NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

A Decision to Branch Out

Evolution and the Domestication of Maize

by
Dongfang Wang
Department of Biology
Spelman College, Atlanta, GA

Part I – Maize vs. Teosinte

Thanksgiving is Emily's favorite holiday. After a few months of cafeteria food at college, she was very thankful for the sumptuous meal set out in front of her. Everything was perfect, if only her big brother would stop teasing her. "Hey, you're a biology major, so you must know where this is from, right?" Ted winked at her from across the table while picking up a corn on the cob from his plate. Emily hated to admit that she didn't know. Clearing her throat, she said, "Well, we haven't covered this in class, but I will tell you all about it next time."

Once back on campus, the first thing Emily did was to find her biology professor. "Professor, could you tell me where our food comes from? Like, the corn. Does it grow on trees?" Emily asked eagerly.

"Hmm, I know just the right video for you to watch," Professor Griffin said slowly while pushing his purple-rimmed glasses up along his nose.

Watch this video with Emily and help her answer the following questions. If you are short on time, you can watch this video from the 0:00 to 4:35 minute mark, and then from the 12:20 to 13:24 minute mark.

Popped Secret: The Mysterious Origin of Corn. HHMI BioInteractive Video.
http://www.hhmi.org/biointeractive/popped-secret-mysterious-origin-corn

Questions

1. Corn (maize) was domesticated around 9,000 years ago through artificial selection. Ancient farmers selectively planted kernels from plants with desirable traits, such as bigger kernels, ease of harvest, and better taste. During this time, the wild ancestor of maize, teosinte, has been under natural selection that favors those traits that improve the chance of survival and reproduction in the wild.

   Maize and teosinte look different in many ways. Assign the following pairs of traits to their respective species by circling the correct response, then provide a hypothesis to explain why these traits were favored during natural or artificial selection in the space allotted.

   Trait #1:
   In *(maize or teosinte)*, the seed is encased in a hard fruit case. This trait may be favored during *(artificial or natural)* selection because _____.

   In *(maize or teosinte)*, the seed is exposed. This trait may be favored during *(artificial or natural)* selection because _____.

Trait #2:

In *(maize or teosinte)*, the plant has one main stalk. This trait may be favored during *(artificial or natural)* selection because _____.

In *(maize or teosinte)*, the plant has many branches. This trait may be favored during *(artificial or natural)* selection because _____.

Trait #3:

In *(maize or teosinte)*, the ear breaks apart to release individual kernels at maturity. This trait may be favored during *(artificial or natural)* selection because _____.

In *(maize or teosinte)*, the ear remains intact at maturity. This trait may be favored during *(artificial or natural)* selection because _____.

2. If both maize and teosinte are grown in the wild, which species is more likely to proliferate? Why?

Part II – Branching

The next day, Emily stayed behind after Professor Griffin's class. "Professor, I've never been to a farm, but now I know where corn comes from." "Well, do you still want to visit a corn field?" Professor Griffin said with a twinkle in his eyes.

Watch the video of Emily and Professor Griffin on their field trip at https://youtu.be/rDG69IHiZM8 and then answer the following questions.

Questions

1. What is the central hypothesis in the video?

2. Multiple lines of evidence were used to support the hypothesis. Briefly describe them below.

   a. Gain-of-function evidence:

   b. Loss-of-function evidence:

   c. Correlative evidence:

Part III – Expression

"This is really cool. Just one gene can change how the whole plant looks." Emily glanced at the white board one more time and then hesitated: "But why do plants need to change the way they look?"

Professor Griffin smiled and said, "Excellent question. Unlike animals, plant growth and architecture are heavily influenced by environment. The ability to adjust the degree of branching can help the plant harvest the sunlight more efficiently. Let's analyze some data to see if the *tb1* gene has similar functions in other plants."

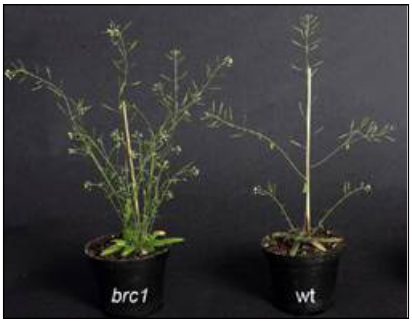

Figure 1. Shoot branching phenotype of a *brc1* loss-of-function mutant. wt, wild type plant. *Source:* Figure 3 of of Aguilar-Martínez et al., 2007, *Plant Cell* 19: 458–472, copyright American Society of Plant Biologists (www.plantcell.org), with permission.

Questions

1. The *tb1* gene has a homologue in Arabidopsis called *BRC1*. To test the function of this gene in Arabidopsis, a group of scientists conducted an experiment to measure the degree of branching in wild type plants and *brc1* loss-of-function mutant plants. Their data is presented in Figure 1. What is the major conclusion in this experiment? In your statement, please clearly identify (1) the independent variable, (2) the dependent variable, (3) the type of evidence presented in this experiment, and (4) how the dependent variable is influenced by the independent variable.

2. To test whether the environment influences the number of branches formed, the scientists planted wild type plants and *brc1* mutant plants at various planting densities, and measured the degree of branching in these plants. Their data is presented in Figure 2. What are the two major conclusions in this experiment? In your statement, please clearly identify (1) the independent variable, (2) the dependent variable, (3) the type of evidence presented in this experiment, and (4) how the dependent variable is influenced by the independent variable.

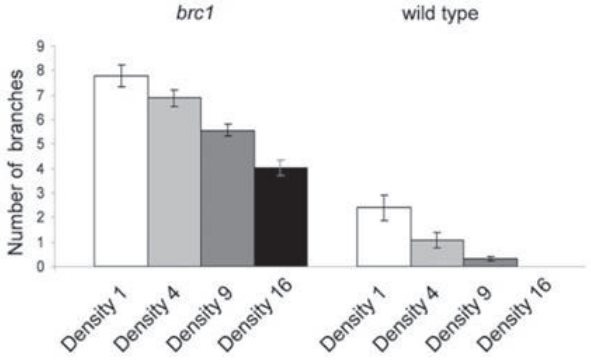

Figure 2. The number of branches was measured in the *brc1* loss-of-function mutant and the wild-type plants grown at different planting densities. Density 1, 4, 9, and 16 indicate 1, 4, 9, and 16 plants per pot, respectively. *Source:* Figure 7 of Aguilar-Martínez et al., 2007, *Plant Cell* 19: 458–472, copyright American Society of Plant Biologists (www.plantcell.org), with permission.

3. In wild-type Arabidopsis plants, is the expression of *BRC1* more likely to increase or decrease when plants are planted at a lower density? Why?

4. A common agricultural practice is to plant the crops at high density for the ease of irrigation and harvesting. Therefore, reduced branching is a desirable trait during artificial selection. Is artificial selection more likely to favor the *BRC1* allele with a low expression level? Why or why not?

Part IV – Transposable Element

Emily looked down at her worksheet and said, "So domestication caused the expression of the branching gene to rise, right?"

Professor Griffin leaned back in the chair and said, "To answer this question, we first need to know what is different between maize and teosinte *tb1*. A small piece of DNA called the transposable element is present near the *tb1* gene in maize, but not in teosinte. The insertion of this transposable element is responsible for the increased *tb1* expression in maize. What makes it interesting is that this insertion can be dated to around 10,000 years prior to maize domestication."

Emily's eyes widened, "Oh, I know, this means that ... ."

Question

1. Finish Emily's sentence for her in the space below. Did domestication cause the expression of the branching gene to rise?