WISCONSIN FAST PLANTS

Farming Fast Plants

How Many Seeds Can You Produce?

Introduction

This *Farming Fast Plants* activity introduces a classroom investigation that is easily adaptable for all grade levels and designed to engage teachers and students as investigators. The activity has the practical outcome of producing an abundant supply of Fast Plants seed for future classroom use and for sharing with other teachers. The central question of the activity is ***"How many seeds can your students produce from each seed planted?"*** This activity draws upon many life science principles as they relate to crop production, farming practices and sustainable agriculture. From the perspective of the teacher and students as "farmers of the Fast Plants crop in the classroom," the activity is rich in investigative learning which leads to an understanding of the role of the environment and its impact on populations of the student-friendly organisms, Fast Plants. (Please note that the Wisconsin Fast Plants website includes many information documents - WFPID's - which provide detailed information for teachers and students.)

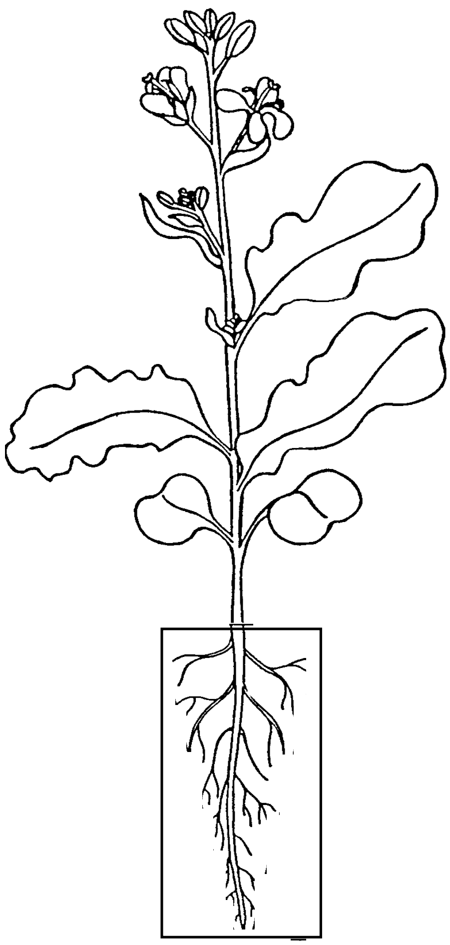
Objectives of the Activity

- Students will grow Fast Plants (*Brassica rapa*), observe a life-cycle and produce a crop of seed. (Seed can be stored and used for further investigations.)
- Students will gain an understanding of the concept of **net seed yield**, i.e. the number of seeds harvested for each seed planted.
- By growing a crop of Fast Plants, students will examine the influence of various environmental components on net seed yield.
- Via the Internet, students can contribute their data on net seed yield to an international database on the Wisconsin Fast Plants website.

Farming Fast Plants uses a simple planting design in soda bottles and a Plant Light House made from a paper box and a low-cost energy saver fluorescent circular bulb. While students may begin with the start-up activity as described on pages 2-5, they are also encouraged to design, hypothesize, and experiment further so they can begin to understand the principles behind seed production. Students may wish to consult the WFPID *Fast Plants Farmers Almanac: A Guide for Growing Fast Plants Farmers* for guidance on sound farming practices.

Farming Fast Plants is featured on the Wisconsin Fast Plants website (http://fastplants.cals.wisc.edu), and teachers and students will be encouraged to post their seed production data. Each classroom will have the opportunity to compare its data to other classrooms around the world. An Internet-based discussion group will connect to this site so that teachers and students can communicate their experiences with Fast Plants.

telephone: 1-800-462-7417 website: http://fastplants.cals.wisc.edu email: wfp@fastplants.cals.wisc.edu



Start-Up Activity

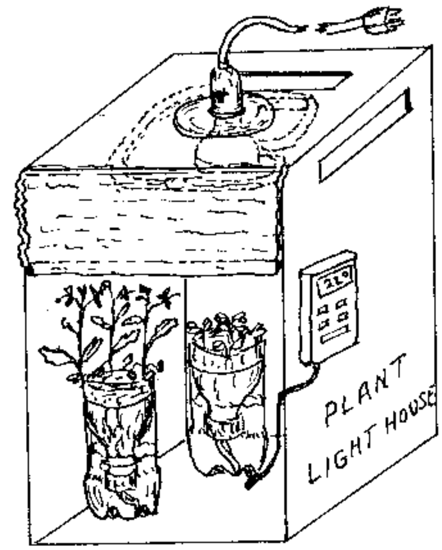
Fast Plants are grown in a hydroponic system, the bottle growing system, or BGS, constructed from a 16-24 oz. soda bottle. Twelve seeds are planted in each BGS and up to nine bottle systems can be placed in one Plant Light House (described below). An alternative, recommended light source is a bank of six 4-foot fluorescent bulbs.

Students will tend Fast Plants from sowing seeds through pollinating flowers and harvesting new seeds. The Fast Plants life cycle from planting to seed harvest is 35-45 days. (See WFPID *Fast Plants Life Cycle*.) Suggested observations and measurements are described on page 6. Teachers can encourage students to note any factors that affect the growth and/or health of their plants and change their farming practices accordingly.

Getting Started: Building a Plant Light House

Materials

- one empty "copy paper" box with sturdy sides
- plastic plate or lid (e.g. lid of a margarine or yoghurt container)
- 30-watt fluorescent circle light (Lights of America) or a 39-watt fluorescent circle light (GE), energy savers
- electrical cord with socket
- aluminum foil
- clear tape (3/4")
- scissors
- glue stick (opional)
- wood strip (optional)



Construction

1. Cut a 1-inch hole in the center of a plastic plate or lid to make a disk, 3-6 inches in diameter, with center hole.
2. Cut a 1-inch hole in the center of box top.*
3. Cut two 4 X 14 cm ventilation slots in top, upper sides or back of box as shown.
4. Apply glue to each inner surface or use clear tape to fasten aluminium foil to cover entire inner surface. Use clear tape to reinforce corners and edges.
5. Insert light fixture base through hole in top and through plastic plate. Secure fixture by attaching socket.
6. Tape an aluminum foil curtain over front from the top front edge of box.
7. Strengthen curtain edges with tape. Tape or clip weights (e.g. wood strip or ruler) on bottom of curtain. If desired, attach environmental monitoring devices (e.g. indoor/outdoor digital thermometer) using Velcro tape. Your Light House is ready!

* Some copy-paper boxes do not have sides of one solid piece of cardboard. In that case, the teacher should glue a solid piece of cardboard to reinforce the side of the box before cutting the center hole and ventilation slots. (We thank Mikell Lynne Hedley, Central Catholic High School, Toledo, Ohio for this suggestion.)

Construction of the Bottle Growing System (BGS)

Materials

- 16-, 20-, or 24-oz. soda bottles
- unpolished cotton string (20-cm lengths) or Watermat® for capillary wicks
- vermiculite (medium-grade horticultural)
- planting medium (a soilless mixture of approximately 1/2 peat moss and 1/2 vermiculite, e.g. peatlite, Scotts Redi Earth®)
- Peters 20-20-20 Professional® fertilizer with minor elements
- dried bees and toothpicks for making beesticks

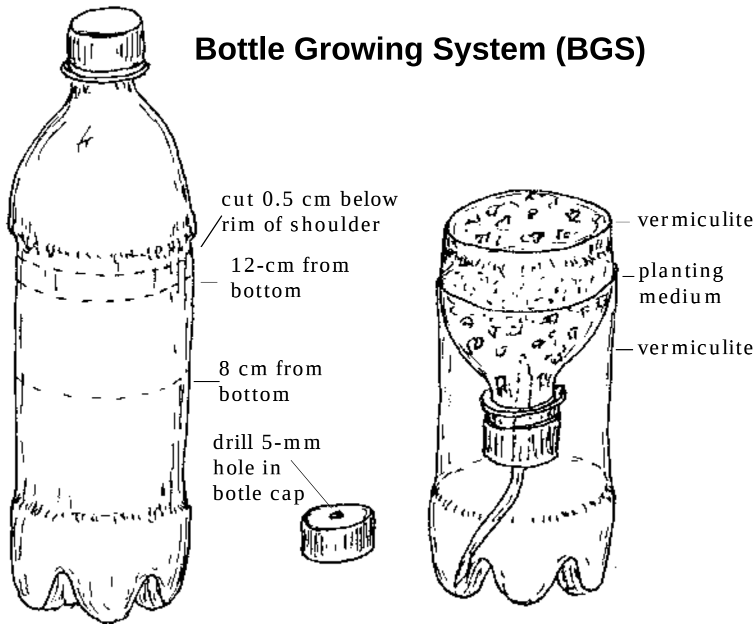
Seeds

- 200 Fast Plant seeds, petite stock. (One packet of 200 seeds should be sufficient for 24 bottles and three Plant Light Houses.)

Construction

1. Cut each soda bottle 0.5 cm below the rim of the shoulder to create the growing funnel, which will hold the vermiculite and planting medium. To make the bottom more stable, make a second cut in the bottom portion of the bottle to create a reservoir, 8 to 12 cm tall, for the hydroponic nutrient solution. (A single Plant Light House can accommodate eight soda bottles.)

[From here on, the instructions refer to a single BGS.]



2. Drill or melt a 5-mm hole in the bottle cap. Screw bottle cap onto bottle top.

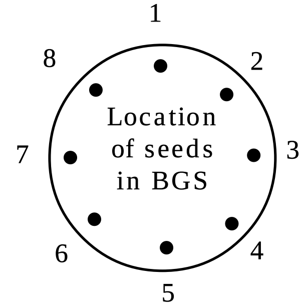
3. Insert a string wick or other capillary wicking, approximately. 0.5 cm X 10 cm, through the hole in the bottle cap. Check your wick before planting to be sure that it draws water well.

4. Invert the growing funnel (bottle top) and place in the reservoir (bottle base). The wick should extend from the funnel to the floor of the reservoir.

Planting*

5. Layer approximately 50 cc (~1/4 cup) of vermiculite into the funnel and then layer approximately 100 cc (~1/2 cup) of your planting medium on top of the vermiculite so that it fills the funnel to the rim. Tap the funnel to help the soil settle loosely, then level off the excess. <u>Do not</u> press or compact the planting medium.

6. Gently soak the soil and vermiculite with tap water, letting it percolate through the soil until it drips from the wick at the bottom of the growing funnel. This is called the *runoff*. The layer of planting medium should shrink down in the funnel about 0.5-1 cm from the rim.



7. Uniformly distribute 8 petite Fast Plants seeds on the surface of the moist planting medium around the perimeter of the funnel about 5 mm from the clear wall.

* Reference WFPID *Understanding the Environment* at the WFP website.

8. Cover the seeds and planting medium with a layer of vermiculite (0.5-1 cm) so that the vermiculite is level with the rim of the growing funnel.

9. Gently moisten the vermiculite with tap water until water again drips from the wick at the base of the funnel.

10. Pour off the water remaining in the reservoir, and replace it with 1/8 strength Peter's Professional fertilizer (hydroponic nutrient solution) to the level of the bottle cap.

    Make a full strength (or "1X") Peters solution by dissolving one level soda-bottle capful of Peters crystals into one liter of water. Then dilute a portion of the full-strength solution to 1/8X for your hydroponic nutrient solution. (For every cup of full-strength solution, add 7 cups of water, then mix well.)

11. Place a label on the completed BGS indicating the date and hour of planting, variety of seed (e.g. petite), and name of the student or group.

12. Put all BGS's in the Plant Light House. Keep light on 24 hours a day.

Observing, Measuring and Monitoring*

A major goal of this *Farming Fast Plants* is to produce abundant seed. Thus, your students should monitor their plants each day and make appropriate notations in their journals. Should your students decide to run additional experiments under different conditions, they can evaluate environmental influences on plant growth and seed production.

13. Monitor and record the temperature inside the Plant Light House each day, if possible, as well as the room temperature. If average temperatures within the Plant Light House exceed 30˚C/ 85˚F, additional ventilation slots can be cut in the top and upper portions of the Light House.

14. Observe the level of the nutrient solution and replenish used solution as needed. The amount used by the plants and lost to evaporation can be measured and graphed. Algal growth in the nutrient solution can be inhibited by wrapping the reservoir in aluminum foil or dark paper to exclude light.

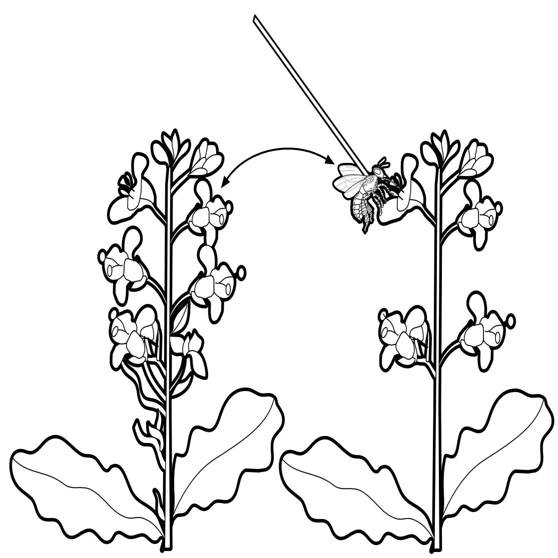
** Reference WFPID "Investigating and Inventing" at the WFP website.*

Pollinating*

The petite Fast Plants will begin to flower about 15 days after sowing. When flowers on more than two Fast Plants are open, your students should begin to pollinate their flowers and continue pollinating every day or two among all open flowers for up to 7 days. Pollen of Fast Plants (rapid cycling *Brassica rapa*) is relatively heavy and sticky. Unlike many grass and some tree pollens, Fast Plants pollen is normally not carried in the air.

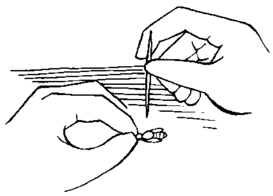
15. Pollinate with beesticks made by gluing a dried bee to the end of a toothpick (see illustrated on page 5).

16. Collect pollen with your beestick from the flowers of one plant and move your beestick to the stigmas of other plants. Be sure to deposit a good load of pollen on the stigma of each flower. Fast Plants are self incompatible: that is, each stigma prevents germination of its own pollen.

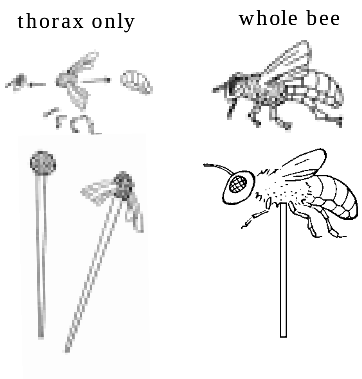


17. If you don't have dried bees, try using pipe cleaners, cotton swabs, or very small pieces of cloth, e.g. velveteen glued to a toothpick. (Your students may wish to test the effciency of different pollination tools with respect to seed yields.)

Making Beesticks



Add a drop of glue to affix a bee to a toothpick. Push toothpick into the top of the thorax (middle section) of the bee.



Let beesticks dry before use.

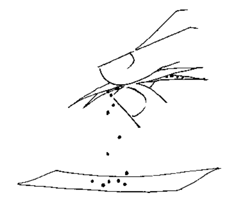
18. Discontinue pollination 7 days after the first flowers open or sooner if no new flowers appear.

19. Keep the reservoirs full. The plants will need nutrient solution for another 20 days after the last flower is pollinated, so it is important to note the date of the last pollination.

* Reference WFPID “Bee and Brassicas” at the WFP website.

Harvesting

20. Twenty days or more after the final pollination, the lower leaves of the plants will be withering, and pods will be turning yellow. (Inside the pods, the seed coats will be turning brown.) At this point, remove the nutrient solution from the reservoir and allow plants to dry until crispy brown (approximately 1 week).

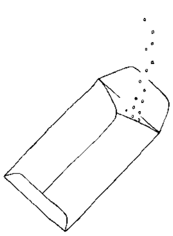


Harvest seeds by gently rolling dry seed pods between hands over a paper towel.

21. Harvest each plant carefully by cutting it off at soil level. Take care not to break off the pods. Number each plant. Harvest seeds from each plant separately by gently rolling the dry seed pods between your fingers over a tray. (Alternatively, you can drop seeds onto adhesive tape which is taped to a card with the adhesive side up.)

22. For each numbered plant, count and record the number of seeds harvested. Count only plump seeds that you think will germinate. Do not count tiny, shriveled “seeds” as these are not truly seeds.

23. For each bottle growing system (BGS), calculate the average number of seeds harvested for each seed sown. [# seeds harvested/# seeds planted] This is your net seed yield (NSY). Then calculate the average number of seeds harvested per each plant harvested. [# seeds harvested/ #plants harvested] Are the averages different? Why?



24. Finally, calculate the net seed yield (NSY) from all the BGS’s in the class to obtain the class NSY. **This is the figure you will enter on the Wisconsin Fast Plants website as the NSY from your class** (as described on page 6).

25. Place the seeds in labeled envelopes. Include: the seed name, e.g. Fast Plants (rapid cycling *B. rapa*) petite; the number of plants that produced the seeds; date of harvest; total number of seeds produced; your name.

26. Test the viability of your seed cropby germinating 20-50 seeds on wet paper toweling in a plastic bag or petri dish. After 24 hours, calculate the percentage of germination (or “viability”) of your seed. Observe the vigor and uniformity of the germination. Note the germination test date and % germination on the seed envelope.

27. For future Fast Plants investigations, store seed envelopes in a cool, dry place, e.g. in a refrigerator in a moisture-proof, sealed container. Ideally, the container would also contain a drying compound, e.g. indicator silica gel, which can be obtained from a pharmacist or from a camera store. <u>Seed that is stored dry and cool</u> will remain viable for over 10 years.

Questions

1. Did you notice any differences in the number of seeds that were produced in the first pods on your plant(s) and the number of seeds produced in the last pods? If there was a difference, to what do you attribute the difference?
2. Do you think that your final net seed yield would be any different if you continued to pollinate as long as your plant kept producing flowers? Why?
3. Can you design a growing system that will be more productive than the original bottle system? Would your design produce higher seed yields? Why do you think so?
4. Can you demonstrate and explain how changing one or more environmental factors influences seed production?
5. Now that you are an experienced farmer of Fast Plants, design ways to improve the net seed yield of your Fast Plants farm. What environmental factors would you modify? What genetic factors would you modify?

Suggested Observations, Measures, Analyses and Comparisons

The following are aspects of the environment and items in growth and development that could be observed, measured, recorded, analyzed and displayed as a function of time (days after sowing) and then compared with results from your classroom.

1. Environmental monitoring

- light = daily energy input, watts/24 hr cumulative energy input (total watts)
- temperature, daily
- nutrient solution - usage (ml/day)
- appearance of algae, pests, etc.

2. Developmental events

- germination
  - first emergence of root and shoot
- first leaf, second leaf, etc.
- flower buds (brassica) or head (wheat)
- flowers open
- pod elongation
- appearance of branches on stem (brassica), tillers (wheat)
- yellowing of older leaves

3. Measures of growth

(averages for 10 plants)

- plant height
- leaf number
- root length, root number
- number of flowers open
- number of seed pods enlarging
- number of seeds

4. Measures of biomass

(average of 10 plants at harvest)

- fresh weight of tops
- dry weight of tops
- fresh weight of roots
- dry weight of roots
- dry weight of seed (brassica)

5. Analyses of biomass (within a variety)

- dry weight/fresh weight ratios, tops, roots
- roots/tops ratios
- harvest index of tops, dry
- harvest index of seed (seed weight/total plant dry weight)
- calculate energy efficiency conversion (grams dry weight/watts)

6. Comparisons (between varieties and species)

- dry weight/fresh weight
- root/top ratios
- total biomass
- harvest indices
- energy efficiencies