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Do It Yourself (DIY) Seed Kits to Evaluate the Effects of Fertilizer on Plant Growth Rates

Charlotte de Araujo[1] and Patricia A. Wright[2]

[1]University of Guelph, Department of Molecular and Cellular Biology, 50 Stone Rd E, Guelph Ontario N1G 2W1, Canada
[2]University of Guelph, Department of Integrative Biology, 50 Stone Rd E, Guelph Ontario N1G 2W1, Canada
(cdearauj@uoguelph.ca; patwrigh@uoguelph.ca)

With the increasing world population, it is critical to develop sustainable strategies for food production. This remote first year laboratory exercise for non-biology students provided a hands-on approach to small scale plant production. Students created indoor mini-gardens by independently planting either beans or corn seeds under varying conditions to evaluate the claim, "Corn and beans are easy to grow and fertilizer has little effect on growth." To carry out their experiments, students received take-home seed kits containing either bean or corn seeds, peat pellets, and fertilizer, accompanied with detailed experimental procedures.
Over the semester, students monitored plant growth in the presence or absence of fertilizer, documenting both qualitative and quantitative results, such as size, length and number of leaves. To promote collaboration in an online setting, students were encouraged to compare their results using discussion boards. Overall the majority (87%, n=47) of students felt this laboratory exercise developed a strong appreciation of plants and were motivated (89%, n=47) to continue with their indoor garden.

Keywords: experiential learning, introductory biology, non-biology majors, basic hypothesis testing

Introduction

The Introduction to Biology (BIOL1020) course offered at University of Guelph is designed to provide students with a general overview of biological concepts ranging from cells to ecosystems. These concepts are often linked to everyday life experiences. BIOL1020 is often a students' first foray in biology, following a grade 10 science credit. The overall course structure involves lectures supplemented with laboratory exercises.

During previous iterations, the lecture and laboratories were held in-person. For instance, one laboratory was conducted on campus where students had the opportunity to visit the green house to plant their own corn seeds. With the global pandemic, the laboratory exercises were converted from a face-to-face session to a remote offering. For each laboratory, students were provided with the laboratory overview and laboratory worksheet. Students had the option to complete the laboratory exercise during the synchronous session. During this period, students were placed in groups to help build a community within the class. Both the course coordinator and teaching assistants were available during the synchronous sessions to assist with questions and discuss concepts related to the laboratory exercises. As students were located in multiple time zones, we created group discussion boards as a means to promote communication among group members.

Prior to working on this particular laboratory exercise, students were introduced to concepts related to food waste and plant-based diets. Students were initially asked to reflect on their own eating habits. They completed a survey about two topics: i) reducing food waste and ii) shifting diet to plant-based food. Students selected which approach they would like to investigate further. Over five days students documented their journey focusing on the topic of choice, recording and presenting quantitative and qualitative data. For instance, students investigated benefits of plant-based diets, supported by scientists and medical professionals. Building on the previous laboratory about food production and strategies to mitigate food waste, we developed a laboratory to

provide students the chance to participate in practical activities.

Here we present an approach to provide hands-on learning, complemented with collaborative work to assess the claim, “Corn and beans are easy to grow and fertilizer has little effect on growth.” With the aid of the DIY seed kits, students grew either corn or bean plants in the presence or absence of fertilizer, monitoring the change in seedlings over time.

Student Outline

Objectives

Apply critical thinking skills to current environmental issues.
Evaluate energy flow with respect to life on earth.
Evaluate the factors influencing the quality of biological data.

Introduction

In the previous laboratory, Feeding the Planet, Part I you considered ways to reduce food wastes or incorporate more plants in your diet. Now in Part II of this lab you will consider the agricultural issues. There are ~8 billion people on the planet and by 2040 the population will be 10 billion. Can we feed all these people without wrecking the planet? Recently, $76.6 million was received to the University of Guelph researchers to find solutions to improve agricultural sustainability and productivity. If you would like to know more about this research, check it out, at www.foodfromthought.ca.
The aim of this lab is for students to experience first-hand the challenges of growing food crops, and to critically evaluate the role of fertilizer in crop production.

Methods and Data Collection

Part A: Getting Started

In this lab you will test the claim that “Corn and beans are easy to grow and fertilizer has little effect on growth.” You should have received your seed kit and can now follow the instructions below.

Part B: Instructions for Planting

To prepare for this laboratory you will need to plant your seeds at least 4 weeks beforehand.

1. Place your 4 peat pellets in a shallow container with a flat bottom

2. Add enough water to cover the pellets. Wait 5-10 minutes for water to be absorbed and add more water until the peat pellets no longer absorb the water. Discard any standing water in your container.

3. The netting should be open at the top of the peat pellet, if not, tear the top of the netting a bit. Push one seed into the peat and use a utensil or your finger to cover the seed with peat. Some of you are planting beans, others corn. You do not have to push the seed deep within the pellet, it should be just under the surface. Cover the container with plastic food wrap or a plastic bag. Cut a few (~3) small holes (~0.5 cm diameter) in the top of the plastic for ventilation. Condensation may collect under the plastic, but this is acceptable, as it ensures your pellets stay moist.

4. Place your covered container on a windowsill or warm place (20-26ºC), if possible. It should take 3-7 days for your seeds to sprout. (It is possible that one or more seeds will not sprout at all.) Monitor for sprouts daily.
5. When you first see a shoot, remove that pellet from under the plastic wrap and place in a new container. Record the date. Label the new container “control” or “fertilizer”. Ideally, you will have two sprouts in the control container and two in the fertilizer container, but fewer in each container is fine. It does not matter if your sprouts appear on different days, just start your experiment whenever you have a sprout ready to go. Label the sprouts #1 and #2. Place the sprouts on a window sill or near a window, if possible.

6. Prepare the liquid fertilizer. You have two packages of Miracle-Gro™ fertilizer which contain Nitrogen (20%), Phosphate (20%), Potash (20%) and a number of minerals (e.g. iron, zinc). You only need one of the fertilizer packages. Find a clean empty container (~1 L), add the fertilizer crystals and 1 liter of tap water, mix and cover.
7. Add water (control) or liquid fertilizer (fertilizer) each day. Make sure you add the same amount, about one tablespoon per pellet per day (but this will depend on room temperature and humidity). If your pellets quickly absorb one tablespoon, then you may need to double the amount each day. Again, keep the total amount the same between "control" and "fertilizer" treatments. The peat pellets should be moist at all times, but they should not be floating in water. Also consider other factors that may impact the growth of your plants. Is there more light on one side of the windowsill? If so, rotate your control and fertilizer groups daily.
8. Record the height of your sprouts at the same time each day using the chart provided. If you miss a day by accident, do not fabricate the data, just continue the next day with the appropriate date. Record growth for 10 days.
   Document the change in your seedlings overtime. You may choose to draw, photograph or create a time lapse video of your plants growing. Be creative!

Laboratory Worksheet

In the table below, record the values obtained for your plants (either bean/corn).

		Control				Fertilizer			
Peat pellet		Height (cm)		# of Leaves		Height (cm)		# of Leaves	
Date	Time	#1	#2	#1	#2	#1	#2	#1	#2

1. Calculate total growth (cm) = Height (last day) – Height (first day)
2. Calculate average growth rate (cm/day) = total growth (cm)/# of days

3. From the chart above determine the maximum growth for each plant on any given day and the minimum growth, your values should be in cm.

Student name: _____
Group members: _____

1. Submit your drawings, photographs or videos of your plants. (2 marks)
2. Did you find evidence from the claim: “Corn or beans are easy to brown and fertilizer has little effect on growth.” Provide numerical values to support your answer (e.g. Total growth, average daily growth and/or maximum/minimum growth). (3 marks)
3. Share your photos/drawings/video with your group. Describe any differences between corn and bean seed germination, growth rates, and/or appearance. If all members of the group grew the same plants, then compare differences in only one seed type between households. (1 marks)*
4. Were there any additional factors, besides seed type, that may have influenced growth between different homes or apartments within your group members? Explain. (3 marks)*
5. List one pro and one con of using chemical fertilizer. List one pro and one con of using organic fertilizer. (1 mark)*

*Note: you may have the same answer as your group members.

Cited References

Food from Thought [Internet].Food from Thought News [June 2020] Available from: https://foodfromthought.ca/

Materials

To set up and perform this laboratory session the following items are required: bean seeds (Veseys Lewis Bean Seeds 11461X5), corn seeds (Veseys Luscious Corn Seeds 13260X5), peat pellets (50 Count - Jiffy 7 Peat Pellets - Seed Starter Soil Plugs - 36 mm, Ferry-Morse, Item #: PP50-36MM), fertilizer (MIRACLE-GRO 680g 20-20-20 Plant Food (Home Hardware, Item: # 5025-002 Model: # 1150612). To prepare the fertilizer, students used 1 bag of fertilizer (0.3 g) and combined with 1 L of water. A plastic container was needed in order to hold the liquid fertilizer. A ruler or device which can be used to determine measurements is also needed.

The DIY seed kits contained either 4 bean seeds or 4 corn seeds and each kit had 4 peat pellets, 2 bags of fertilizer (0.3 g in each bag) and a copy of the experimental procedures. Each component was allotted to separate Ziploc bags. The kits were mailed to students either living at home or in residence. We provided a copy of the experimental procedures.

To set up seed germination, students used a shallow container (e.g. Tupperware container) or clay pot. The peat pellets were placed in the containers. A clear plastic bag or plastic food wrap was used to cover the container housing the peat pellets.

Notes for the Instructor

Troubleshooting guide

Students enrolled in BIOL1020 were predominantly located in Ontario. For a few students residing in locations outside of Canada, we were unable to provide the DIY seed kits due to challenges with mailing plant materials across international borders. To ensure students could participate in the laboratory, we provided them with the option to obtain the materials on their own. If they were unable to obtain corn or bean seeds, we suggested to replace them with any seeds which produce food or flowers. The fertilizer could be substituted with a replacement that was nitrogen/phosphate based. The peat pellets could be substituted with potting soil.

For some students, who received their DIY seed kits, their plants' growth took 2 weeks longer than anticipated. If students informed us about the delays in growth, we asked them to ensure that the peat was moist. We asked the students to wait additional time (2 more weeks) in case they observed growth. This delay might have been due to differences in room temperature. However if they observed mold on top of the peat, we informed the students that they may not observe growth. After 2 weeks, with no mold, some students did not observe sprouting (<13% of the students did not observe sprouting in any plants).

For instances where students were unable to observe sprouting, we encouraged students to collaborate with other students in their groups. Students shared their data/observations on discussion boards to help their peers complete the laboratory exercise. They also used the data obtained from their peers to compare with their own results.

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About the Authors

Charlotte de Araujo, Ph.D. is an Instructor/Course Coordinator at University of Guelph and an OntarioExtend Program Facilitator (eCampusOntario). Dr. de Araujo has many years of undergraduate and graduate teaching experience geared towards biology and biomedical science students.

Patricia A. Wright, Ph.D. has been a faculty member at the University of Guelph since 1991, where she has taught large first year biology courses and smaller animal physiology courses.

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