Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JBBC097

Project Title: To what extent does soil pH affect the rate of germination?

Project Type: Investigation

***To our best knowledge, there are similar works in the field*; related research links are as below:**

Yes there are, the links are below:
https://csef.usc.edu/History/2004/Projects/J1422.pdf

https://www.gardenexpress.com.au/soil-ph-plant-growth/#:~:text=A%20soil%27s%20pH%20is%20directly,from%20nutrient%20deficiencies%20or%20toxicities

https://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_measure_ph#:~:text=pH%20is%20determined%20by%20measuring,is%20used%20to%20do%20this.&text=A%20sub%2Dsample%20of%20soil,measured%20after%201%20hours%20shaking

The enhancement our project proposed / the difference with related research are:

Existing research has only ever conducted experiments measuring the rate of growth from a seed to a fully grown plant and has not detected any relationships between germination and growth, and we aim to suggest this in our research. It is evident that the rate of growth from a seed to a seedling via germination in comparison to the rate of growth of a seed to a fully matured plant is different.

I. Background

Initially, we looked to alter the humidity and pH levels to seek the optimum ratio needed for rapid plant growth. However, after an inquiring our teacher, we decided not to pursue this and focused on the pH levels of the soil only. Due to difficulties in creating a controlled environment that mimics a realistic humid environment with no fluctuation in data caused by air inflow, we instead tested how watercress responds to different pH levels to determine the optimal pH for germination.

From prior research conducted, it was apparent that alongside marigolds, cress seeds would take the least amount of time to undergo germination, and we opted for cress seeds. We believed this made the experiment more scalable as cress seeds are a great addition to a healthy diet.

Futhermore, we thought that just using the time for germination was a time-efficient method of estimating the rate of growth for the rest of the cress seed to mature into a plant. This would be beneficial for local farmers as this information can be applied to estimating the rate of growth for a range of other seeds that hold similar growth patterns to cress seeds, including mustard, radish and alfalfa.

Preliminary Research

Firstly, pH is determined by measuring the hydrogen activity in an aqueous solution. In a lab setting, an electronic pH meter could be utilized to produce a quick and accurate reading as it would measure the pH and the temperature simultaneously and calculate the correct differences.

Simplified soil sampling methods

Method I
- Add deionised water and place on a stirrer to mix for approx 30 minutes.
- Cover for 60 minutes to produce accurate measurements (this allows the buffer and the soil sample to arrive to room temperature)
- Insert pH probe into varying soil volumes

Method II
- Place soil sample in a 236 cm^3 jar and pour distilled water to cover soil, shake the jar.
- Let the mixture stand for 15 minutes (to dissolve the salts in the soil)
- Calibrate the pH tester with a pH 7 and pH 9 buffer solution
- Place the pH tester into the wet soil sample

Sources that increase the pH level of soil
I. Add leaf matter or manure
II. Pulverised eggshells- due to their high calcium content
III. Baking Soda mixed with water (only holds a short-term effect)

Sources that decrease the pH level of soil
I. Powdered sulphur in the situation that the soil pH is excessively high (sulphur from sulfuric acid takes time for it to increase the soil acidity even with the aid of soil bacteria)
II. Aluminium sulfate (rapidly decrease the pH in contrast to sulphur)
III. Lime, agricultural pulverised limestone or powdered chalk

Preliminary Investigation & Experiment
Prior to officially starting the experiment we attempted to increase the soil pH by using mushroom compost and poultry manure. However, this increased the alkalinity and defeated our objective. Thus, we deemed changing the pH levels through such organic methods as an unreliable and inefficient method. This resulted in the use of buffer solutions instead of the methods listed above.

II. Objective(s)

To investigate the effectiveness of different percentages of hydrogen (pH) of soil on germination

III. Hypothesis

If cress seeds are grown in solutions with varied pH levels, then the growth and development of the seeds would be affected, as pH affects nutrient availability for the plants. Specifically, cress seeds grown in acidic conditions (low pH) would have decreased rate of growth, since acidic solutions can limit the availability of certain essential nutrients, such as nitrogen and phosphorus, that plants require for proper growth and development. In contrast, cress seeds grown in basic conditions (high pH) could potentially result in a decreased growth rate, as basic solutions can lead to soil salinization and reduced water and nutrient uptake by the roots. Hence we predict that cress seeds grown in a solution with a neutral pH of 7 would exhibit the most vigorous growth and development, as it is the optimal pH level for most plants, and will provide the necessary nutrients for the plants to thrive. Overall, the experiment aims to test how varying pH levels affect the growth and development of cress plants, and whether there is an optimal pH range for cress seed germination and growth.

IV. Methodology

Apparatus

- Cress seed
- Water
- Soil
- Plastic lid
- Pot
- Pipette
- Measuring cylinder
- pH probe
- pH buffers

Germination

1. Prepare the seed-starting soil mix (DCM vivimus, groenten & fruits ver).
2. Place the seeds in soil or a wet paper towel. (4mm deep in the soil, the soil must be moist but never wet or dry)
3. Cover the seedlings with a plastic bag or lid.
4. Place the seeds in a warm location near sunlight/light. (science lab near window)
5. Keep the potting mix/environment moist (distilled water).
6. Thin seedlings to encourage larger plants

Experiments

1. Place soil in the pot (around 70 cm^3 of soil)
2. Place cress seeds in before adding more soil over (4 ml)
3. Add 2 ml of water into the soil via a pipette
4. Add 2 ml of pH4 buffer to the soil via measuring cylinder/plastic pipette(s)
5. Measure growth every 24 hours and the pH of soil using a pH probe (to identify any fluctuations) and ruler
6. Repeat for the other pHs (up to 10, range of 7)

PH Buffer Solution

1. dripping an acid (or alkali) into an aqueous solution of salt while measuring the pH with a pH metre
2. making an aqueous solution of acid with the same concentration as the salt and mixing while measuring the pH with a pH metre.

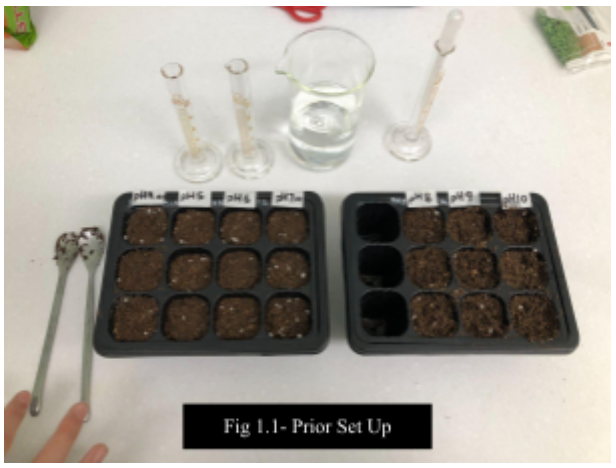


Fig 1.1- Prior Set Up

Fig 1.2- Final Set up

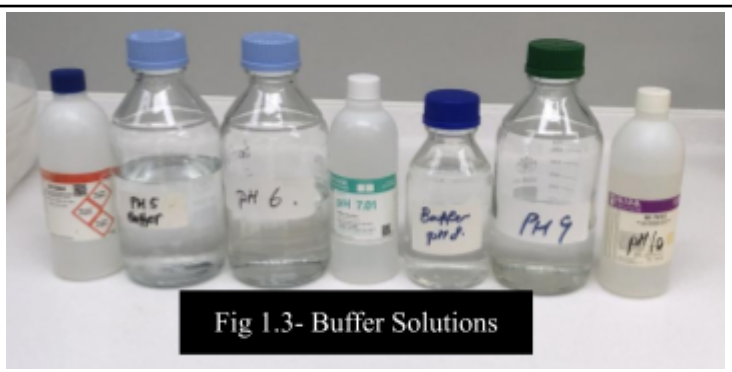


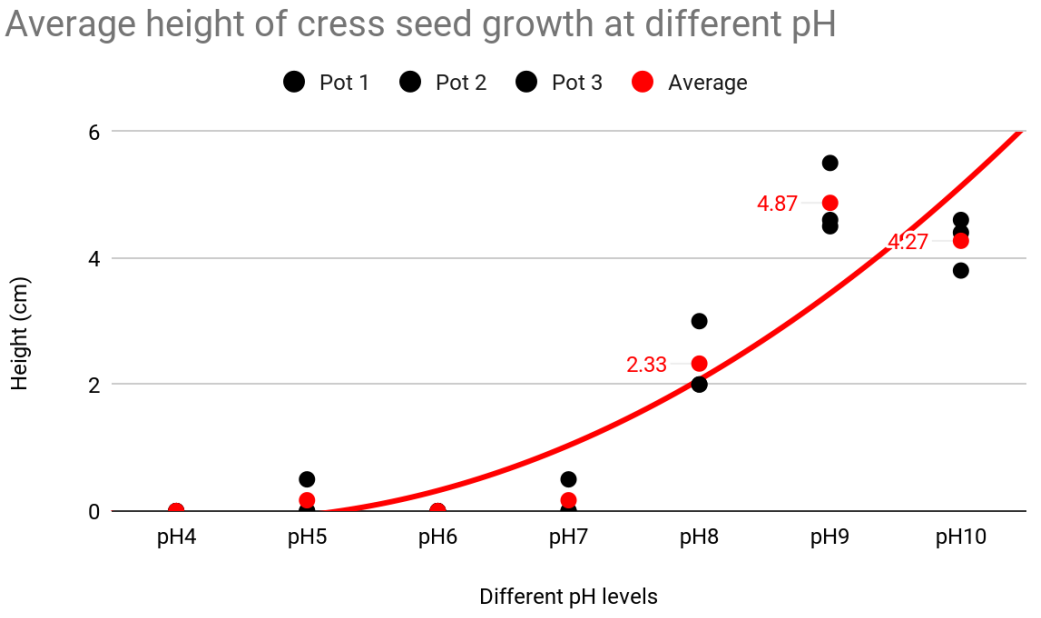
Fig 1.3- Buffer Solutions

V. Results

Data

The following results were achieved over a 14-day trial, adding the buffer and water every 3 days: (a growth of 0.00 cm signifies no seeds germinated/were under the soil)

pH	Pot 1 height (cm)	Pot 2 height (cm)	Pot 3 height (cm)	Average height (cm)
4	0.00	0.00	0.00	0.00
5	0.00	0.50	0.00	0.17
6	0.00	0.00	0.00	0.00
7	0.50	0.00	0.00	0.17
8	2.00	3.00	2.00	2.33
9	5.50	4.50	4.60	4.87
10	4.40	4.60	3.80	4.27



Explanation of Data

The height is taken from the highest stalk of the 3 germinated seeds per pot, with Pot 1 being the one nearest to the label and Pot 3 being the outermost plant pot. (Figure 1.1)

Data Analysis

The data obtained from our experiment is partially reliable, given the uncontrolled indoor conditions. The two-week average conditions in the room were a temperature of 20°C, 55% humidity, and an air pressure of 1023 mbar. If another were to use this exact set of conditions, the result would be extremely similar.

Our findings demonstrate a direct correlation between pH levels and seed growth. The data observed indicated plant wilting and yellowing at pH 5, no growth at pH 6, mold formation at pH 7, and limited growth at pH 9 and 10. Lower pH levels increase toxicity in plants due to the increased availability of aluminium and manganese, while essential nutrients, such as calcium, phosphorus, and magnesium, become less available to the plants. Lower pH levels also lead to enzyme denaturation, thus restricting growth.

Our experiment's limitations were due to time constraints and equipment unavailability, which include the inability to adjust the humidity for optimal seed growth and our inability to conduct parallel experiments. Human error and environmental changes may have influenced the abnormalities observed in the pH 6 and pH 9 data.

Our research's potential real-life application relates to agriculture and horticulture, precisely optimizing the soil pH level for optimal plant performance and improving germination rates. Farmers and growers could use our findings to increase crop yields, while individuals who grow plants at home can optimize their growth by following our recommendations.

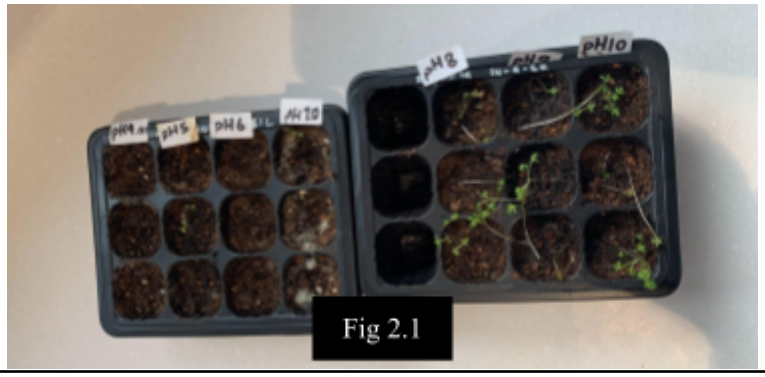


Fig 2.1

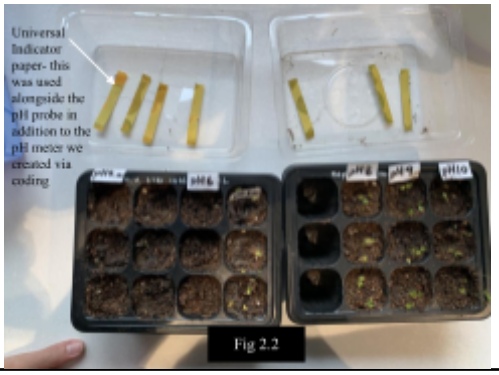


Fig 2.2

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pH Probe for Science Competition
[07:30:04] pH4.02
[07:30:37] pH4.97
[07:31:13] pH6.03
[07:31:46] pH7.05
[07:32:15] pH8.00
[07:32:52] pH9.03
[07:34:45] pH10.00
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Fig 2.3- Code pH Meter

Fig 2.4

If your team will compete for the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. ***(Word limit: 300 words)***

Our experiment centred on Sustainable Development Goals 2 and 15, which aim to eliminate food insecurity and promote sustainability for ecosystems, respectively. Given the rise in global population, there is an increased demand for food which necessitates resource optimization for maximum output of arable land and water. Plant growth is particularly environmentally advantageous when compared to livestock farming, as it is a more efficient use of resources and fits more easily into limited arable land. The United Nations Food and Agricultural Organization has reported that 77% of agricultural land is currently used to raise livestock, despite contributing only 18% of the world's calories. Consequently, our experiment focused on identifying the ideal pH for soil, as this can be easily modified using buffers, thus improving crop yield and efficiency. Understanding and adapting effective methods such as pH modification can contribute towards addressing the issue of food insecurity.

VI. Conclusion

The obtained results indicate that the cress seeds exhibit the highest growth rate in basic soil pH levels of 9 and 10, whereas the more acidic and neutral pH levels did not yield significant growth. These findings contrast with our initial hypothesis, which predicted the optimal growth of cress seeds in a solution with a neutral pH of 7, suggesting potential errors during the experimentation process or human error.

Overall, the stated objectives of the experiment were achieved, and we successfully investigated the effects of varying pH levels on the growth of cress seeds.