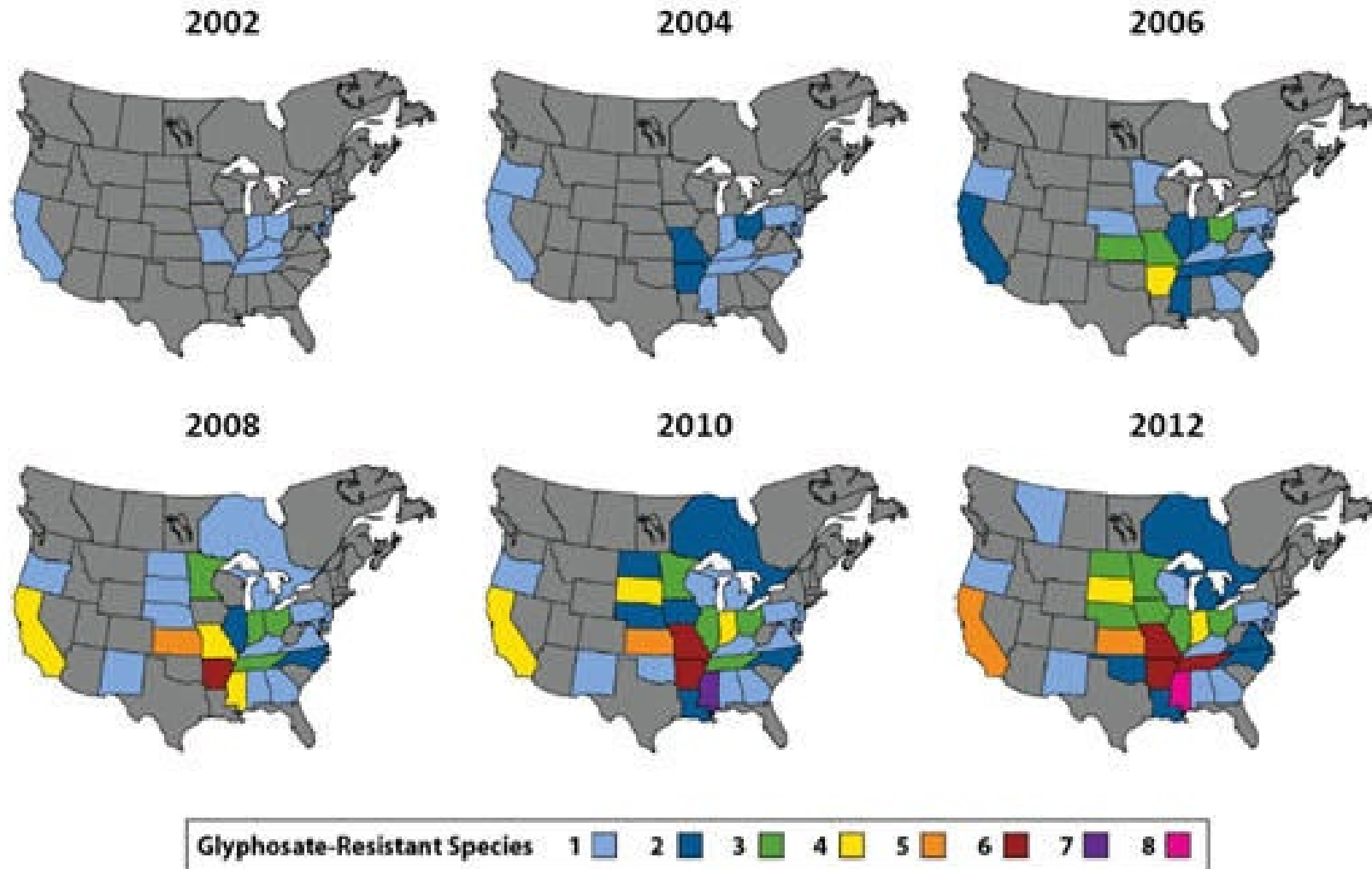
Herbicide Resistance



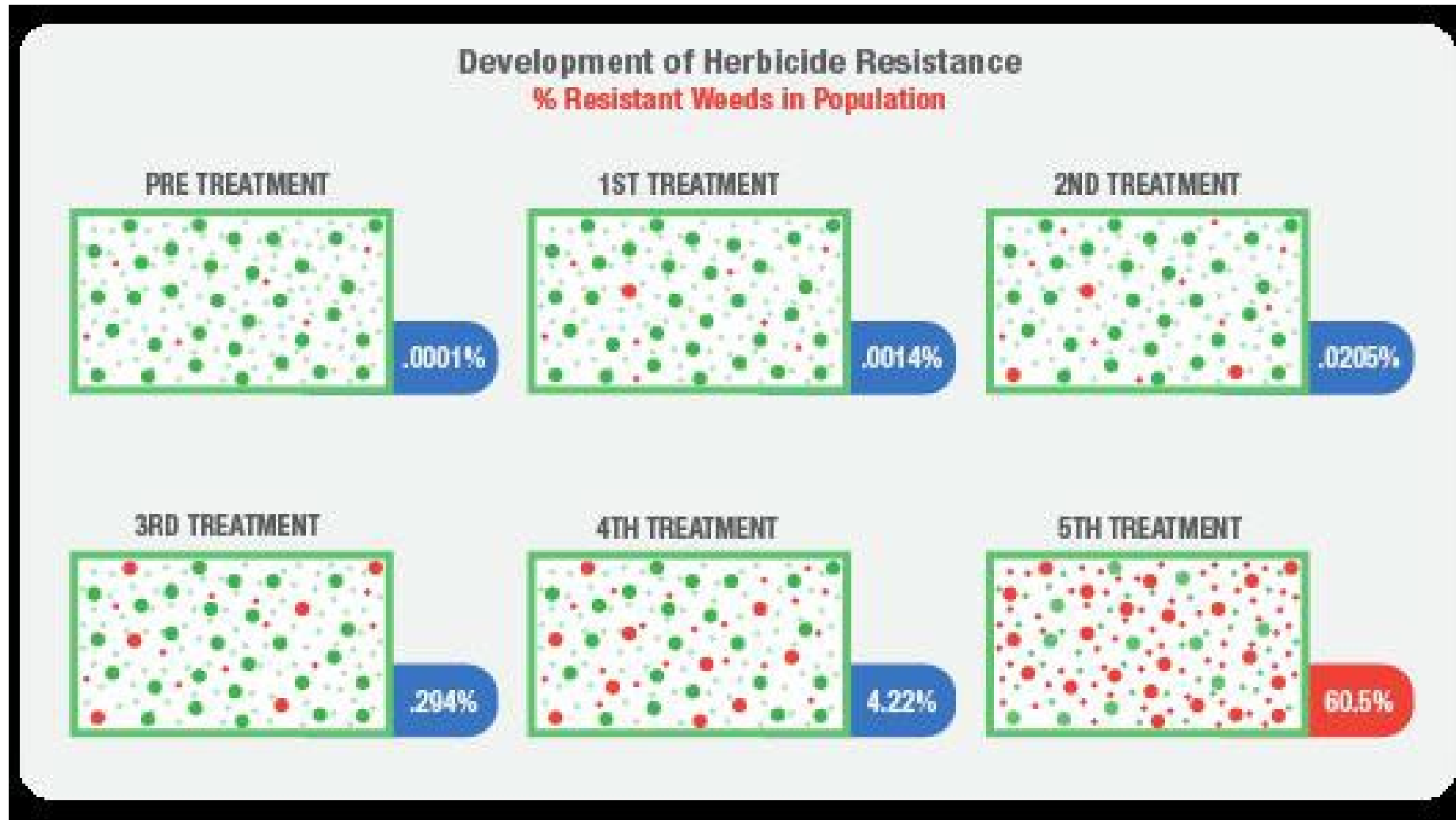
Herbicide Resistance



Herbicide Resistance



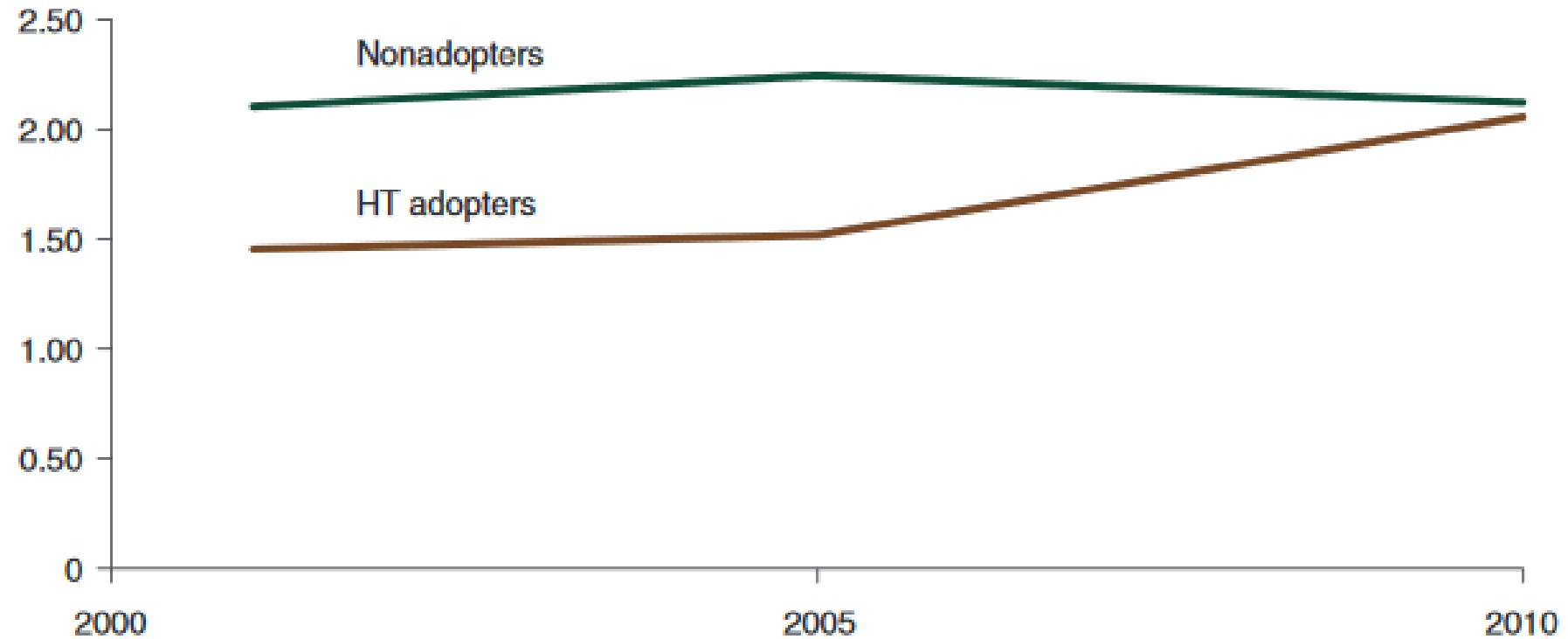
Herbicide Resistance



Herbicide Resistance

Herbicide use on corn: HT adopters and nonadopters, 2001-2010

Pounds per planted acre

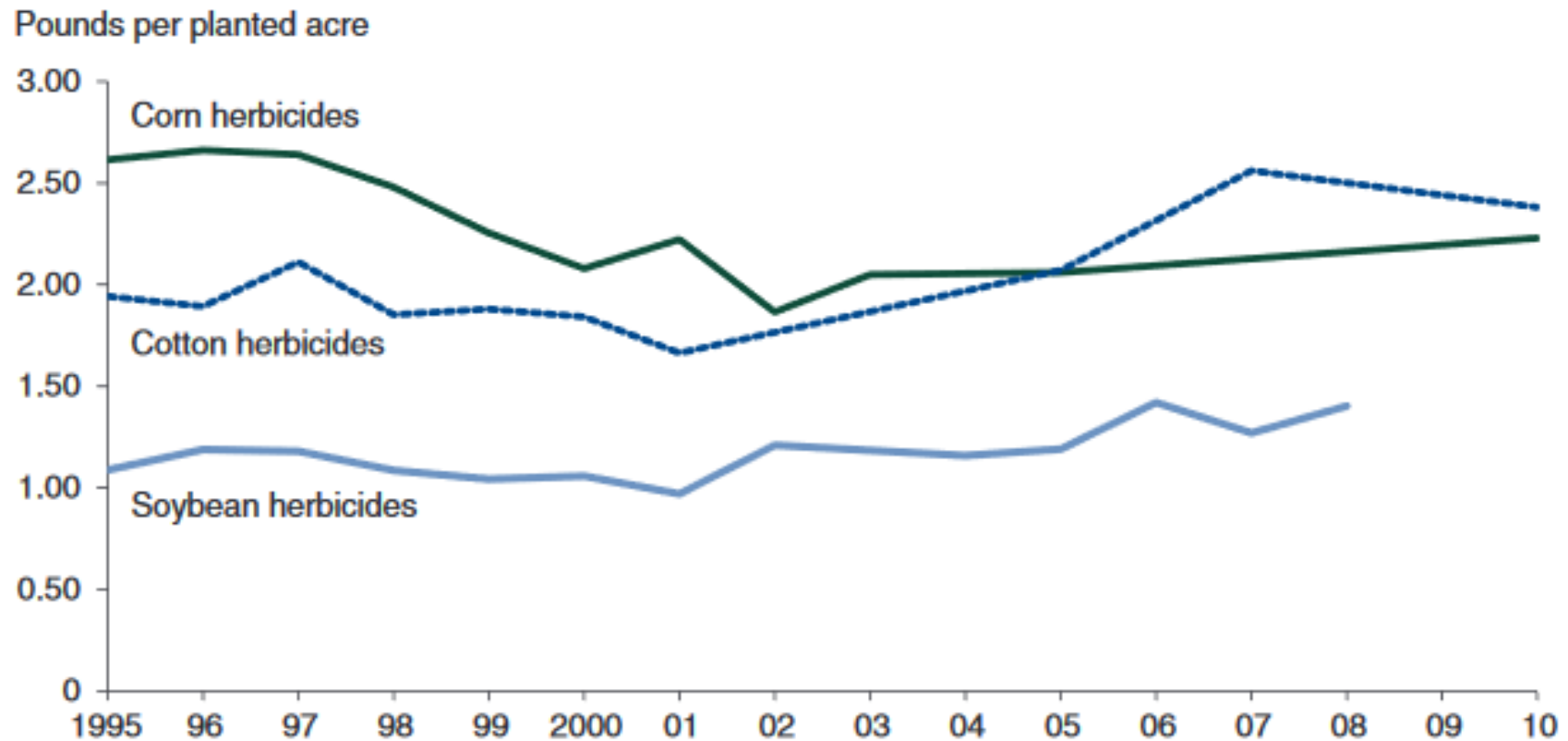


HT crops have herbicide tolerance traits.

Source: USDA Economic Research Service using data from 2001, 2005, and 2010 ARMS Phase II corn surveys.

Herbicide Resistance

Herbicide use in cotton, corn, and soybeans, 1995-2010





Data for herbicide use for soybeans in 2007 and 2008 are from proprietary data.

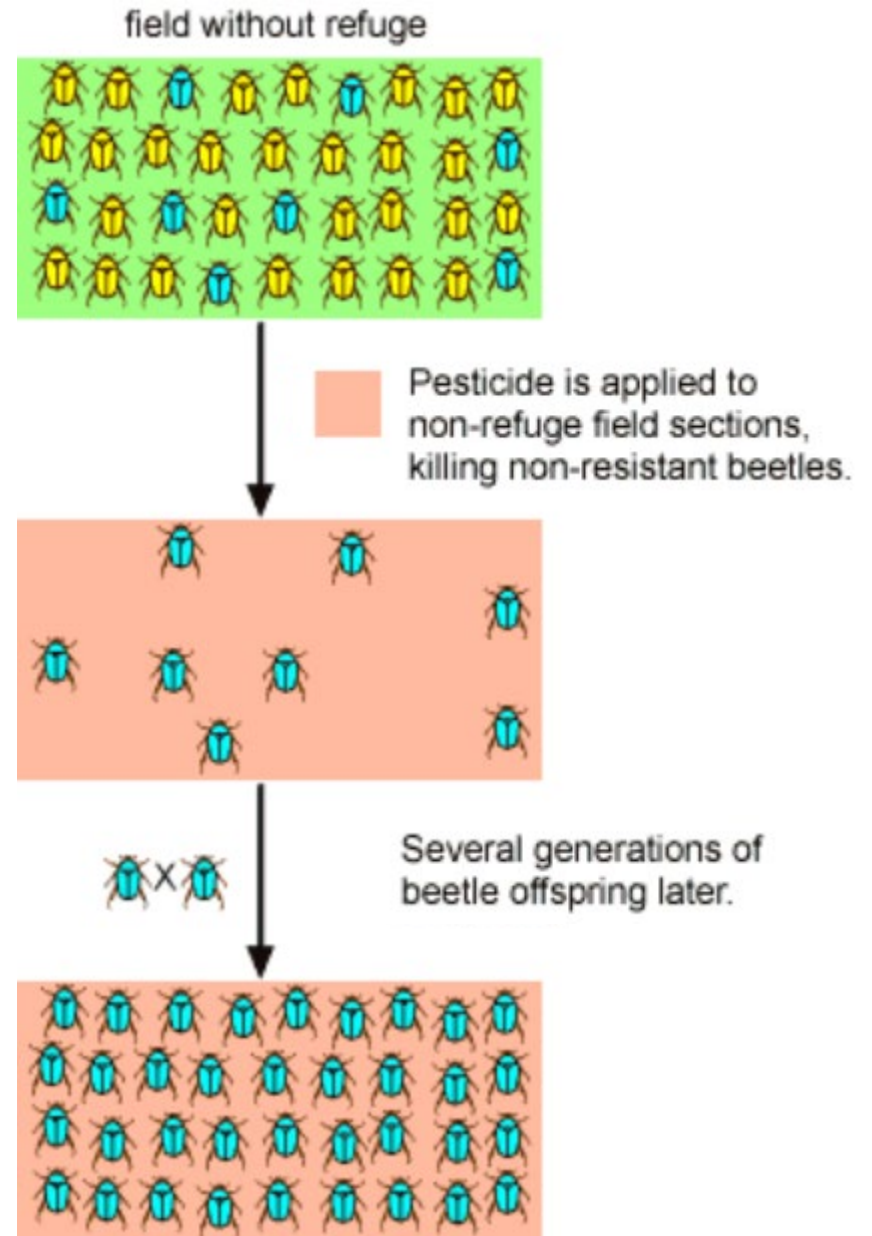
Source: USDA/NASS Agricultural Chemical Usage reports and USDA/NASS Quickstats.

Problems with GMOs

- Herbicide Resistance
- **Pest Resistance**
- Disease Resistance?

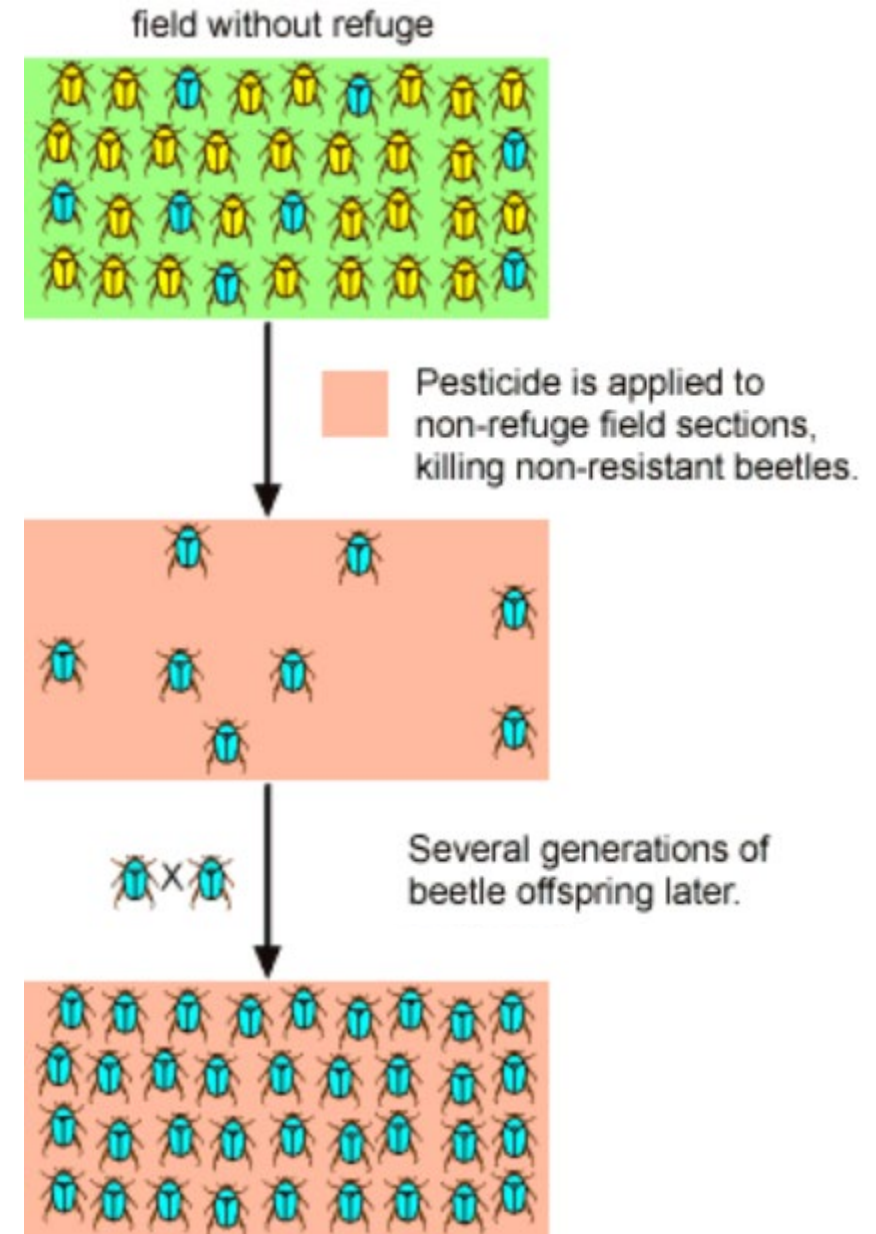
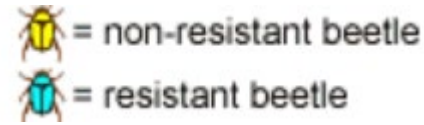
Insecticide Resistance

 = non-resistant beetle
 = resistant beetle



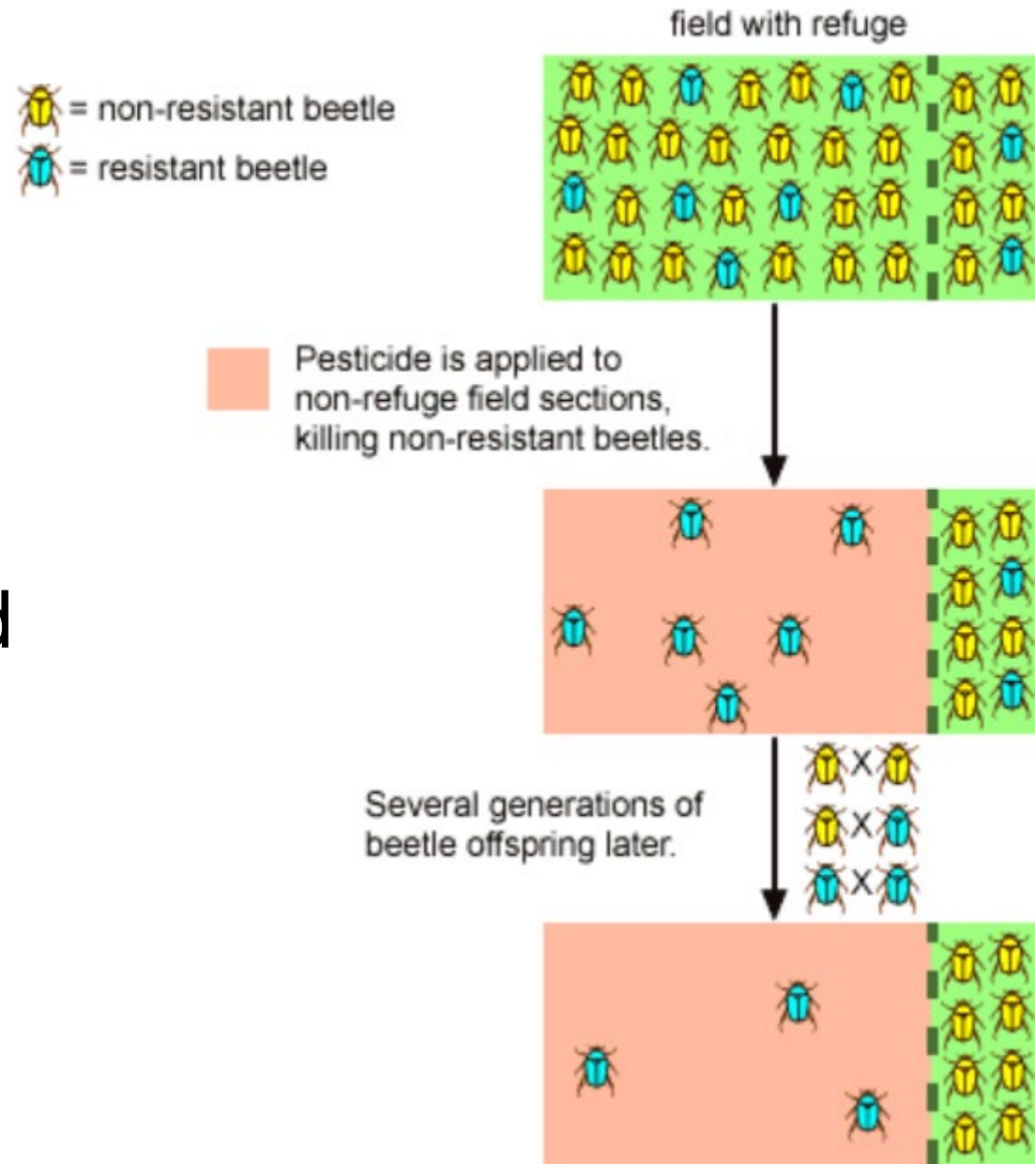
Insecticide Resistance

- **refuge** – area of the field planted with non-GMO seed





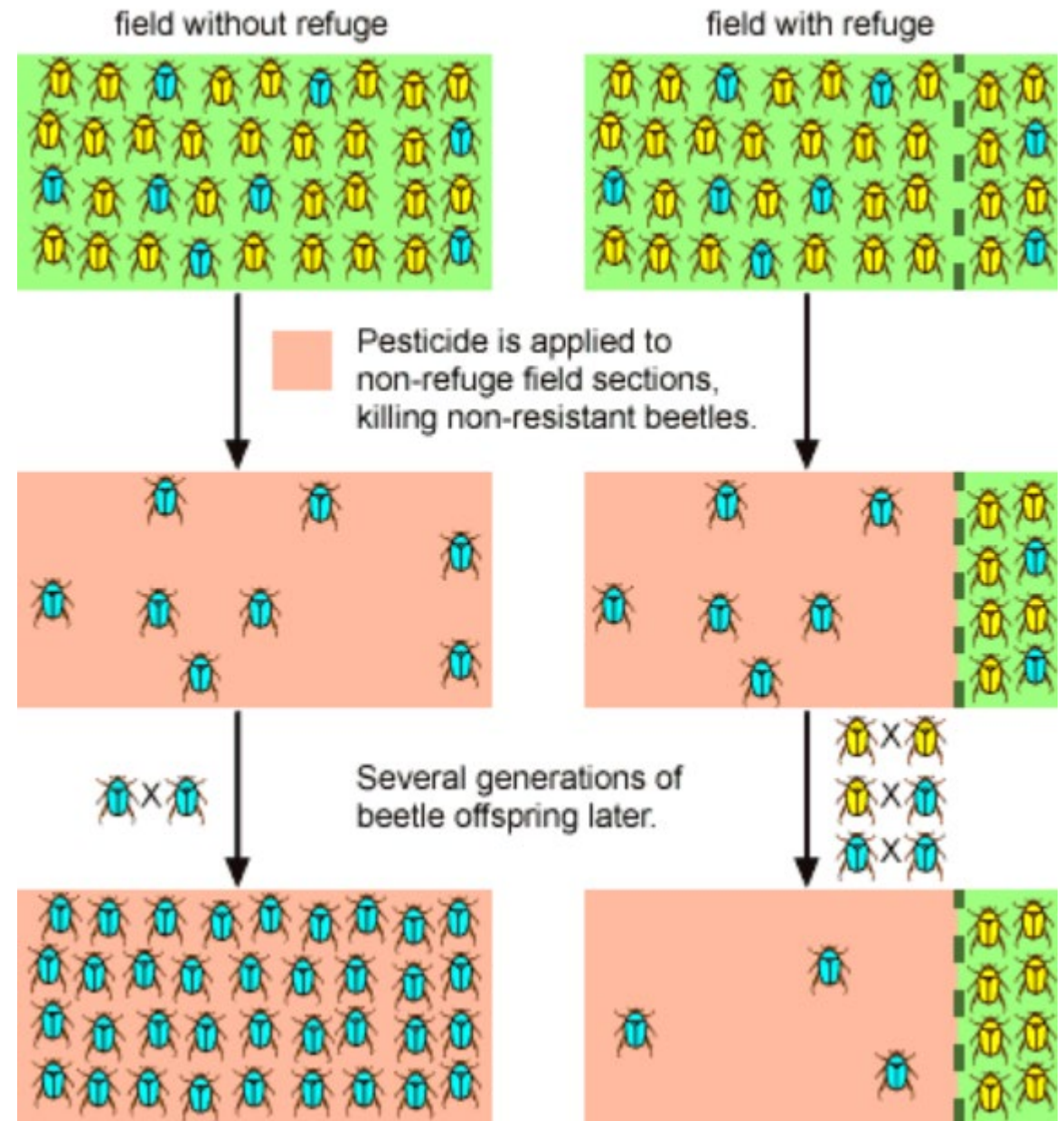
Insecticide Resistance

- **refuge** – area of the field planted with non-GMO seed
 - 10 % of the field
 - Refuge in a Bag



Insecticide Resistance

 = non-resistant beetle
 = resistant beetle



Problems with GMOs

- Herbicide Resistance
- Pest Resistance
- **Disease Resistance?**

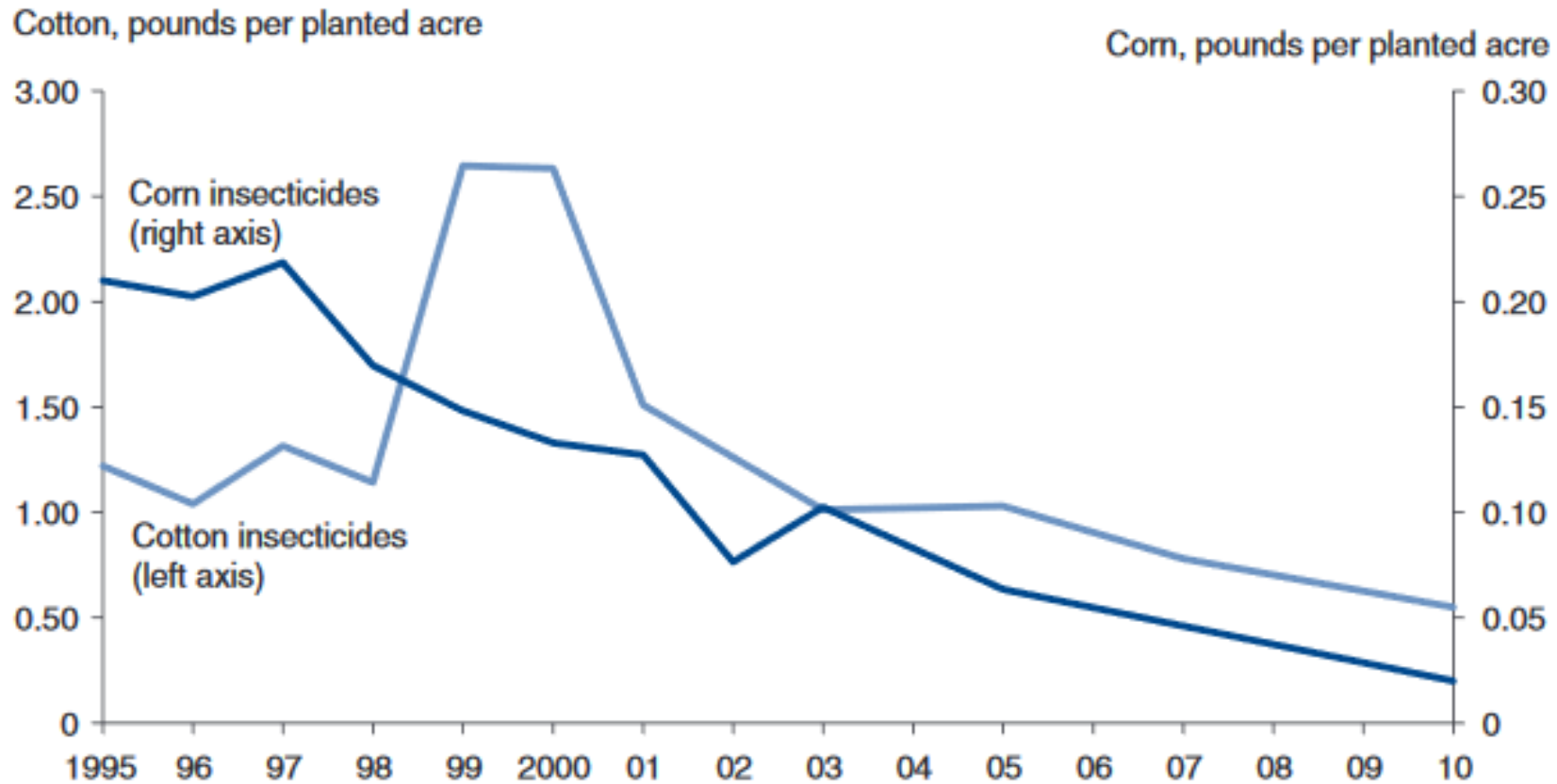
Benefits of GMOs

Benefits of GMOs

- **Decrease in Insecticide Use**

Benefits of GMOs

Insecticide use in corn and cotton production, 1995-2010

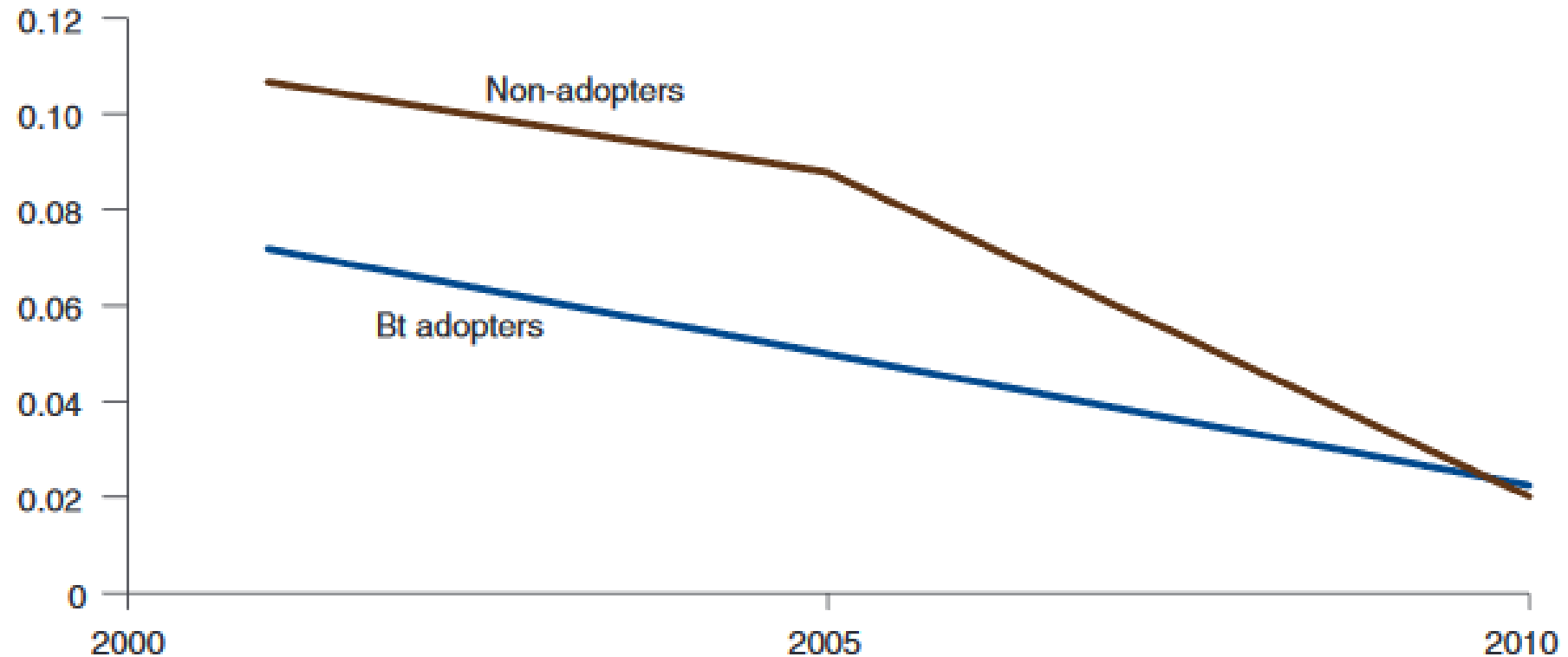


Source: USDA Economic Research Service using data from USDA National Agricultural Statistics Service Agricultural Chemical Usage reports.

Benefits of GMOs

Insecticide use in corn farms: adopters and non-adopters of Bt corn, 2001-2010

Pounds per planted acre



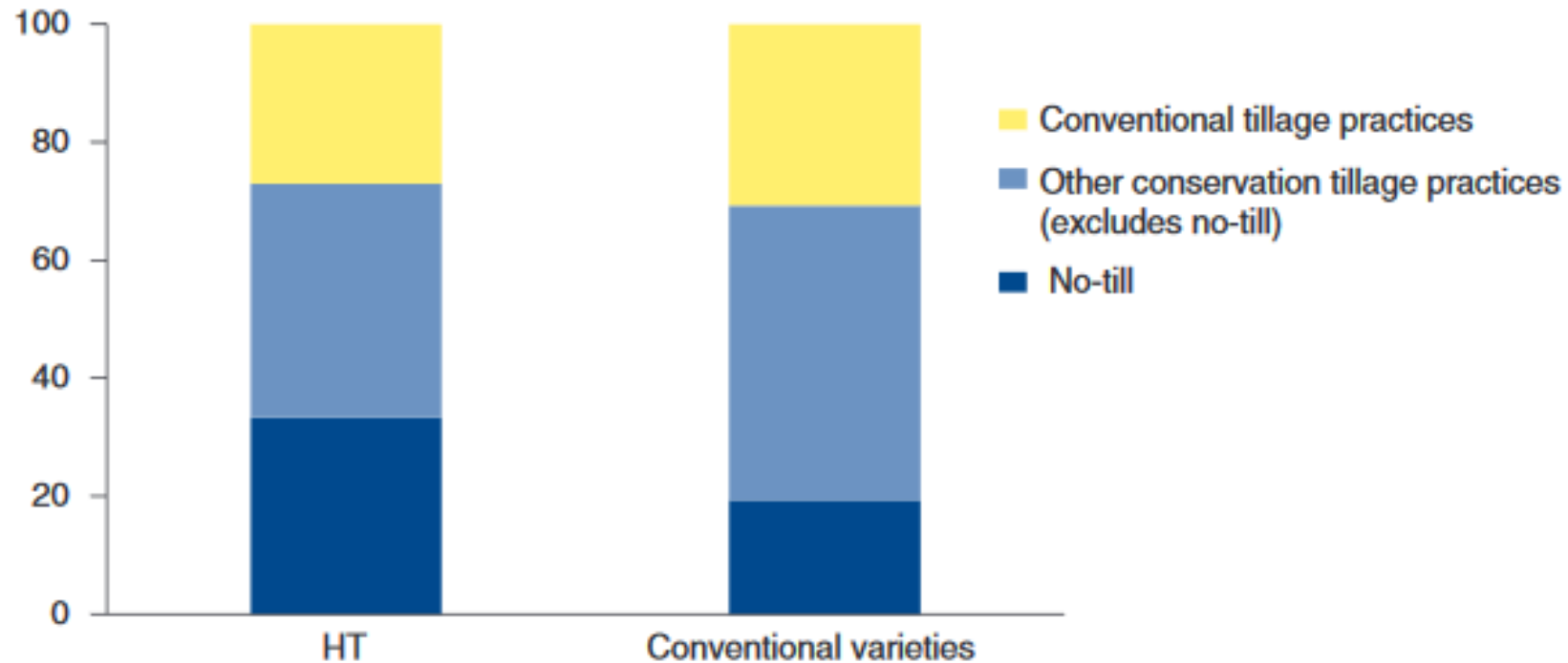
Benefits of GMOs

- Decrease in Insecticide Use
- **Increase in Conservation Tillage**

Benefits of GMOs

Adopters of herbicide-tolerant crops used conservation tillage more than did growers of conventional varieties: corn, 2005

Percent of acres



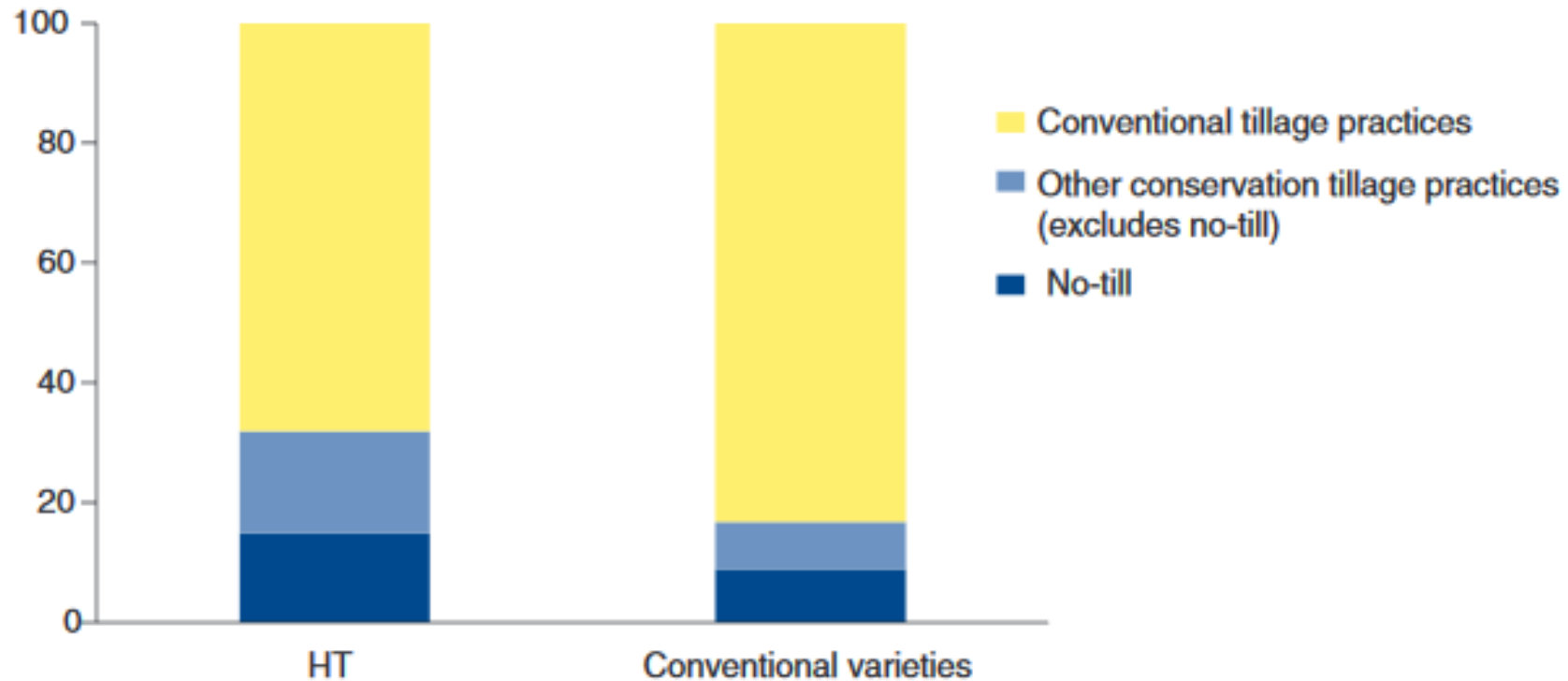
Conservation tillage includes no-till, ridge-till and mulch-till.

Source: USDA Economic Research Service using data from 2005 ARMS Phase II corn survey.

Benefits of GMOs

Adopters of herbicide-tolerant crops used conservation tillage more than did growers of conventional varieties: cotton, 2007

Percent of acres

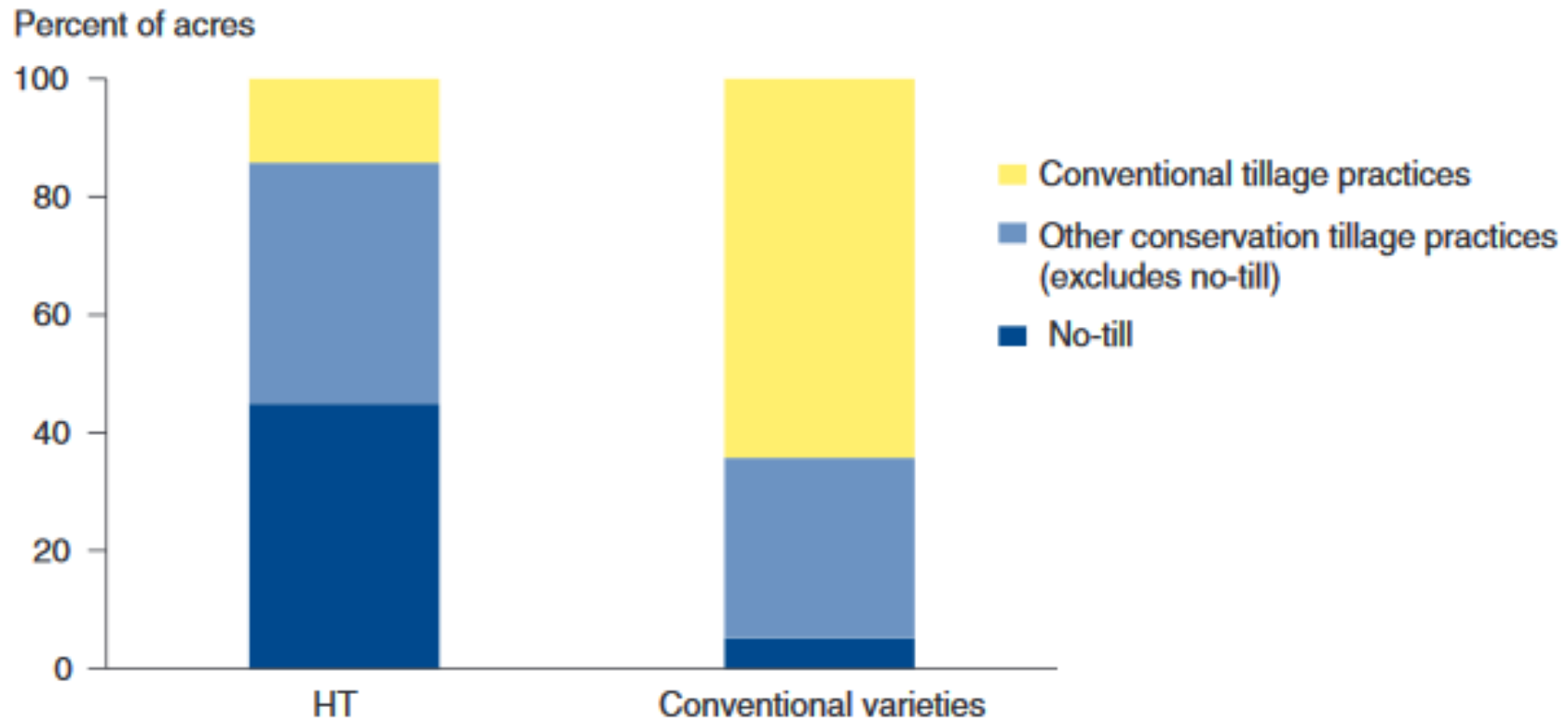


Conservation tillage includes no-till, ridge-till and mulch-till.

Source: USDA Economic Research Service using data from 2007 ARMS Phase II cotton survey.

Benefits of GMOs

Adopters of herbicide-tolerant crops used conservation tillage more than did growers of conventional varieties: soybeans, 2006



Conservation tillage includes no-till, ridge-till and mulch-till.

Source: USDA Economic Research Service using data from 2006 ARMS Phase II soybean survey.

Common Misconceptions

Common Misconceptions

Herbicide Tolerant Crops Contain Herbicides

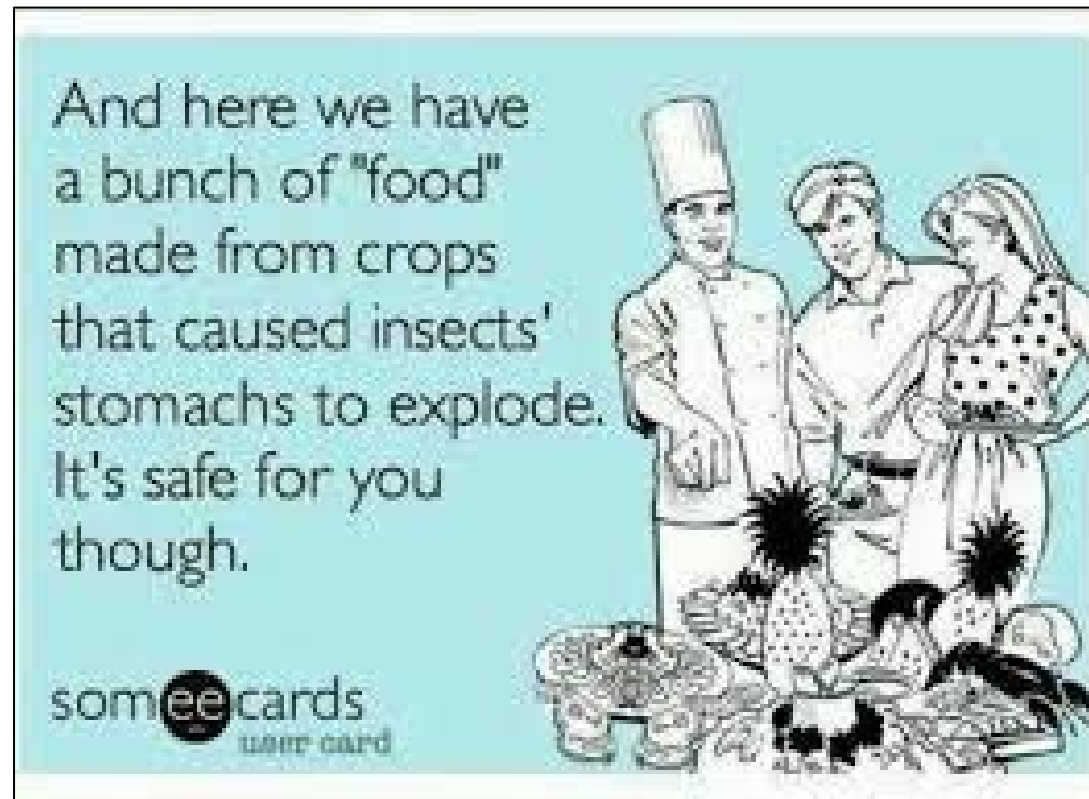
Common Misconceptions

Herbicide Tolerant Crops Contain Herbicides

FALSE!

Common Misconceptions

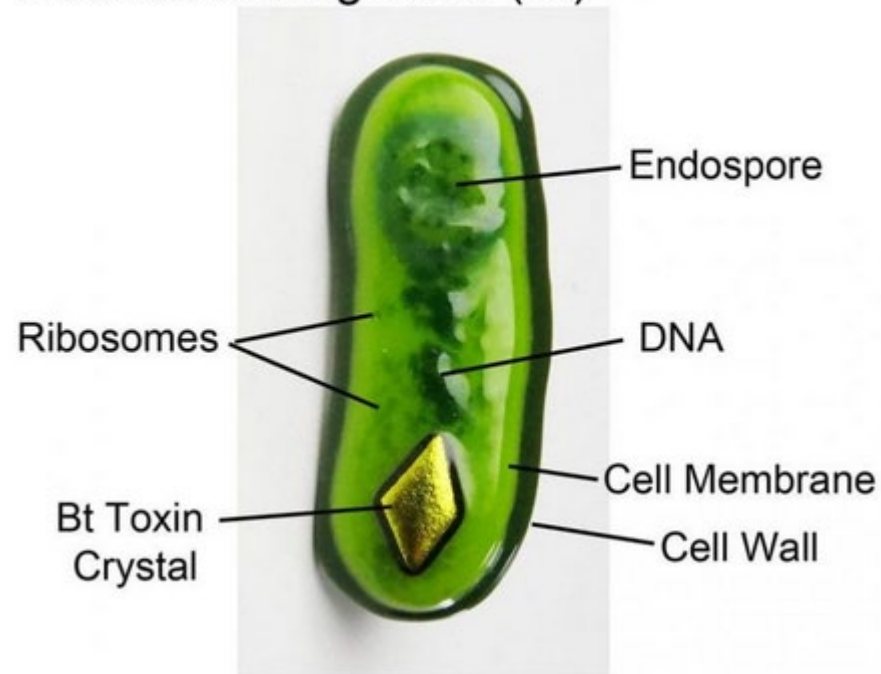
- *Bacillus thuringiensis* (Bt)



Common Misconceptions

- *Bacillus thuringiensis* (Bt)

Bacillus thuringiensis (Bt)



Ohio State University



Ohio State University

Common Misconceptions

- ***Bacillus thuringiensis (Bt)***

- Naturally occurring soil bacteria
- Used for 30+ years as an insecticide in the US
- Considered a biopesticide
- Used in organic production



Common Misconceptions

- *Bacillus thuringiensis* (Bt)

**S A SOUTHERN
5 0 A G.** **OMRI LISTED**
For Organic Use

THURICIDE BT CATERPILLAR CONTROL

BIOLOGICAL INSECTICIDE

ACTIVE INGREDIENT:
Bacillus thuringiensis Subsp. Kurstaki strain SA-12 solids, spores and lepidopteran active toxins (At least 6 million viable spores per mg) 98.35%

OTHER INGREDIENTS 1.65%

TOTAL 100.00%

*The percent active ingredient does not indicate product performance and potency measurements are not federally standardized.

**KEEP OUT OF REACH OF CHILDREN
CAUTION**

Thuricide is a registered trademark of Certis USA
See inside of booklet for continued Precautionary Statements and Directions for use.

**CONTROLS WORMS and
CATERPILLARS ON FRUITS,
VEGETABLES,
ORNAMENTALS
and SHADE TREES**

**Net Contents Liquid:
1 Pint (.474 liters)**

**TRUSTED SINCE 1926
BONIDE**

CAPTAIN JACK'S
FOR ORGANIC GARDENING

Bt

Bacillus Thuringiensis

FOR ORGANIC GARDENING

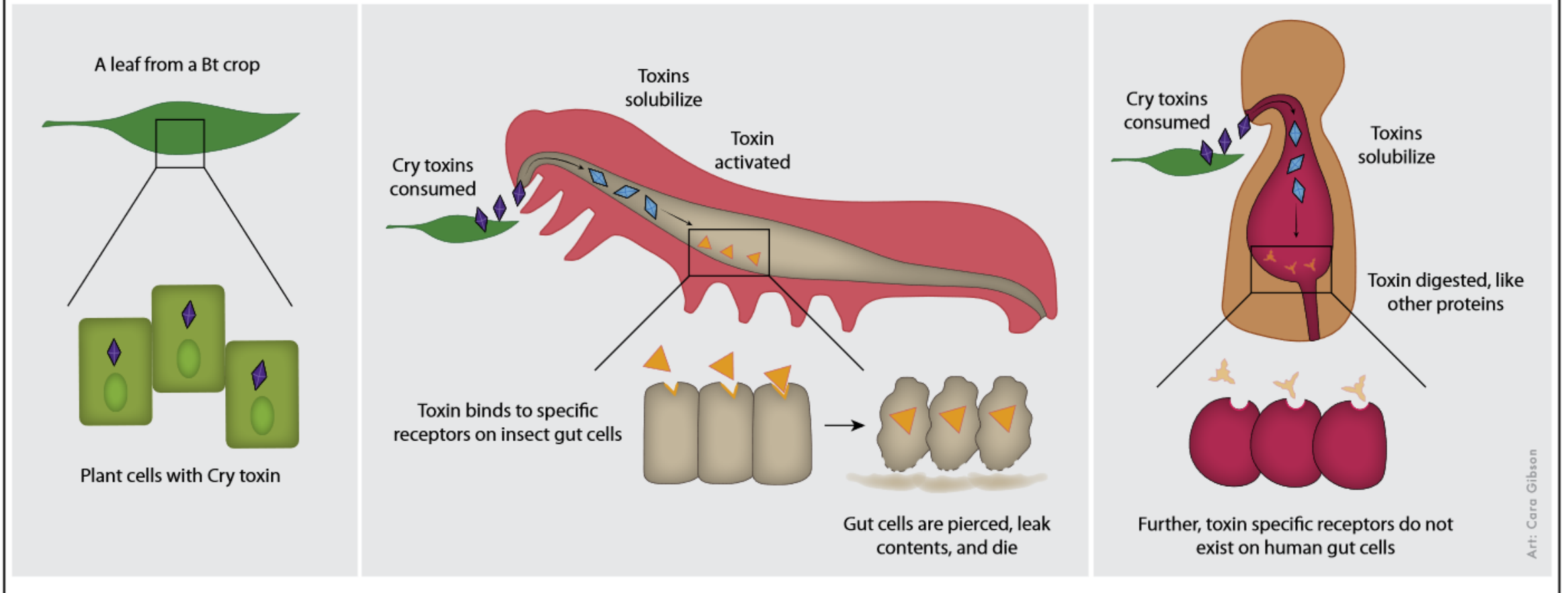
Bt Bacillus Thuringiensis Ready to Use

Controls worms & caterpillars on
fruits, vegetables and ornamentals

CAUTION

Common Misconceptions

How Cry toxin affects target pests, but not humans



Controversy

Controversy

- Evil Corporations



Controversy

CBS / April 26, 2008, 7:58 PM

- **Evil Corporations**

Agricultural Giant Battles Small Farmers

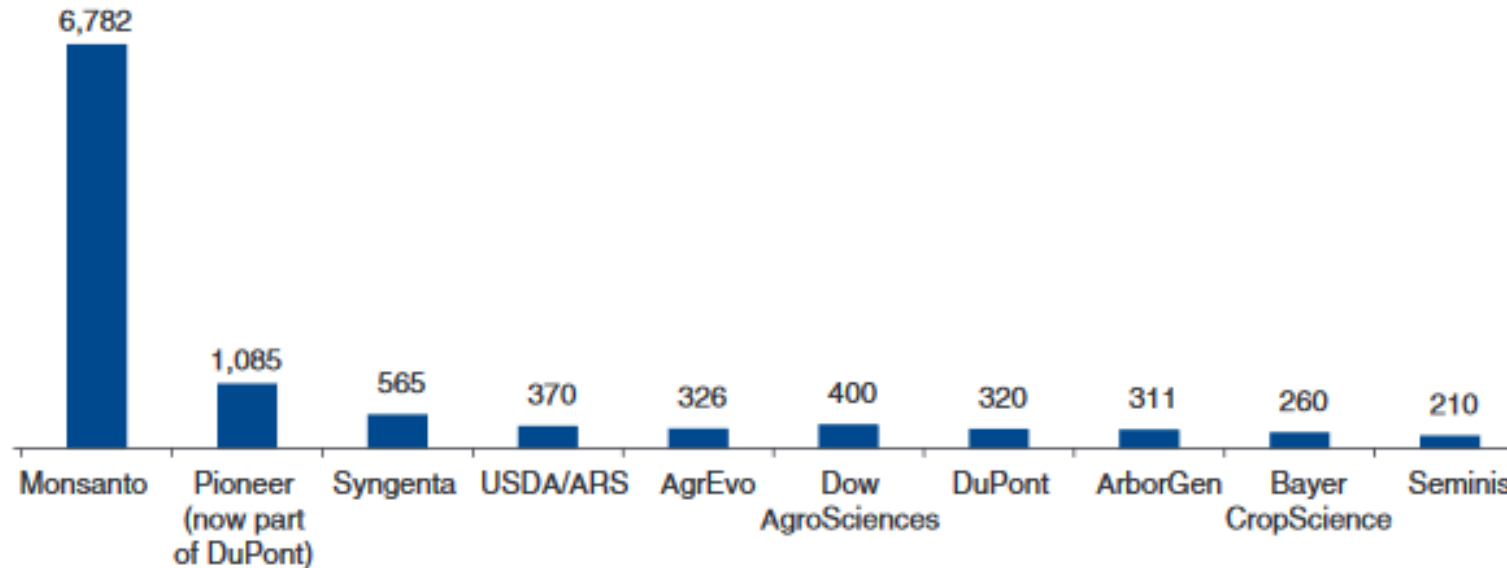
The agricultural giant Monsanto has sued hundreds of small farmers in the United States in recent years in attempts to protect its patent rights on genetically engineered seeds that it produces and sells, a new report said on Tuesday. – February 2013

Monsanto Sues Farmers Over Modified Soybean Seeds: Farmers Harvested and Planted GM Seeds

Dec 11, 2001

Controversy

Institutions having the most authorized permits and notifications (number held)



*As of September 24, 2013.

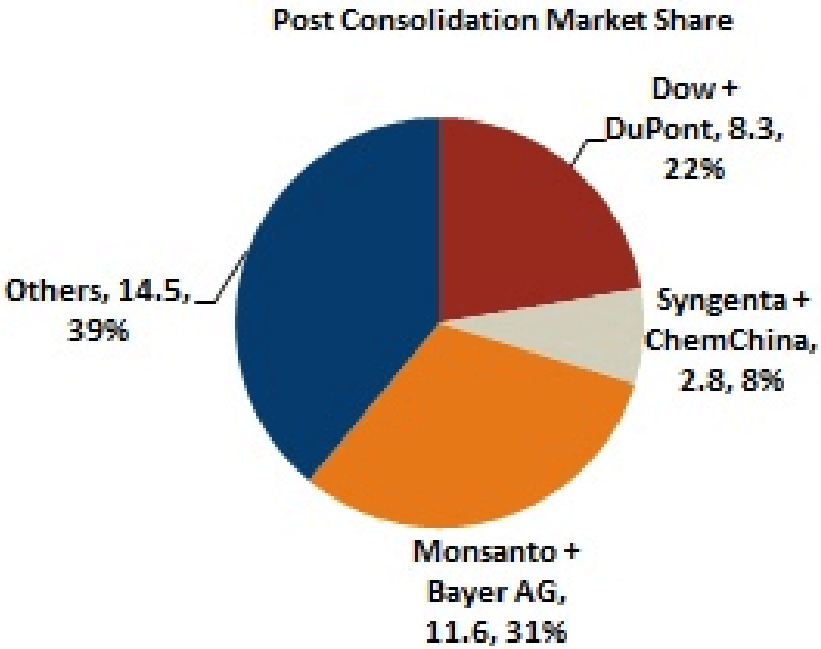
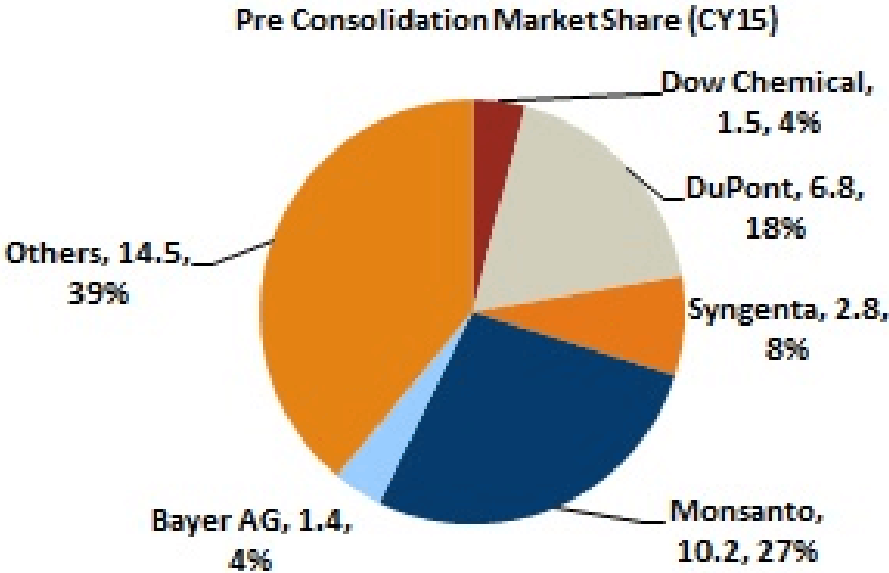
Authorizations for field releases of GE plant varieties are issued by USDA's Animal and Plant Health Inspection Service (APHIS) to allow technology providers to pursue field testing.

Source: Information Systems for Biotechnology (ISB, 2013).

Controversy

- **Evil Corporations**

Global seed Industry market share trend & prospect



Source: Bloomberg; ICICI Securities

Controversy

- Evil Corporations
- **Franken Foods**



Controversy

- Evil Corporations
- **Franken Foods**

“If genetically modified foods were properly labeled, I could still eat tomatoes,” was the angry remark. I was puzzled by this, but the gentleman went on to clarify. “I have a fish allergy,” he said, “and I have no way of knowing which tomatoes have been modified with fish genes, so I just don’t eat any tomato products.”



Controversy

- Evil Corporations
- Franken Foods
- **Misinformation**



Controversy

- Evil Corporations
- Franken Foods
- **Misinformation**

2. Pay attention to how the product looks.



Normal tomatoes



GM tomatoes



Controversy

- Evil Corporations
- Franken Foods
- **Misinformation?**



Controversy

- **Misinformation?**



8. What does “high risk” mean? What crops are high risk?

When the Non-GMO Project says a crop (also referred to as an input or an ingredient) is “high-risk,” it does not mean that the crop is harmful or worse than other crops. It means a GMO version of that crop is widely commercially available, and that crop is therefore at “high risk” of being a GMO.

Example: Corn is high risk because over 90 percent of corn grown in North America is GMO corn – it is widely commercially available.

High-risk crops currently include alfalfa, canola, corn, cotton, papaya, potato, soy, sugar beet, and zucchini. Find more information about high-risk crops and inputs [here](#).

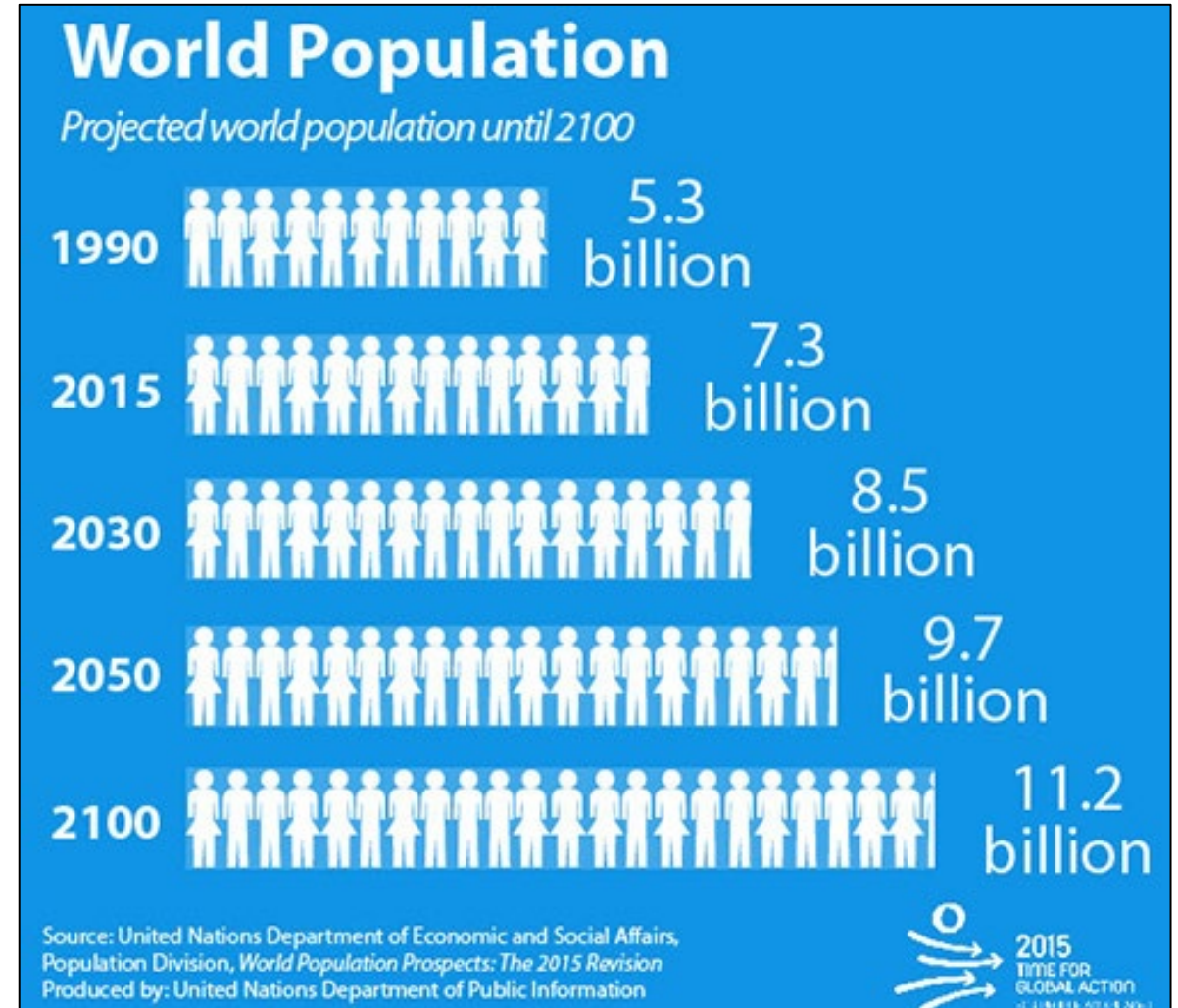
Controversy

- Evil Corporations
- Franken Foods
- Misinformation



The Future of GMOs

- **Pest Problems**
- **Micronutrient Content**
- **Environment Issues**



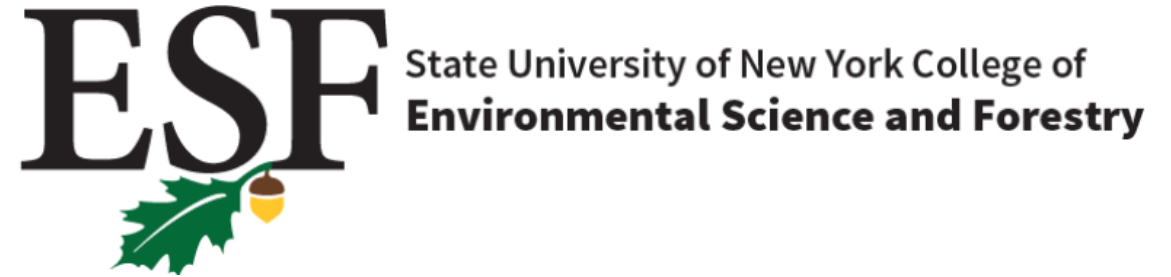
The Future of GMOs

- **Pest Problems**
 - GMO Eggplant



The Future of GMOs

- **Pest Problems**
 - GMO Chestnut



The American Chestnut
Research & Restoration
Project at ESF

The Future of GMOs

- **Micronutrient Content**
 - Golden Rice



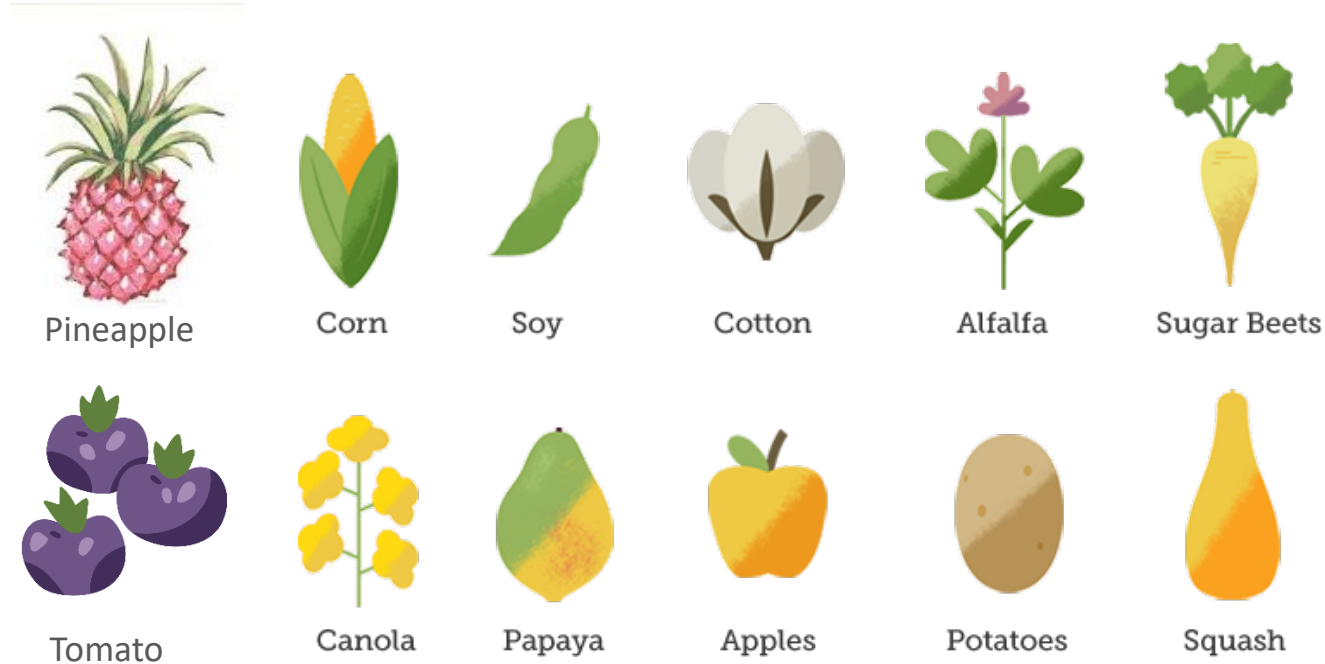
The Future of GMOs

- **Environmental Issues**

- Drought Tolerance
- Salinity Tolerance

To Eat or Not to Eat?

- Where do you draw the line?



Review

- **What is a GMO?**
- **Why do we genetically engineer plants?**
- **How do we genetically engineer plants?**
- **Current GMO Crops**
- **Problems with GMOs**
- **Benefits of GMOs**
- **Controversy**
- **To Eat or Not to Eat?**



Resources

[Genetically Engineered Crops in the United States](#) – USDA – ERS

[Genetically Modified Alfalfa Production in the United States](#) – USDA – ERS

[How to Make a GMO](#) – Signal to Noise Special Edition: GMOs and Our Food – Harvard University

[Recent Trends in GE Adoption](#) – USDA – ERS

[The Adoption of Genetically Engineered Alfalfa, Canola, and Sugarbeets in the United States](#) – USDA – ERS

[What GMO crops are currently available on the market?](#) – GMO Answers



Questions?