

# SAMPLE OF RESEARCH REPORT - PARTS I & II

(name) \_\_\_\_\_

Per. \_\_\_\_ (date) \_\_\_\_\_

## THE EFFECT OF THE FERTILIZER VF-11 ON OAT SEED GERMINATION

### I. INTRODUCTION

A. PROBLEM: How does a fertilizer affect the germination of oat seeds?

B. BACKGROUND: With the time rapidly approaching when we will need to grow food plants in an orbiting space station, in a lunar base, and in a station on Mars, it would be important to know just how much fertilizer is absolutely necessary for maximum growth in those environments. Payload size for launching support materials is very precious, so we don't want to send up any more than necessary. Baseline data can be gathered from ground-based studies on various food plants and various fertilizers.

Since a seed is essentially a plant in a very early stage, it is reasonable to expect that anything that helps a plant to grow should also help a seed to germinate and grow.

C. HYPOTHESIS: The fertilizer, VF-11, will stimulate the germination and early growth of oat seeds.

### II. INVESTIGATION

A. PROCEDURE:

1. Two clear plastic vials (8.1X3.2 cm diam.) are set up, each with a strip of masking tape around it, 1 cm from top of vial (with marks numbered 1-6, 15mm apart to mark the position of each seed, and to identify the vial), and with a rolled-up half-piece of brown paper towel slipped inside (to hold the seeds in position against the vial).
2. The paper in each vial is moistened with a small amount of water to help hold seeds in position.
3. 12 oat seeds (*Avena sativa*) of approximately equal length and thickness are selected. 6 will go into each vial, as follows:
4. Using forceps, each seed is grasped gently in such a way that its sharpest point is pointing away from the hand, and just a few mm from the end of the forceps.
5. Working the forceps points into the space between paper towel and plastic vial, each seed is inserted to a position where its pointed (lower) end is just even with the upper edge of the tape (1 cm from lip of vial), and just above one of the numbered marks.
6. One vial (the "experimental") is half-filled with a tapwater solution of VF-11, diluted according to directions on bottle. The other vial (the "control") is just half-filled with tap water.
7. Both vials are kept in a wood block on the window sill in room 18, at right angles to the window.
8. Each day, the vials are checked for water level (maintained at 1/2 full) and seed germination.
9. When green shoots begin to appear from several seeds, each will be measured (from edge of vial to upper tip of shoot) to the nearest mm, and the measurements are recorded in two data tables (one for the control vial, one for the experimental vial), designed for easy data entry and calculations.
10. Both members of each research team are responsible for BOTH VIALS: measuring, recording, and watering as needed, at each lab session.
- 11 Measurements are made daily for about 1 week after first measurements are started.
12. At the end of the study, a graph of the summarized data is prepared, and a statistical analysis made (using the t-Test) to compare shoot lengths on the last day of measurement. These are used to help interpret the data and reach a conclusion.

B. PREDICTIONS: If the hypothesis is *correct*, then the shoots grown in VF-11 should be significantly taller on average than those grown in plain tapwater for the same period of time. Also, the slope of the growth-rate curve should be steeper for the fertilized seedlings. Both of these observations would indicate a faster rate of growth in the fertilizer.

If the hypothesis is *wrong*, then the length of fertilized shoots should be equal to or shorter than the tapwater shoots, and the graph slope of the fertilized shoots should be the same or lower than that for the tapwater shoots, both indicating that the fertilizer had either no effect, or an inhibiting effect, respectively.

III. RESULTS [See attached data tables, graph, and t-Test results.]

IV. DISCUSSION [See attached "Discussion" page for this part.]

## RESEARCH REPORT: DISCUSSION FORMAT

Specific points that should be included in your report. Use complete sentences.

### IV. DISCUSSION

A. INTERPRETATION: This should express the following as an interpretation of the data collected:

1. Team Data: Were there any significant differences observed between the two groups (vials), e.g....
  - a. different slopes (angles of growth curves), showing clear and consistent trends, moving apart, which indicate different rates of growth?
  - b. average lengths on any day or days found to be significantly different?
  - c. little or no overlap of ranges on any day or days?
  
2. Class Data: How do your data compare or contrast with the data of other students or previous studies reported? Are your data typical of the class, or not typical, or are the data mixed (inconsistent)?
  
3. Basis: On what do you base these comments (above)? Graph? t-Test? Checking other teams? (how many?). Explain this clearly.

<u>FACTORS AFFECTING DATA INTERPRETATION</u>
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- |  |
|--|
| <ol style="list-style-type: none"><li>a. Size of sample (no. of seeds used in each vial): t-Test only</li><li>b. Differences in averages: t-Test AND graph</li><li>c. Amount of data overlap: t-Test AND graph</li><li>d. Trends of growth: graph only</li></ol> |
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### B. CONCLUSION

1. What does your interpretation lead to, in terms of your prediction of the outcome, (based on the hypothesis): DID the "fertilizer" seeds grow faster than the control seeds, or not?
  
2. Are there any reasons to suspect errors in the experiment, e.g. any variables that were not controlled? If so, what are they?
  
3. Does this study appear to support the hypothesis, or weaken it, or does it have no clear impact on it? Why?

### C. RECOMMENDATIONS

1. What, specifically, would you suggest be done to improve this study, (to further test the hypothesis, with greater clarity, to deal with uncontrolled variables, or to resolve any uncertainties)?
  
2. What other studies can you think of that might shed more light on the question (problem) studied here? Are there any other similar or related studies that examine how other factors affect plant growth, which you might suggest (or which you might like to try)?

# SAMPLE OF RESEARCH REPORT PART IV: DISCUSSION

[VERSION #1: For: Predicted positive effect, but with **NO** effect observed]

## IV. DISCUSSION

### A. INTERPRETATION:

1. When the average shoot lengths are plotted on a graph against time, the lengths of the plant food shoots are seen to run fairly close to the control shoots, with considerable overlap in their respective ranges. In addition, the slopes of their growth curves run nearly parallel at the same slope, which is further indication that both sets of seeds grew at essentially the same rate.

2. The t-Test analysis, done on their relative status on the last day of measurements, gave a t-value of \_\_\_\_\_, which falls in the "less than 95%" level of confidence, so the difference in growth between the two groups on that day should be considered as statistically not significant.

3. In addition, an informal survey of the results of other teams in the class revealed similar results in most cases.

4. The consistent agreement of all the above observations provides a strong indication that the seedlings in the plant food grew at the same rate, and had the same shoot lengths as those in plain tap water. These results are contrary to the predicted results based on the hypothesis that VF-11 should stimulate plant growth.

### B. CONCLUSION:

It appears that the plant food (VF-11) had no significant effect on the germination and early growth of the oat seeds. This clearly indicates that the hypothesis is probably not correct.

### C. RECOMMENDATIONS:

1. Before throwing the hypothesis out too hastily, it might be wise to try a few alternatives. Since VF-11 has been found to help the growth of established house plants, any effect it has might only be detectable during later stages of growth, so extending the study done in class for two or more weeks would be more likely to show a significant effect.

2. It is also possible that VF-11 is effective only on broad-leaf (dicot) plants (as most house plants are), so the study could be repeated with radish, cucumber or mustard seeds, or the seeds of some other food-producing dicot plant. It would be interesting to try VF-11 on the seeds of a variety of different types of plants, to see if there is any pattern in its effects, e.g., different for dicots and monocots.

3. Another variation in this study would be to try different plant foods. They, too, might work differently on different seeds.

4. As for the study itself, it is quite possible that the wrong indicators were being observed. The significant effects might be on the percentage of seeds that actually germinate. Or it might be the roots that show the most striking differences. Weighing the blotted seedlings at the end of the study could give some insight into this last possibility.

5. In any case, any subtle effects would be more likely to show up if larger sample sizes (e.g. 10-30 seeds for each condition) were used. Also, the variables introduced would be reduced if only one person set up, watered, and measured the seedlings in both sets, and all plants were kept in precisely the same amount of light and at precisely the same temperature.

# SAMPLE OF RESEARCH REPORT PART IV: DISCUSSION

[VERSION #2: For: Predicted positive effect, AND the results match this]

## IV. DISCUSSION

### A. INTERPRETATION:

1. When the average shoot lengths are plotted on a graph against time, the lengths of the plant-food shoots are seen to run increasingly taller than the control shoots, with progressively decreasing overlap in their respective ranges. In addition, the slope of the VF-11 curve tends to be steeper than the control curve, which further indicates that the seeds in plant-food grew at a faster rate.

2. The t-Test analysis, done on their relative status on the last day of measurements, gave a t-value of \_\_\_\_\_, which falls in the "\_\_\_\_\_% " level of confidence, so the difference in growth between the two groups on that day was statistically \_\_\_\_\_ significant.

[IF CLASS RESULTS WERE THE SAME...]

3. In addition, an informal survey of the results of other teams in the class revealed similar results in most cases.

4. The consistent agreement of all the above observations provides a strong indication that the seedlings in the plant food grew faster, and had longer shoot lengths than those in plain tap water. These results agree with the predicted results based on the hypothesis that VF-11 should stimulate plant growth.

[OR... IF CLASS RESULTS WERE DIFFERENT...]

3. In contrast, a survey of the results of other teams in the class revealed that \_\_\_\_\_ teams out of \_\_\_\_\_ showed no significant difference between the plant-food vials and the tap-water controls. In view of this inconsistency, weighted strongly in favor of the "no-significant-difference" results for most of the class, it is suggested that special circumstances (or mere coincidence) may have prevailed in the group of seeds used for this report. There may have been errors in setting up, measuring, recording, or maintaining a constant environment. Suggestions for reducing such errors are made below under "Recommendations".

4. In view of the relative uniqueness of the results of this team, in contrast to the class results as a whole, it seems best at this time to discount this team's results, and report the stronger, more consistent observations from the much larger sample size of class at large, which indicate that the seedlings in the plant food grew at the same rate, and had the same shoot lengths as those in plain tap water. These results are contrary to the predicted results based on the hypothesis that VF-11 should stimulate plant growth.

### B. CONCLUSION:

[IF CLASS RESULTS THE SAME...]

It appears that the plant food (VF-11) stimulated the germination and growth of the oat seeds. This clearly shows that the hypothesis was correct.

[OR.... If class results were different, the CONCLUSION would be the same as for version #1]

### C. RECOMMENDATIONS: same as for version #1