

Selective Breeding and GMOs

Modeling Selective Breeding

Background

- Soybean aphids are an invasive species that can impact yield.
- It is estimated that the combined loss of yield and cost of fighting soybean aphids is \$2–\$5 billion each year.
- Soybeans have some natural resistance to these pests, but farmers want to improve the chances that their beans will be protected.
- Breeders and seed companies work to create “stacked” traits that will help to protect the yield using selective breeding.
- The genes that determine this host plant resistance are *Rag* genes.

In this activity, you will simulate the process of selective breeding for stacked *Rag* host plant resistance traits in soybeans. Different colored candies will represent different resistance traits (i.e. physical characteristics) that a plant may express.

Red candy = *Rag1* resistance traits

Orange candy = *Rag2* resistance traits

Yellow candy = susceptible (No *Rag* resistance)

Materials

candies of different colors (Starburst® are ideal as they are individually wrapped)
opaque plastic cups

Procedure

1. You have been given three candies that represent the physical characteristics for the parent plant. Use the table below to determine which resistance traits your plant is expressing.

R	R	R	R	R	R	O	O	O	Y
R	R	Y	R	O	O	O	Y	O	Y
R	Y	Y	O	O	Y	Y	Y	O	Y
<i>Rag1</i>	<i>Rag1</i>	<i>Rag1</i>	<i>Rag1</i> & <i>Rag2</i>	<i>Rag1</i> & <i>Rag2</i>	<i>Rag1</i> & <i>Rag2</i>	<i>Rag2</i>	<i>Rag2</i>	<i>Rag2</i>	None

2. Work with the person sitting next to you to create a new soybean cross by placing all six of your soybean traits into a opaque plastic cup. Shake the cup and draw out three candies without looking. This represents the traits of the offspring from your cross. What is your offspring's trait combination?
3. Repeat step 2 two more times. Do you get the same result each time? How might you improve the consistency of your breeding process?
4. Create a new cross with maximum resistance to aphids. Using your offspring, find another group with an offspring that will increase your plant's resistance to aphids. What are the traits in your offspring and traits the in the offspring that you would choose to cross with?
5. How might you guarantee that all offspring will have traits that resist aphids?

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Modeling Advanced Selective Breeding

In this version of the modeling activity, each candy will represent an individual **allele** for two *Rag* resistance genes (**genotype**). They are not the physical resistance traits that a plant expresses (**phenotype**). Using the table below, determine a plant's phenotype based on the combination of candies or alleles.

Materials

2 red and 2 orange candies per person (Starburst® are ideal as they are individually wrapped)
black marker

Procedure

1. Each person gets two red and two orange candies.
 - a. red candies represent two alleles for the *Rag1* resistance genes
 - b. orange candies represent two alleles for *Rag2* resistance genes
2. Use a black marker to write an 'r' (to denote the susceptible version of the *Rag* gene) on one of the red candies and one of the orange candies.
3. Use a black marker to write an 'R' (to denote the resistant version of the *Rag* gene) on one of the red candies and one of the orange candies.
4. Based on the table below, what is the phenotype (i.e. the physical *Rag* resistance traits) that your plant will have.

<i>Rag 1</i> Alleles (red)	R	R	R	R	R	R	r	R	r
	r	R	r	r	R	R	r	R	r
<i>Rag 2</i> Alleles (orange)	r	r	R	R	R	R	R	R	r
	r	r	r	R	r	R	r	r	r
Plant HPR traits	<i>Rag1</i>	<i>Rag1</i>	<i>Rag1</i> & <i>Rag2</i>	<i>Rag1</i> & <i>Rag2</i>	<i>Rag1</i> & <i>Rag2</i>	<i>Rag1</i> & <i>Rag2</i>	<i>Rag2</i>	<i>Rag2</i>	None

Selective breeding simulation

5. Work with a partner to create a new soybean cross. Place all eight of your candies on the table with the allele side facing down. Slide the candies around to mix them up. (This is analogous to shaking the candies in the cup in the previous version).
6. Randomly select two candies of each color. This represents the offspring from your cross. Using the above trait table to determine your offspring plant's trait combination.
7. Repeat step 6 two more times. Do you get the same result each time? How could you improve the consistency of your breeding process?
8. Create a new cross with maximum resistance to aphids. Using your offspring, find another group with an offspring who will increase your plant's resistance to aphids. What are traits in your offspring and the offspring that you would choose to cross with?

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9. Both the *Rag1* and *Rag2* genes are dominant. This means that for both genes, an offspring will express Rag resistance traits if they are homozygous dominant (RR) or heterozygous (Rr). How would the breeding process change if one of your genes was recessive. For example, *rag4* is a recessive gene that confers HPR in soybeans. For a soybean to express *rag4*, the plant needs to have two resistant alleles.

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