Growing energy: comparing biofuel crop biomass
Featured scientist: Gregg Sanford from University of Wisconsin-Madison

Research Background:

Most of us use fossil fuels every day. Fossil fuels power our cars, heat and cool our homes, and are used to produce most of the things we buy. These energy sources are called “fossil” fuels because they are made from plants and animals that grew hundreds of millions of years ago. After these species died, their tissues were slowly converted into coal, oil, and natural gas. An important fact about fossil fuels is that they are limited and nonrenewable. It takes a long time for dead plants and animals to be converted into fossil fuels. Once we run out of the supply we have on Earth today, we are out! We need to think of new ways to power our world now that we use more energy than ever.

Biofuels are made from the tissues of plants that are alive and growing today. When plants are harvested, their tissues, called biomass, can be converted into fuel. Biofuels are renewable, meaning we can produce them as quickly as we use them up. At the Great Lakes Bioenergy Research Center sites in Wisconsin and Michigan, scientists and engineers are attempting to figure out which plants make the best biofuels.

Gregg is a scientist who wants to find out how much plant biomass can be harvested from different crops like corn, grasses, weeds, and trees. The bigger and faster a plant grows, the more biomass they make. The more biomass the more fuel can be produced. Gregg is interested in maximizing how much biomass we can produce while also not harming the environment. Each plant species comes with a tradeoff – some may be good at growing big but need a lot of inputs like fertilizer and pesticide.

Corn is an annual, meaning it lives only for one year. Corn is one of the best crops for producing a lot of biomass. However, farmers must add a lot of chemical fertilizers and...
pesticides to their fields to plant corn every year. These chemicals harm the environment, cost farmers money, and are actually produced using fossil fuels themselves! Other plants harvested for biofuels, like switchgrass, prairie grasses and forbs, poplar trees, and Miscanthus grass are perennials. Perennials grow back year after year without replanting. Thus, they require much less chemical fertilizers and pesticides to grow, and require less fossil fuel powered equipment to maintain them. Because of these advantages, perennials could make a viable alternative to corn as a source of biofuels.

Gregg thought it might even be possible to produce the same amount of perennial biomass as corn biomass with fewer chemicals and less energy. To figure this out, he worked together with other scientists to design a very large experiment. Gregg and his team grew multiple plots of six different biofuel crops on experimental farms in Wisconsin and Michigan. The soils at the Wisconsin site are more fertile and have more nutrients than the soils at the Michigan site. At each farm, they grew plots of corn as well as plots of five types of perennial species. The types included a mix of prairie species, switchgrass, Miscanthus grass, young poplar trees, and weed fields. Every fall the scientists harvested, dried, and then weighed the biomass from each plot. They continued taking measurements for five years and then calculated the average biomass production in a year for each plot type at each site.

Scientific Questions: Are any perennial crops a good alternative to corn for biofuel production, and if so, why? How does the location of biomass production affect the outcome?

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

**Use the data below to answer the scientific questions:**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Type</th>
<th>Wisconsin: Average biomass (Mg ha(^{-1}) yr(^{-1}))</th>
<th>standard error</th>
<th>Michigan: Average biomass (Mg ha(^{-1}) yr(^{-1}))</th>
<th>standard error**</th>
</tr>
</thead>
<tbody>
<tr>
<td>corn</td>
<td>annual</td>
<td>16.1</td>
<td>0.6</td>
<td>12.3</td>
<td>0.9</td>
</tr>
<tr>
<td>prairie</td>
<td>perennial</td>
<td>3.7</td>
<td>0.3</td>
<td>2.8</td>
<td>0.2</td>
</tr>
<tr>
<td>switchgrass</td>
<td>perennial</td>
<td>6.9</td>
<td>0.3</td>
<td>6.0</td>
<td>0.6</td>
</tr>
<tr>
<td>miscanthus grass</td>
<td>perennial</td>
<td>12.0</td>
<td>1.2</td>
<td>15.6</td>
<td>1.3</td>
</tr>
<tr>
<td>poplar trees</td>
<td>perennial</td>
<td>4.6</td>
<td>0.9</td>
<td>12.5</td>
<td>0.3</td>
</tr>
<tr>
<td>weed field</td>
<td>perennial</td>
<td>2.8</td>
<td>0.3</td>
<td>2.6</td>
<td>0.2</td>
</tr>
</tbody>
</table>

* Biomass is measured as the amount of dried biomass harvested from a certain area. In this study the units are “Megagrams of dried biomass per a hectare in one year (Mg ha\(^{-1}\) yr\(^{-1}\)).”

** Standard error (SE) tells us how confident we are in our estimate of the mean, and depends on the number of replicates in an experiment and the amount of variation in the data. A large SE means we are not very confident, while a small SE means we are more confident.

What data will you graph to answer the question?

Independent variable(s): __________________________________________

Dependent variable(s): __________________________________________

**Draw your graph below:** Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.
Interpret the data:

Make a claim that answers each of the scientific questions.

What evidence was used to write your claims? Reference specific parts of the table or graph.

Explain your reasoning and why the evidence supports your claims. Connect the data back to what you learned about the tradeoff between annual and perennial crops.
Did the data support Gregg’s hypothesis? Use evidence to explain why or why not. If you feel the data was inconclusive, explain why.

Your next step as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Gregg’s research? What future data should be collected to answer your question(s)?