## **Procedure**

Set Up:

1. Obtain all necessary materials (ours were bought from Home Depot and seeds were bought on-line).
2. Use a five-foot workbench with a shelf to “house” the experiment. Using the three identical light fixtures, mount them parallel to the workbench counter approximately above at ten inches, thirty inches, and fifty inches from the edge of the bench. Drill screws into the underside of the shelf as shown in the mounting directions, and then use wire between the bulb and the fixture to secure the part of the light that juts out beyond the shelf. Clean bulbs with glass cleaner before inserting into the fixture. The plant light should be on the far left, followed by the two fluorescent lights. It may be a good idea to test the fixtures before setting up to make sure they work.
3. Using sturdy black plastic trash bags, lay uncut plastic trash bags on top of the light fixtures to cover the entire bench. Cut four two-foot by two-foot squares, piecing together if necessary. Starting at the very end of the bench, tape up the four cut pieces (which will be dividers) at zero inches, twenty inches, forty inches, and sixty inches by taping to the shelf, the plastic trash bag above the lights, and the very back of the work bench. Use enough tape so there are no gaps for light to shine into a different section.
4. Using the three seed starters, fill each compartment three-quarters full with Scott’s Potting Soil for Seed Starting. Remove any sticks present and make all levels of soil as equal as possible.
5. In two separate containers, soak about one-fourth of a cup of soybean seeds and one-eighth of a cup of red winter wheat seeds in about two and a half cups cold water for eleven hours. In a third container, soak eighteen teaspoons of alfalfa seeds in two and a half cups warm water for eight hours. Oat seeds don’t need to be soaked. (Put the alfalfa in to soak one and a half hours after the others so all the seeds are planted at the same time.)
6. After seeds have soaked, drain three containers (be careful with alfalfa seeds as they can easily go down the drain). The three seed starters should already be divided into four removable sections, each containing twenty-four wells. For future reference, each well will be numbered as follows:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| \*1 | 2 | 3 | 4 | --- | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | --- | … | … | … | ... |
| 9 | 10 | 11 | 12 | --- |  |  |  |  |
| 13 | 14 | 15 | 16 | --- |  |  |  |  |
| 17 | 18 | 19 | 20 | --- |  |  |  |  |
| 21 | 22 | 23 | 24 | --- |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | --- | 1 | 2 | 3 | 4 |
| … | … | … | … | --- | … | … | … | .... |
|  |  |  |  | --- |  |  |  |  |
|  |  |  |  | --- |  |  |  |  |
|  |  |  |  | --- |  |  |  |  |
|  |  |  |  | --- |  |  |  |  |

Quadrant I (upper left-hand corner) contains alfalfa; II (upper right-hand corner) contains oat; III (lower left-hand corner) soybean; and IV (lower right-hand corner) wheat.

Seed starter under the plant light will be referred to as P; Fluorescent light only will be F; and Fluorescent light with saran will be S.

Wells will be referred to by (Light) (Plant) (#). For example, if the above diagram was under the fluorescent light, the starred well would be FA1.

1. In each alfalfa well, put one-eighth of a teaspoon alfalfa seeds. In each oat well, put four oat seeds. In each soybean well, put three soybean seeds. In each wheat well, put six wheat seeds. For the wheat quadrants only, wet a paper towel, wring it out, and fold it into fourths. Lay it on top of the wheat seeds (without covering them with soil) and cover the paper towel with part of a black plastic trash bag to block any light. Make sure that the bag and the towel do not cover any other quadrants.
2. Cover the three remaining quadrants for each seed starter with soil up to the base of the indents found between the wells. The day the seeds are planted will be referred to as T=0 (3/31). Do not yet turn on the lights or water the seeds.

Experimental Procedure:

1. At T=1, in the evening, water each well with two teaspoons tap water. (T=1 was April 1 in our experiment.) For the far-right fixture, suspend a piece of saran wrap (or similar cling wrap) six inches under the light bulb (it should cover all of the seed starter underneath).
2. Around 7:30 AM T=2, turn on the lights for the first time. Around 4:00, water (again, two teaspoons) and turn lights off at 6:30.
3. In the morning T=3, remove the bags and paper towels from the wheat and cover seeds with soil to the same level previously described. Turn on the lights at 6:30 AM and turn off at 5:30 PM. At 9:00 PM, water wheat (only) with one teaspoon tap water per well. Record any observations, as seeds may already be sprouting.
4. For the remainder of the experiment, turn the lights on at 6:30 AM and turn them off at 5:30 PM. Water seeds only on these days: T=15, all with .4 ml tap water (using an eye dropper); T=16, water all but soybeans with .4 ml tap water, also using an eye dropper. Continue recording all observations.

Data Collection:

1. Starting at T=12, record the height of the tallest sprout in each well for all the different lights and types of plants, using the numbering system described earlier. Using a ruler with the measurement starting right at the edge, measure the height of the tallest sprout from the bottom of the indent between the wells (what should be the top of the soil level) and record the number of sprouts in each well. If Record the tallest height every day at the same time from T=12 until T=19. Also record any additional sprouts and the day they appeared.
2. For final data collection, starting on T=20 (this may take a long time so allow an entire day from sun-up ‘til sun-down), measure the height of every sprout in each container (except the alfalfa). It may be easiest to mark the starting point of the height (where the plants would be measured- at the base of the indent between the wells) on each sprout with a permanent marker. Remove the plants from the wells carefully (one at a time) by lifting out the dirt and sprouts together, and then carefully “massaging” out as much of the dirt from the roots as possible. Using a bowl of room temperature tap water, work the rest of the dirt off the roots (carefully- try not to tear the roots as they will be measured) and carefully untangle the roots from each other. Measure the roots’ length and record along with the height of the sprout and the well it came from.

For the alfalfa sprouts, count the number of sprouts in each well. It would be ideal to weigh the alfalfa sprouts from each well on a very sensitive scale (+/- .01 g). However, we did not have access to a scale such as this.

Once all sprouts have been collected and recorded, lay all sprouts from one light only on a cookie sheet covered with aluminum foil. Preheat the oven at 200 degrees. Bake the sprouts at 200 degrees for fifteen minutes. There should be three batches each of oat, wheat, and alfalfa sprouts. (Due to mold and rotting from over-watering, the soybean seeds did not sprout and final data was not collected for these plants.)

1. With a sensitive-enough scale, weigh each sprout to the closest .01 g and record. Another option is to weigh all the sprouts of one type from under one light and to find the average weight of each sprout (we used this option).
2. All data should be transferred to Excel worksheets to be transferred (eventually) to a website and to be easily evaluated. All the data should include total weight of sprouts, number of sprouts, and average weight of each sprout; daily charts of numbers and heights of tallest sprouts; and the final charts of heights and roots.

Statistical Analysis:

1. With a TI-83, type in all the data for one of the days for one plant only, putting each separate light into a different list. Using a two-sample t-test, record the two x-bars, the null and alternative hypotheses, degrees of freedom, the t-value and p-value, as well as the conclusion of the test. Anything with results within alpha-level of .05 resulted in a rejection of the null hypothesis. If the test had a p-value greater than .95, star the data (the reverse of the alternative hypothesis has enough evidence to reject the null hypothesis). Repeat this for each day, comparing PO, FO, and SO, as well as PW, SW, and FW. Do the same for the number of sprouts, as well as height and roots for the final data collection. The only type of test used for statistical analysis was a two-sample t-test.
2. Compare the height of the sprouts to their roots graphically (with height on the x-axis and roots on the y-axis).