Student Checklist /Timeline

Date Due (□= check when completed)

_____ □1. Your **Topic/Idea** must be approved by your teacher before you start work on a project!

Your teacher must first set up a GSDSEF Account at gsdsef.org→Teacher→Register
Once your teacher has set up an account, you must set up a GSDSEF account at gsdsef.org→Student→ Register
If you already have an account from last year, you can use that instead of setting up a new account.

_____ □2. **Abstract,** a brief, no more than 250 words, summary of the main points of your project, including your hypothesis, procedures, results and conclusion. THIS IS **WRITTEN last** but goes in the **front** of your Project Notebook.

_____ □3. **Acknowledgements,** a place for you to give credit to those who helped you with advice or supplies.

_____ □4. **Introduction,** a brief look at the background and goals of your research.

_____ □5. **Review of the Literature** (aka: background research), this is your written report about the information you discovered when you researched your topic. A minimum of three typed pages

_____ □6. **Statement of the Problem or Purpose,** the question you want to answer during this project.

_____ □7. **Hypothesis,** a testable prediction about the answer to your problem.

_____ □8. **Materials**, everything you used for your experiment, including size and volume. All should be in metric measurements (cm, mm, mL, grams, etc.)

_____ □9. **Procedures**, a step-by-step description of how you did your project.

_____ □10. **Results**, this is the **DATA** that you collected, the responses, reactions and results you observed. Keep your rough handwritten notes, drawings, and your daily log etc. (These all go in the appendix of your Project Notebook).

_____ □11. **Data Table, Graphs, Charts.** organize your data into appropriate data tables, graphs and charts

_____ □ 12. **Data Analysis**, write an analysis of your data (why you think you got those results) based on the trends, patterns, and any calculations of the data

_____ □13. **Conclusions**, how did your tests and experiments work out? Did your findings support or not support your hypothesis? Include a statement based on your results.

_____ □14. **Recommendations**, your ideas on possible uses for your findings and any additional tests which should be made. Would you do this project again, or could you continue this project another year?

_____ □15. **Bibliography**, a list of items referenced/used as you researched this project. Include interviews of people who gave you information. Jr. Division projects should have a minimum of 5 sources and Sr. Division projects a minimum of 10 sources.

_____ □16. **Appendices**, selected photos, graphs, your Daily Log **and all Raw Data**.

_____ □17. **Completed Project Notebook and Display are ready for school fair**

Title

(reflects what your experiment is about)

Example: The Effect of Pre-treament of Raphanus sativus Seeds On Percent Germination and Growth Rate

Insert image if desired

Table of Contents

Abstract

The abstract is a summary of your project and is written--AFTER ALL YOUR WORK IS COMPLETED--using 200 to 250 words--one page or less, be succinct!

Start with the title and your hypothesis then briefly describe your procedures and results, then summarize your conclusions.

You do your abstract LAST but it goes in the FRONT of your Project Notebook.

REMINDER:
Your abstract is an important part of your work and must appear in the front of your notebook, in your PowerPoint submission and you should also attach a copy of it to your display board; or put it in a plastic sleeve and lay it in front of your display board where judges will see it first as they begin to evaluate your project.

Example Abstract:

This project examined the effect of pre-soaking radish seeds in water 4 hrs. and 24 hrs to determine if it affected the germination percentage and growth rates vs. a non-soaked control. It is hypothesised that the seeds soaked in water for four hours will have a higher germination % and a higher growth rate than control seeds and 24 hr soaked seeds. Trials of 30 seeds were set up for each condition-Control, 4 hr. pre-soak and 24 hr. pre-soak-and data were recorded for seed germination and plant growth (cm.)

Results indicated that the initial hypothesis was not supported—the seeds soaked for 24 hrs. produced the highest germination % (16.9% more than control) and growth rate (45.2% more than control, slope of growth curve = 1.33 for 24 hour soak, 1.00 for 4 hour soak and 0.916 for the control). Seeds soaked for 4 hrs produced a germination of 7.8% more than control and a growth rate of 9.2% more than control. The 24 hr. pre-soak was the most beneficial to plant germination and growth. As the seed coverings became more permeable, the inside of the seeds may have absorbed the water better and started the process of germinating. This would lead to a better germination rate which would result in a higher yield from the garden.

Acknowledgements

This is where you thank all the people who helped you. No more than a single page.

Example:

I would like to thank my parents and teacher(s) for their wonderful help and support. I would also like to thank Prof. John Smith for allowing me to use equipment from his laboratory at State University to run my experiments. And I give a big thank you to the *Home Improvement Store* for donating the materials I needed to test my seed germination.

Introduction

Here you tell why and how your project came to be.

In no more than a single page give a brief overview of the background and goals of your project.

Why did you choose this topic?

Example:
Home gardening is popular among many families. "Farm to fork" is a fast growing movement. Since the areas are so small that people use, it is crucial for as many seeds as possible to germinate and grow to maturity more quickly and yield edible products that can be used by the families. Is there a way that seeds can be pre-treated to ensure higher germination rates and improve growing?

Review of Literature

This section of your notebook is a report on the topic you have researched for your project. Write it so that a reader (judge/teacher) can see how much work you have done. This report should be at least three typed pages and will summarize the information you found about your topic before you start your experiment. This report should be double-spaced and in a readable 12 pt font. "Times New Roman" or “Times" would be good choices. Remember to use the writing skills you have learned in English classes, including:

1. Start with an introductory paragraph that generates interest and indicates what is coming.
2. The main body of your report should be written in complete paragraphs that describe information you found while researching your topic.
3. Give credit where credit is due! Copying, rephrasing or reporting on someone else’s work or idea is fine as long as you give the person credit for their thought or work.
4. Have a concluding paragraph that “pulls” it all together.

Make sure you proof-read your work AND have someone you trust also proof-read your work!

For the radish experiment some of the topics I would research are:

- What is a radish and what is its latin name?
- What are the parts of a seed and what are their functions?
- How does a seed germinate?
- What are the parts of the radish plant and what are their functions?
- What is potting soil (or whatever I will use to grow the seeds?
- What are the nutrients that a seed needs in order to germinate?
- What are the nutrients that a radish plant needs in order to grow?
- What are the light requirements that a seed/plant need in order to grow?
- Interview someone at a gardening center to find out about soil, best place to grow plants and seed starter trays

These topics might lead to more research that you will need to do. This is just a starting point.

Statement of Problem

This is where you put in words exactly what you want to test. This could be a question or a statement.

Example:
Does pretreating radish seeds by soaking them in water for different times affect the germination percentage and ~~or~~ growth rate of the plants?

Or

The effect on radish seeds' germination percentage and growth rate of plants when they are soaked in water for different times.

Hypothesis

This can go on a new page or be part of the previous page. Your choice.

> A hypothesis is a tentative, testable answer to a scientific question. Once a scientist has a scientific question she/he is interested in, the scientist does research by reading to find out what is already known on the topic. Then she/he uses that information to form a tentative answer to her/his scientific question, but keep in mind, that the hypothesis also has to be testable since the next step is to do an experiment to determine whether or not the hypothesis is right!

NOW, based on what you have read as you did a review of the literature on your topic, the research paper you have written, and the problem you have identified, you are ready to ask a question about your topic. You will be making a "prediction" as to what the answer or outcome will be.
This is called your hypothesis and it goes here in your notebook!

Example:
It is hypothesised that the seeds soaked in water for four hours will have a higher germination percentage and a higher growth rate than the seeds that are not soaked (control) and seeds that are soaked for twenty four hours.

Materials

On this page you will put what materials you will need to conduct your experiment.

Example:
Three packs (put name of company after you purchase) of radish seeds
1 – 5 kg bag of Miracle Gro Potting soil
Seed starter trays (enough for 100 seeds) include sizes when you purchase them in centimeters
Three 250 mL beakers (for measuring soil and soaking seeds)
Digital scale set in grams (1 gm to 1000 gm)
Tap water
100 mL graduated cylinder for measuring water to moisten plants
Celsius thermometer (-20 to 120^{o}C degree range)
Metric ruler (0-30.5 cm range)
Device for taking pictures

Procedure

On this page you want to give a step by step description of what you did. It should be clear enough that someone could repeat your experiment exactly as you did it. Documenting your procedure with pictures is very helpful. Include a picture at the end of the procedure, if possible.

Example

1. **Obtain all supplies.**
2. **Count 30 seeds and place them in 250 mL beaker with 100 mL tap room temperature water for 24 hours. Take the temperature in Celsius of the water and record.**
3. **Count 30 seeds and place them in a different 250 mL beaker with 100 mL tap room temperature water for 4 hours. Take the temperature in Celsius of the water and record.**
4. **Put the seed starter trays in the place where the experiment will be done (you will need to describe whether it is a sunny location or an inside location).**
5. **Put _____ grams of soil in each of ninety sections of the seed starter trays. (You will have to test first to see how many grams are needed to fill the sections and then fill in the bland with that amount.)**
6. **After the seeds have been soaking for their allotted times, place one seed per treatment in each section of tray. Take 30 seeds that have not been soaked and put them in the other 30 sections. Mark the trays with which seeds have had which treatment.**
7. **Water all seeds with 10 mL tap water. (If more water is needed than than change your procedure accordingly)**
8. **Check trays each day and water as needed. Record when watered and amount of water that was put on plants in log book. Record temperature of water.**
9. **Once seeds start to germinate, record in a data table when each seed germinated. Start measuring height in cm and record in the data table. Keep track of number of leaves in each plant. Take pictures to document your results.**
10. **In log book where your raw data is, make any observations about the different treatments that might be used later in analysis.**

11. Calculate % difference between Control germination rates and 4hr. and 24hr. soaked seeds germination rates.
12. Calculate % difference between 4hr. and 24hr. soaked seed germination rates.
13. Calculate % difference between Control average height and 4hr. and 24hr. soaked seeds average height.
14. Calculate % difference between 4hr. and 24hr. average height
15. Calculate % difference between Control germination rates and 4hr. and 24hr. soaked seeds germination rates.
16. Calculate % difference between 4hr. and 24hr. soaked seeds germination rates.
17. Calculate % difference between Control average height and 4hr. and 24hr. soaked seeds average height.
18. Calculate % difference between 4hr. and 24hr. average height

Empty Seed Starter Tray

Day 6 Control

These are pictures I got from internet. Your pictures would be the actual pictures of your experiment.

Results and Statistical Analysis

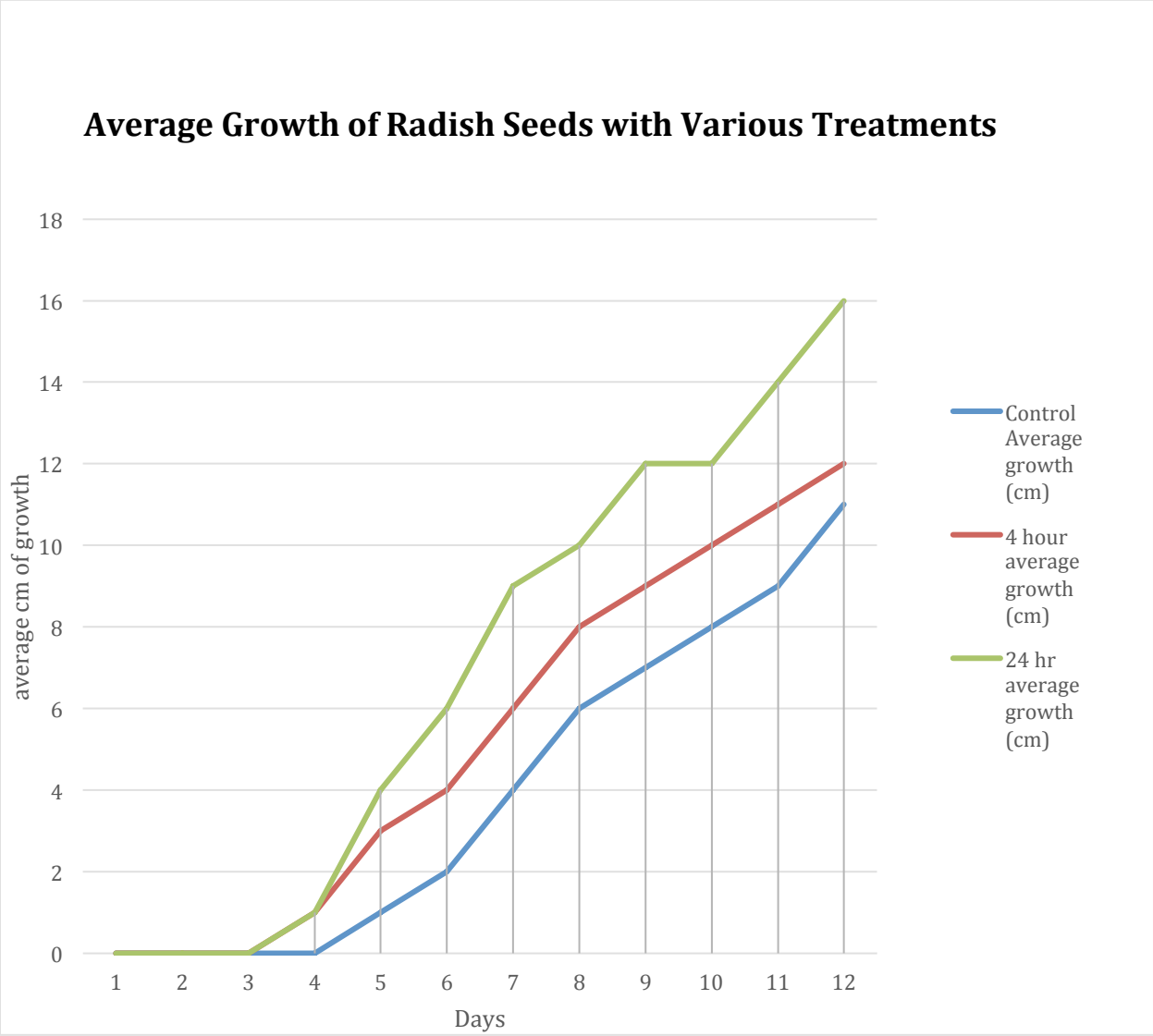
A formal version of the "raw" data you have collected, like responses, reactions, results you observed and recorded goes here. You may need many pages for all your results. Including pictures of your results as the experiment progresses is essential. This allows judges to visualize what you have done and what the results were. KEEP the raw data (hand scribbled notes, extra photos, etc.) as is and include it at the end of your notebook.

Example:
You would keep the results of all ninety seeds in your notebook as "raw data." Then you would start making data tables to reflect what you want to show. The question you are answering is about sprouting rates and growth so that would be the main focus of your graphs and data table.

Data Table of Averages of Control, 4 hr soak and 24 hr soak

Day	Control sprout	Control avg.number of leaves	Control Average growth (cm)	4 hour sprouted	4 hr avg. number of leaves	4 hour average growth (cm)	24 hr. sprouted	24 hr avg.number of leaves	24 hr average growth (cm)
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	2	0	0	5	1	0
4	2	0	0	8	1	1	17	4	1
5	7	3	1	17	3	3	27	5	4
6	19	4	2	25	3	4	27	5	6
7	23	4	4	25	4	6	27	6	9
8	23	5	6	25	5	8	27	6	10
9	23	5	7	25	5	9	27	6	12
10	23	5	8	25	5	10	27	6	12
11	23	6	9	25	5	11	27	6	14
12	23	6	11	25	6	12	27	6	16

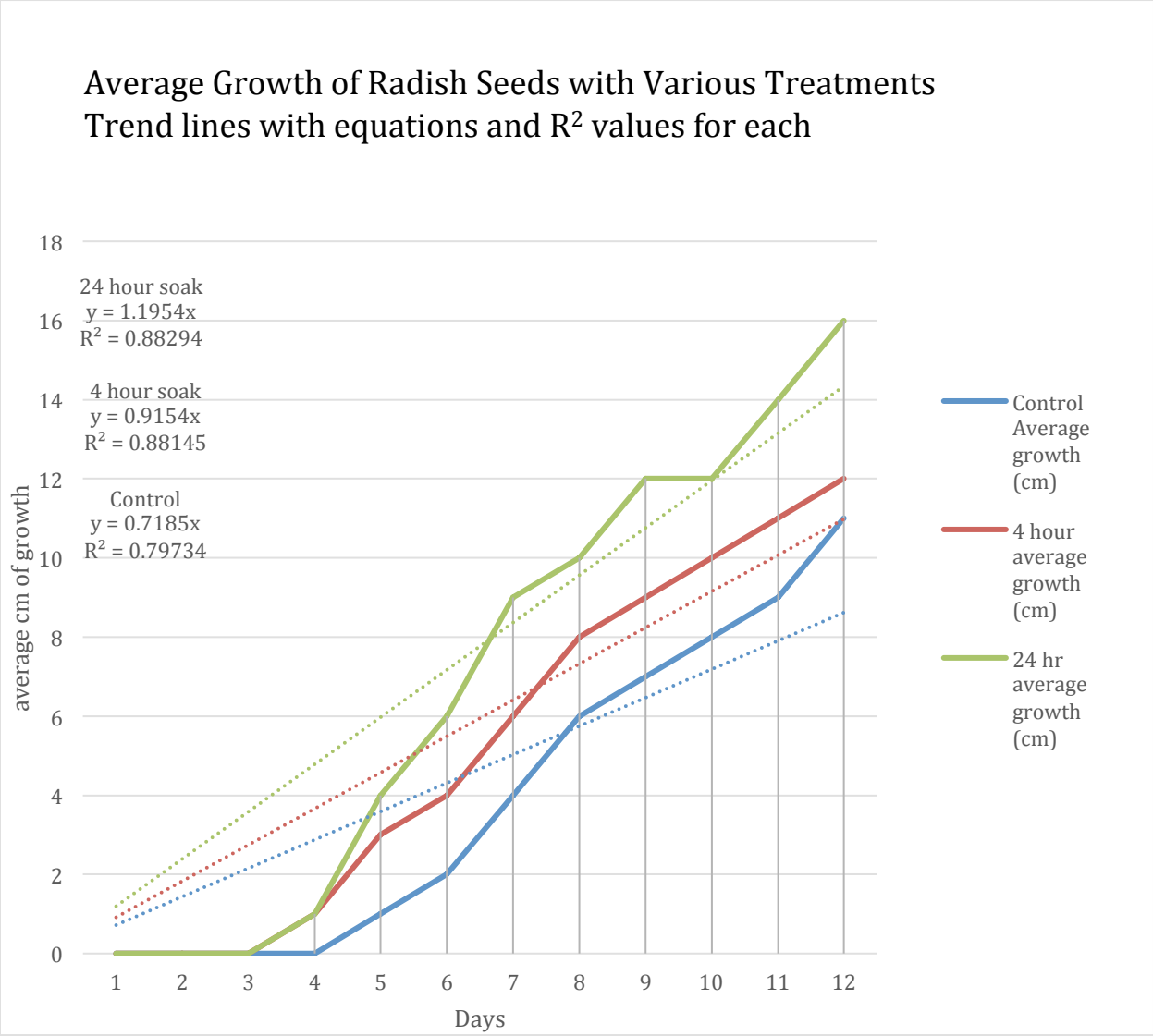
Next you would start adding some of the charts to demonstrate how you answer the questions.
You would start by talking about each graph and what they represent. For example:



To calculate the rate of growth one compares the slopes or steepness of the lines: $(y_2-y_1)\div(x_2-x_1)$ and I will use the beginning and ending points in my calculations:
Control: (11-0)÷(12-0)= 0.916 cm/day
Four hour soak: (12-0)÷(12-0) = 1.00 cm/day
24 hour soak: (16-0)÷(12-0) = 1.33 cm/day

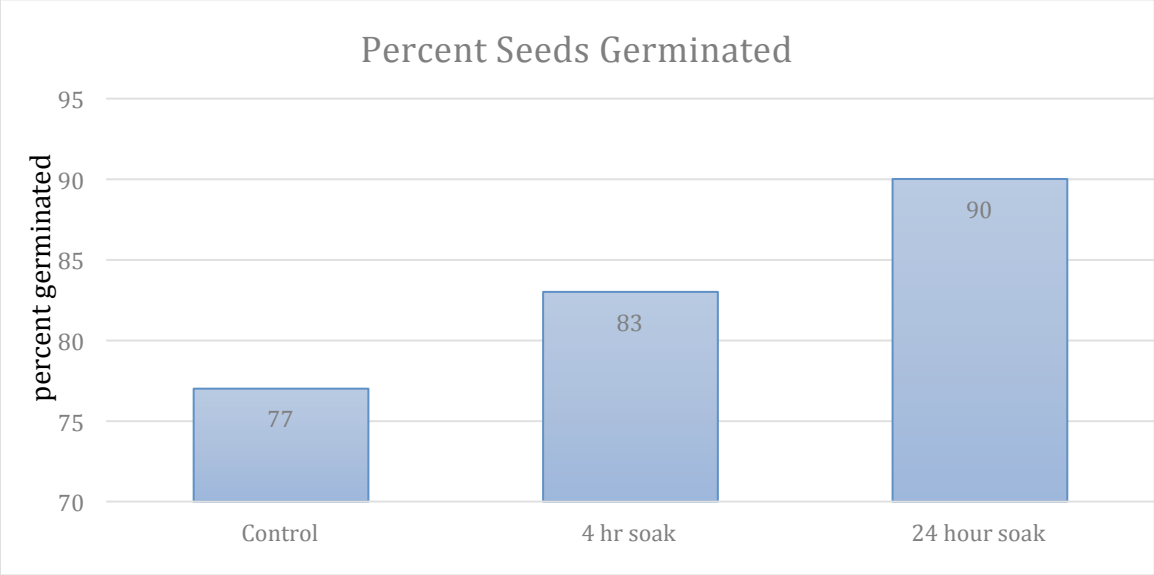
The larger the number for the slope of the line, the faster the rate of growth of the plants. By comparing these numbers, it is apparent that the 24 hour soak had a faster rate of growth. Percent change in growth for each is:
4 hour soak: (1.00-0.916)÷0.916 x 100 = 9.2% increase in rate of growth from control
24 hour soak: (1.33-0.916)÷0.916 x 100 = 45.2% increase in rate of growth from control

(If you are further along in your understanding of statistics, another way of showing this is to do a best fit line (trend line) and an R^2 value on the graph using the computer to draw the trend line and calculate the R^2 value)



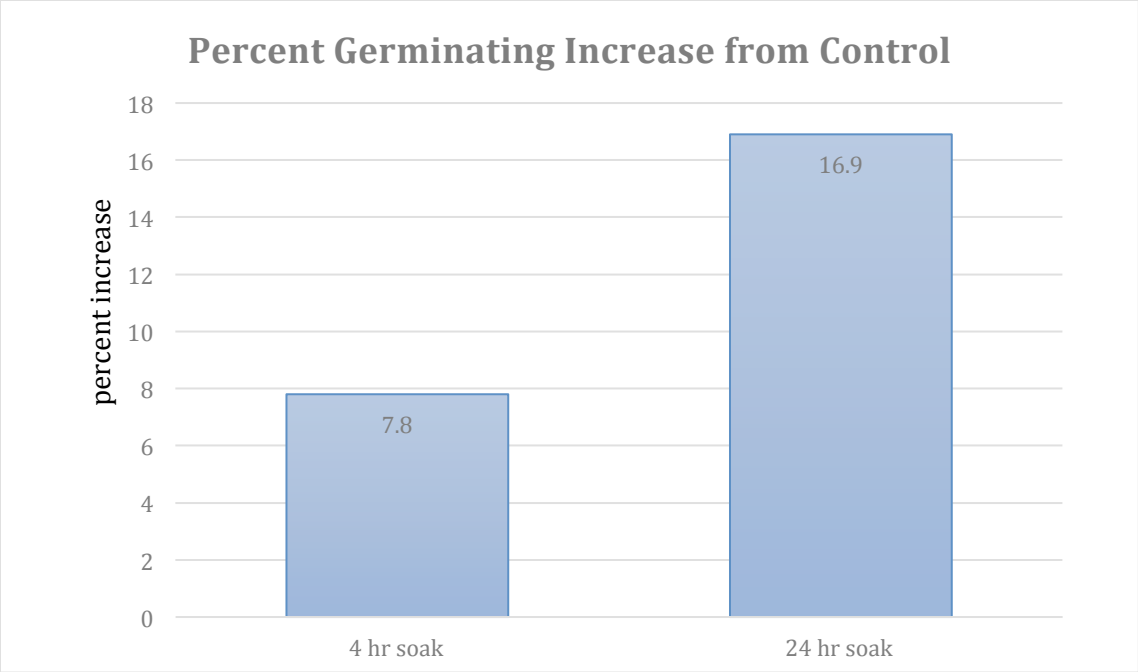
The same kind of analysis can be done on these slopes as was done previously.

Slopes differ from previous calculations because all data points are taken into consideration rather than just two in the other example
The trend line is the best fit line for the data. One can use the R^2 value to see how much deviation the points are from the trend line. An R^2 value of 1.00 means all the points are exactly on the line. Usually an R^2 greater than 0.7 means that the trend line is a good representation of your data. One can then compare the slopes of the lines that are in y=mx+b format to compare the data. The "m" is the slope of the trend lines and all the R^2 values are greater than 0.7 so one can safely compare the slopes of these lines to show that they are statistically significant. There is no "b" value as the y-intercept is 0.



Percent sprouted = (number sprouted ÷ 30) X 100
Calculations:
Control: 23÷30x100 = 77%
4 hr. soak: 25÷30x100=83%
24 hr. soak: 27÷30x100-90%

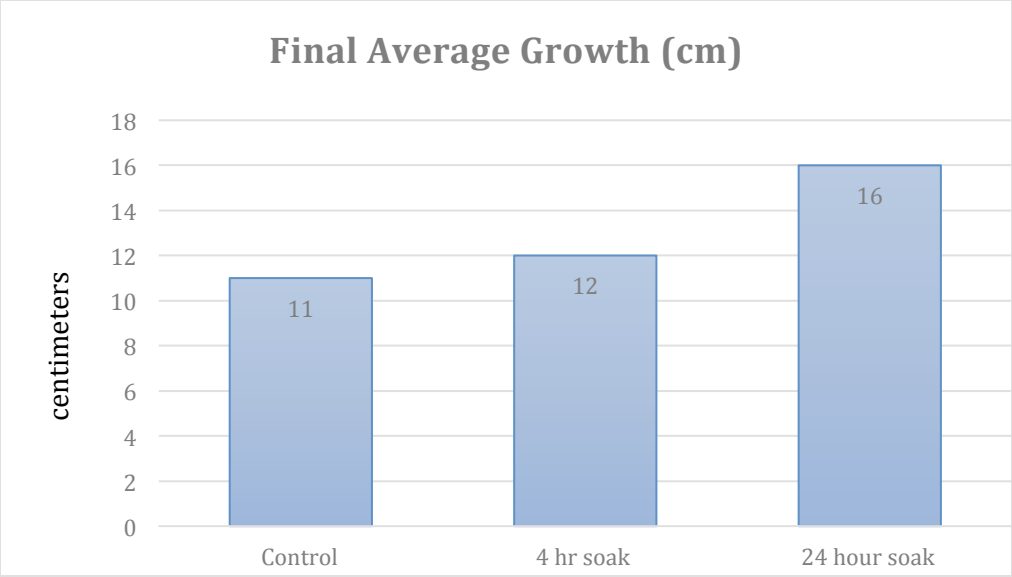
The percent seeds that sprouted (germinated) were 77% for the control, 83% for the four-hour soak and 90% for the 24-hour soak. This is shown in the above graph.



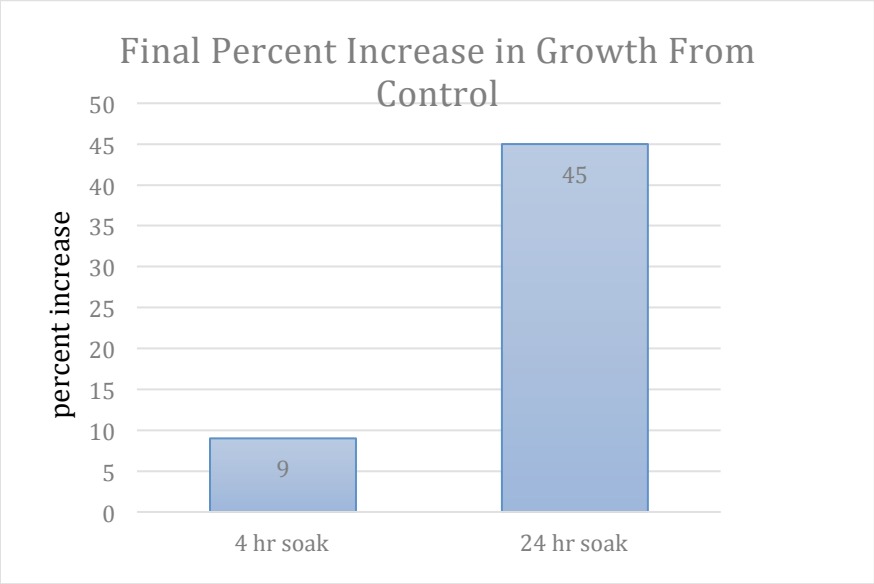
To calculate percent increase from control, the following was done:
(Percent soaked – percent control) ÷ percent control x 100

Calculations:
4 hr. soak
83-77=6
6÷77 x 100 = 7.8%
24 hr. soak
90-77=13
13÷77x100 = 16.9%

There is a 7.8% increase for the 4 hour soak and a 16.9% increase for the 24 hour soak from the control of sprouting (germinating).



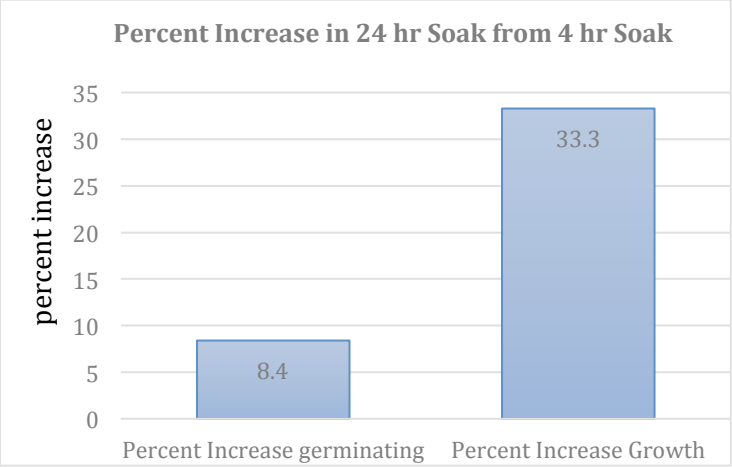
The average growth for the different treatments are 11 cm for the control, 12 cm for the 4 hour soak and 16 cm for the 24 hour soak.



To calculate growth increase from control, the following was done:
(growth soaked – growth control) ÷ growth control x 100

4 hr. soak:
12-11 = 1 ÷ 11 x 100= 9%
24 hr. soak:
16-11= 5 ÷11x100 = 45%

The final average growth for the 24 hour soak was 45% higher than the control and the 4 hour soak growth was 9% higher than the control.



Germination:
90-83 = 7
7÷83x100= 8.4% increase
Growth:
16-12 = 4
4÷12x100=33.3% increase

To calculate the percent increase in 24 hour soak versus 4 hour soak:
(24 hour soaked percent germinated – 4 hour soaked percent germinated) ÷ 4 hour percent x 100
To calculate percent increase in growth of plants:
Growth of 24 hr soak – growth of 4 hr soak) ÷ growth of 4 hr soak x 100

This final graph represents the difference in germination and growth from the 24 hour and 4 hour soaks. The 24 hour soak had 8.4% more sprouted seeds and the plants had 33.3% more growth than the 4 hour soak.

Analysis

You've just organized your data into tables and graphs. What information does the data you collected tell you? What trends or patterns do you see?

By closely analyzing your data and identifying any patterns, you will be able to draw and support a conclusion.

In your Analysis summary, identify and discuss any trends or patterns that you see in your data.

Compare and contrast the data. Refer to the calculated averages/mean, median, mode, percentage differences, and/or standard deviation or other statistical analyses.

The statements in your analysis need to be objective and based only on the data.

Example:
Based on the results soaking the seeds in tap water for 24 hours is beneficial to the germination as well as the growth of the radish plant. Germination % and growth rate were greater in the 24 hr soaked seeds compared to the control and to the four hour soaked seeds.
Germination %--
There was a 16.9% increase in germination of the seeds when soaked for 24 hours vs. control. For 4 hr. soaked seeds, there was a 7.8% increase in germination compared to control.

Growth Rate--
The 24 hour soaked seeds growth rate was 9% more than the four hour soaked seeds and 45% more than the control. The growth rate shows the higher value for the 24 hour soak at 1.33 cm/day versus 0.916 cm/day for the control and 1.00 cm/day for the four-hour soak.
There was no difference in the average number of leaves per plant per treatment.

Conclusion

In the conclusion you restate your questions/problem, your hypothesis and state whether your hypothesis was supported or not. You then use your data and your background research to offer an explanation as to why you think you got these results.

Example:

The question of soaking seeds for differing amounts of time before planting to obtain a higher germination and growth rate was addressed. The hypothesis was that the four-hour soaked seeds would have a higher germination rate and growth rate. The hypothesis was not supported by the data as the 24-hour soaked seeds had a higher germination percentage and better growth rate. Based on the review of literature it seems that the coating on the seeds became more permeable the longer the seeds soaked. As the seed coverings became more permeable, the inside of the seeds may have absorbed the water better and started the process of germinating. This would lead to a better germination percentage which would result in a higher yield from the garden. It also affected the growth rate in that the growth rate was higher for the 24 hour soak than the 4 hour soak or the control.

Recommendations

Here is where you tell what problems arose during your experiment and what you would have done differently. Also if you were to continue this project, what would you do next?

Example:
If I were to continue to do this project, I would try different kinds of seeds that would normally be found in a family garden. I also might try adding a mild fertilizer to the water during the soaking to see if that changes the data.

Works Cited/Bibliography

Here is where you list the sites where you used in your background research. Junior Division needs a minimum of five sites and Senior Division needs a minimum of ten sites. You can reference MLA for information as to how the sites should be listed or another format if your school uses a different one other than MLA.

Example:

All About Radishes. Burpee Company.
https://www.burpee.com/gardenadvicecenter/vegetables/radishes/all-about-radishes/article10099.html

Appendices

This is where you would put your raw data (all the measurements of EACH seed) and any extra pictures that you want to show.