Selective breeding vs. genetic modification

NOURISH THE FUTURE

Tomorrow’s science is looking for leaders

Case study

- According to several studies, the loss in corn yield due to drought ranges from 40–80 bu/acre in the U.S, with higher ranges in the western states.
- Economic effects of drought can be up to $9 billion in a drought year.
- Economic impacts may include farmers who lose money because drought destroyed or lowered the yield of their crops.
- These economic impacts can be both direct, such as decreases in corn production, and indirect, as seen by increases in the price of animal feed.
- The traits that will help reduce the effects of drought in corn include: a strong root system, resistance to root worm, and resistance to seedling diseases.

Selective breeding activity

- You have three Starburst® candies. These candies represent the traits that determine resistance to drought.
- Stack your three Starburst and determine your trait combinations using the following key:
  - **Red** for strong root system
  - **Yellow** for seedling diseases resistance
  - **Pink** for rootworm resistance

Table of traits for drought resistance

Make note of what characteristics your plant has.

R	R	R	R	R	R	P	P	P	Y
R	R	Y	R	P	P	P	Y	P	Y
R	Y	Y	P	P	Y	Y	Y	P	Y
• Strong root system	• Strong root system • Seedling diseases resistance	• Strong root system • Seedling diseases resistance	• Strong root system • Root worm resistance	• Strong root system • Root worm resistance	• Strong root system • Root worm resistance • Seedling diseases resistance	• Strong root system • Seedling diseases resistance	• Strong root system • Seedling diseases resistance	• Root worm resistance	• Seedling diseases resistance

Find another person at your table and combine your Starburst.

- Place your six traits in the cup
- Shake the cup
- Draw out three Starburst® (traits)
- This represents the offspring from your cross

Table of traits for drought resistance

What characteristics does your offspring have?

R	R	R	R	R	R	P	P	P	Y
R	R	Y	R	P	P	P	Y	P	Y
R	Y	Y	P	P	Y	Y	Y	P	Y
• Strong root system	• Strong root system • Seedling diseases resistance	• Strong root system • Seedling diseases resistance	• Strong root system • Root worm resistance	• Strong root system • Root worm resistance	• Strong root system • Root worm resistance • Seedling diseases resistance	• Strong root system • Seedling diseases resistance	• Strong root system • Seedling diseases resistance	• Root worm resistance	• Seedling diseases resistance

Choose another person to cross plants with.

- Plant breeders do not rely on random combinations to see what happens.
- Find another plant with traits that you would like. Put the traits in the cup and see what the offspring results are.
- How many plants result with all of the desired traits?
- How might plant breeders increase the chances they will get the desired traits in their offspring?

Reflection

- How did the offspring from your cross differ from the “parents”?
- What traits did your offspring have?
- The first process we used is random and the offspring are not easily predictable. However, scientists can select for traits they desire and there are predictable results, but the ratios of offspring rarely produce 100% of the traits desired each time. The second time, we were more selective… Did all of the offspring have the desired traits?
- Seed researchers can selectively breed for resistance.
  How long might it take to get the desired traits?

If it were only that easy…

- These traits (drought resistance) are controlled by many genes on different areas of several chromosomes.
- How might the process of meiosis affect the breeding of different plants to create the traits desired?
- How might plant breeders overcome these obstacles?
- How much might it cost (economically and time) to make these modifications? What are the environmental costs and benefits?

What other methods exist for “modifying” plants to get the desired traits?

- Genetic modification (GMOs) aka transgenic, genetically engineered
- Mutagenesis
- CRISPR

Which crops are GMO in the United States?

There are 13 commercially available crops (according to the USDA):

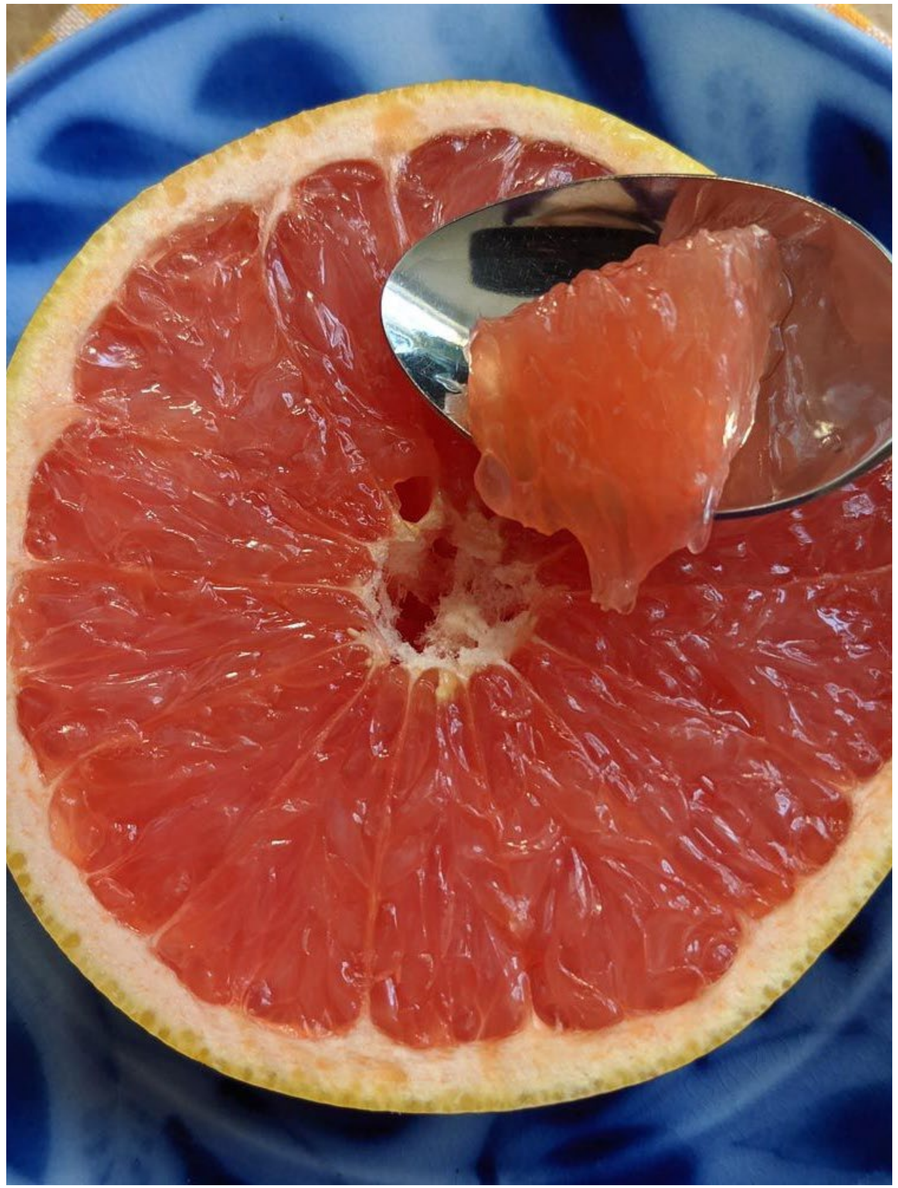
- Alfalfa
- Arctic Apple
- Canola
- Cotton
- Corn
- Eggplant
- Papaya
- Pineapple (pink)
- Potato
- Salmon (AquAdvantage)
- Soybean
- Squash
- Sugarbeet

What are the modifications?

- **Corn (field and sweet):** drought and herbicide tolerance; insect resistance
- **Alfalfa:** herbicide tolerance
- **Canola:** herbicide tolerance
- **Cotton:** herbicide tolerance and insect resistance
- **Soybeans:** herbicide tolerance and insect resistance; health benefit
- **Sugar beets:** herbicide tolerance
- **Rainbow papaya:** disease resistance
- **Potatoes:** insect and disease resistance; reduce food waste
- **Summer squash (zucchini):** disease resistance
- **Arctic apples:** reduce food waste

Mutagenesis

- Using gamma rays or other irradiation to change DNA
  (example: Ruby Red grapefruit)



CRISPR

- Using a palindromic sequence to isolate a gene and knock it out or add a gene to a sequence (knock it in)
- Many applications from changing amino acid production in soybeans to protecting bananas from bacterial pathogens.

Costs and benefits

- What are the costs of making these genetic modifications (both economic and environmental)?
- What are the benefits of these genetic modifications?