

# DATA *Nugget*

## Fair traders or freeloaders?

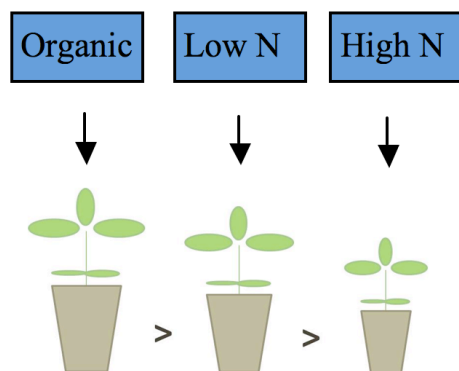
Featured scientist: REU Jennifer Schmidt from the Kellogg Biological Station

### Research Background:

When two species do better when they cooperate than they would on their own, the relationship is called a **mutualism**. One example of a mutualism is the relationship between a type of bacteria, rhizobia, and legume plants. Legumes include plants like peas, beans, soybeans, and clover. Rhizobia live in bumps on the legume roots, where they trade their nitrogen for sugar from the plants. Rhizobia fix nitrogen from the air into a form that plants can use. This means that legumes that have rhizobia living in their roots can get more nitrogen than those that don't.

Under some conditions, this mutualism can break down. For example, if one of the traded resources is very abundant in the environment. When the plant doesn't need the nitrogen traded by rhizobia, it doesn't trade as many sugars to the rhizobia. This could cause the rhizobia to evolve to be less cooperative as well. Less-cooperative rhizobia may be found where the soil already has lots of nitrogen. These less-cooperative bacteria are freeloaders: they fix less nitrogen, but still get sugars from the plant and other benefits of living in nodules on their roots.

One very important legume crop species is the soybean. Soybeans are used to produce vegetable oil, tofu, soymilk, and many other food products. Soybeans trade with rhizobia for nitrogen, but often farmers add more nitrogen into the field as fertilizer. Since farms use a lot of nitrogen fertilizer, researchers at KBS were interested in how different types of farming affected the plant-rhizobia mutualism.



Scientists expected Rhizobia from organic soil to be more cooperative and cause soybeans to grow bigger than Rhizobia from low N or high N soil.



Measuring chlorophyll content in the greenhouse.

They grew soybean plants in a greenhouse and added rhizobia from three different farms: a high N farm, low N farm, and organic farm that used no N fertilizer. After four weeks, the researchers measured chlorophyll content of the soybean plants. Healthy plants that have lots of nitrogen will have high chlorophyll content, and plants with not enough nitrogen will have low chlorophyll content. Because high nitrogen could lead to the evolution of less-cooperative rhizobia, they expected that rhizobia from organic plots would be most cooperative. They predicted rhizobia from high N plots would be the least cooperative, and rhizobia from low N plots would fall somewhere in the middle. More-cooperative rhizobia provide more nitrogen, so the researchers expected plants grown with cooperative rhizobia to have higher chlorophyll content than plants receiving less-cooperative rhizobia.

*Scientific Question:* What evidence do we have that the addition of nitrogen in farming can lead to the evolution of less cooperative rhizobia?

*What is the hypothesis?* Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

*Scientific Data:*

Use the data below to answer the scientific question:

<b><i>Chlorophyll Data, Per Unit Leaf Area</i></b>		
<b>Treatment</b>	<b>Leaf Chlorophyll Content</b>	<b>Standard Error</b>
<i>High N</i>	26.66	0.7191
<i>Low N</i>	21.91	0.6952
<i>Organic</i>	22.13	0.6829

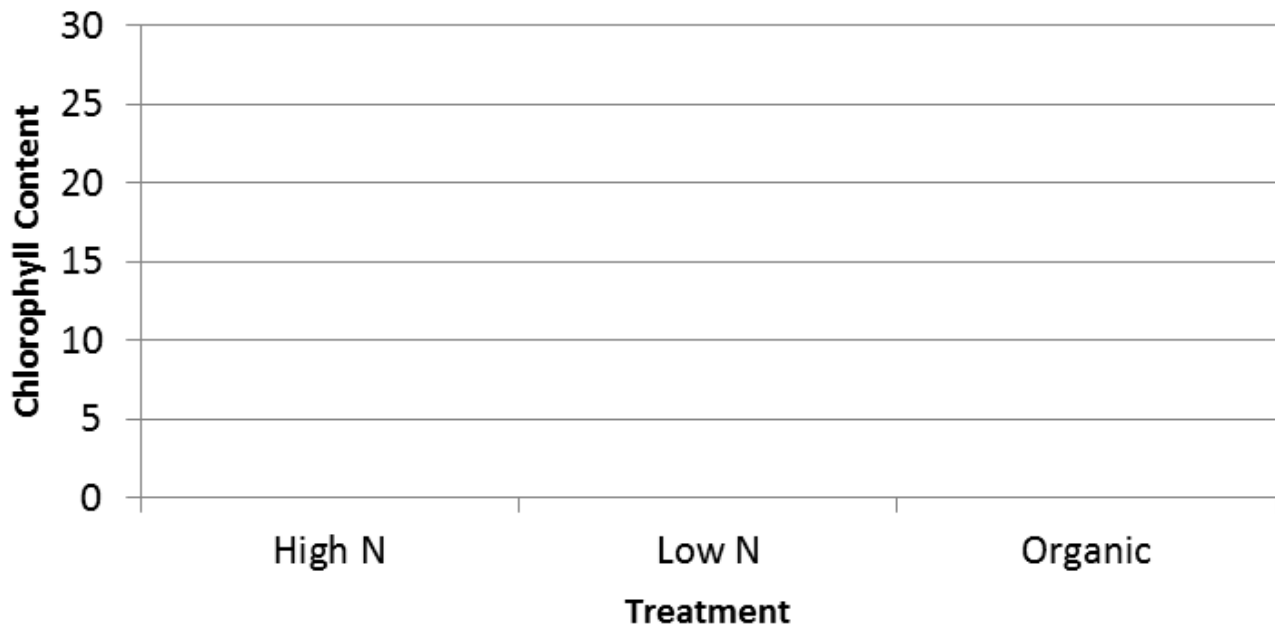
What data will you graph to answer the question?

Predictor variable: \_\_\_\_\_

Response variable: \_\_\_\_\_

Name \_\_\_\_\_

Graph the data below:



Interpret the data: Make a claim based on the evidence that helps answer the original research question. Connect the pattern in the data to a pattern in the natural world. Justify your reasoning using data.

Name\_\_\_\_\_

*Your next step as a scientist:* Science is an ongoing process. Did this study fully answer your original question? What new questions do you think should be investigated? What future data should be collected to answer them?