Radish Roulette

Which roll of the dice, gets served with spice

(Abstract)

Due to the conditions of Arizona's environment, optimizing the minimization of water waste while maximizing crop yield is essential for regional food security and local agriculture production. However with rules and regulations in place, there is a research gap which exists regarding the effect on which minerals and ph fluctuations could have on the development of plants. In this study, it investigated how various aqueous solutions would influence the growth,crop yield, and first sign of germination of cherry radish (Raphanus sativus).

To ensure the most high degree of experimental accuracy, the radishes were exposed to natural Arizona outdoor climate within a highly controlled environment. Each group of radishes were organized into experimental sectors with each group being given their own solution for the trial. With the creation of precise documentation for the initial germination that was noted for each group. And collected data on the several key attributes which were measured in this experiment. Including, leaf length, final root length, stem height, the hypocotyl diameter, and finally the total mass of each radish. Then averaged and compared to the other trails, creating a system of comparison. Creating the comparison in each category and finally each group will be summarized allowing to find the most effective method.

The results demonstrate the necessary call for action to reduce the waste of water in a desert and determine the most effective way to increase crop yield. By identifying the most effective combination of ph and TDS (Total dissolved solids/ minerals) in the water, determining the more efficient pathway for desert cultivation. Ultimately, This study and research can serve as a data driven outline for Arizonan agriculture to help preserve water reserves while successfully boosting overall crop yield.

The effect on growth of Rupanis sativus with aqueous multivariate dihydrogen monoxide homogenous solutions

- The independent variable is the type of water used for the watering the radish plants
- The dependent variable is the growth of the radish plants

● Table of content:

- **(Page 1)**

Abstract, Question, Variable

- **(Page 2-3)**

Background research

- **(page 4-5)**

Material list

- **(page 6-7)**

Experimental procedure/method

- **(page 7-8)**

Data Analysis and Discussion

- **(page 9)**

Conclusion

- **(page 10)**

Ideas of further research

- **(page 11)**

Acknowledgement

- **(Page 12)**

Work cited

Agriculture has been one of the key components for human society for thousands of years. It is what led to the growth of society of what it is today and is essential for human life. However, agriculture requires the most important natural resource our planet has: water. Water is necessary for every single living creature on the planet, including the foods that we grow and eat. However, as the population grows across the planet and water usage increases, the availability of clean water is becoming more scarce across the globe. This causes some countries to have to resort to the usage of recycled or dirty water for the growth of agriculture. But what is the effect of this on the plants being grown? Does this stunt growth? Does this

increase maturing time? Do different solutions of water drastically change the growth of plants? These questions are essential and need to be answered as agricultural products are what feed the entire human population. We believe that differing water solutions and water quality will affect plant growth drastically and that different solutions may have differing effects on a variety of plants.

There are many different factors at play that can affect a water solution, many factors determine if water is ‘dirty’. Factors such as a water's pH level, the amount of domestic sewage water, and how the water is treated can all affect a water solution. These different solutions can affect certain plants' growth differently, such as the Helianthus Annus L. sunflower, which at different solutions and dilutions of water did have ranging mean growth. While some results were miniscule and could have been a normal range of plant growth, these results could show that certain dilutions of water can help a plant grow. Values such as a plant's leaf area or stem width saw averages of 10-30% differences between different dilutions and solutions of water.

Another quality of the water can also be affected by TDS (total dissolved solids). TDS applies to most of the water contaminants that would affect water quality, with dissolvents like chlorine and calcium in the parts per million. (Gizaw Ebissa, Urban Agriculture in Addis Ethiopia. 2024) Explains the effect of Tds of plant growth and or contaminants, with the water being mild in studies. However the full metals and chlorines to clean the city water are vastly different from the water used in the study. With the water in the study being dirty water but clean water, the opposite would be said about the TDS of the water of Tucson. In this study we believe that the fully contaminated water would affect how quickly the plants would grow; with the chlorine, organic salts, minerals, and some organic matter would affect the plants health. With Tucson water being about 400 parts per million, which is not good by any means. This is mandated by the city's government but this number is very high, with humans drinking water with a TDS of 50 or under. So if the water is not good for humans, it can’t be good for the plants.

The cleanliness and quality of the water used in agriculture is essential. The real-world societal impact of knowing how clean water must be for maximum growth is essential for the entirety of human society. Ensuring that the best water is used for specific crops can cut down on water waste and serve as a gateway to water treatment. Not only this, but the maximum growth of plants can allow for more food to be grown and assist certain regions in dire need of both water and food.

AI can also help us identify bad water levels for our plants. AI hydroponic systems are computer systems that can control and notice a lot about the plants farmers take care of. These abilities include self watering to specific plants, These systems are automatic so that the

farmers don't even have to turn them on. Although you do need to do maintenance on them, its way better compared to the previous workload. These Ai systems are also significantly better than humans because they can give exact amounts of nutrients to a plant. The Ai systems in these machines also can take care of numerous plants.

The cleanliness and quality of the water used in agriculture is essential. The real-world societal impact of knowing how clean water must be for maximum growth is essential for the entirety of human society. Ensuring that the best water is used for specific crops can cut down on water waste and serve as a gateway to water treatment. Not only this, but the maximum growth of plants can allow for more food to be grown and assist certain regions in dire need of both water and food

Material List and Explanation:

- Radish seeds

(cherry belle) Chosen to be the plant used in this experiment, each seed will be weighted to be the exact same.

- Growing containers, a small trough per radish

Used to house the radish seeds throughout the trials.

- Potting soil

Potting mix (miracle gro). Used as the medium between the soil and the liquid solutions.

- Distilled water

Reverse osmosis, zero water. Use as the base for the solutions used in this experiment.

- Also used as the 0 TDS water, Zero TDS water.

- Tap water, Tucson’s city tap water

Used as the control for the experiment.

- White vinegar

Used as the acid to create the Low Ph solution, when mixed with distilled water.

- Baking soda

Used as the base to create the High Ph solution, when mixed with distilled water.

- Table salt

Used as the medium to create the High TDS solution, when mixed with the distilled water

- Ph meter and ph testing strips

Hydrion pH strips. To test the pH level of liquid solutions used.

- Tds meter

HoneForest - white TDS meter. To test the total dissolved solids in the liquid solutions.

- A ruler

Stander college rule. To measure up to 12 inches of a plant's growth.

- Markers and pens/ labels

Full set of sharpies. Used to mark the ruler and to take notes.

- A trowel

To dig up plants after the growth phase of the trials are complete and to set up soil.

- Spray Bottles 1.5L

Used to apply the varying waters to the radish groups.

- Scale

A standard scale used to measure the final weight of the radish at the end of the growing period.

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Procedure:

- **Setting up each trial**

1) Each radish seed was weighted, until 6 radish seeds were the same starting mass.
2) Then each radish was placed into a trough, then was covered by the soil until all troughs were equally covered.
3) 60mL of each radish's unique solution was then measured and sprayed onto each radish.
4) The growing period took place during a 6 to 8 week phase.
5) Step 3 was repeated each week 3 times, to have a total of 180mL per week per radish unique solution.
6) Each radish once a week had its stem height, length of leaf, weight, stem width, measured and recorded (how calculations were made are listed in detail in the Data Collection section).
7) Repeat steps 3,4,5 and 6 until the 6-8 week growing phase was completed.
8) After the growing phase of the radishes was completed, the radishes were dug up from the soil and were cleaned off. The weight and the root length of each radish was measured and recorded (how calculations were made are listed in detail in the Data Collection section).

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Preparation of Water Sources

- **Control Group:**

1) 1.5L of tap water with no added additives was obtained by the sink and was poured into a container.
2) The pH and TDS levels of the tap water were tested and noted. The target for the tap water's pH was 7 (dark green on the pH strip).
3) The tap water TDS was noted and recorded as 450 ppm (average ppm of tap water in Tucson) using a TDS meter.
4) After the TDS and pH were measured, the control group was then poured into a newly cleaned container to prevent contamination.

- **Acid Solution (pH):**

1) 150mL of water was added into a container and the pH level was tested to be 7/dark green using a pH strip.
2) 1.3L of a 5% white vinegar was poured into the container, the pH level was tested to be 2/dark orange using a pH strip.
3) The solution was stirred until fully mixed.
4) Water or vinegar may have been added to adjust for the concentration of the solution to create the ideal pH tested level of 4/ yellow on a pH strip.
5) The strip was measured and recorded to be a yellow, more vinegar may have been added if necessary to create the result.

- **Base Solution(ph):**

1) 1.5L of pure distilled water was added to a container.
2) 110mL of the bar soap Irish Springs which had a pH level of 10 was shredded into 11mL pieces.
3) 11mL of the bar soap was added into the distilled water.
4) The soap was slowly stirred into the 1.5L of distilled water, until fully dissolved.
5) The solution's pH level was measured using a pH strip to see if the desired pH level of 9 was obtained.
6) Steps 3,4 and 5 were repeated until the desired target pH level of 9 was reached.

- **TDS Meter Usage: Necessary for 0(ppm) and 1000+(ppm) solution**

1) The TDS Meter was turned on and leveled to zero.

2) The meter was submerged half way into the glass.

3) The meter stayed submerged for 30-50 seconds until a read became visible.

4) After each trail, the TDs meter was wiped clean to be reused.

- **0 parts per million(ppm) TDS Solution:**

1) 1.5L of distilled water was poured into a container.
2) The water's TDS was tested using the TDS meter to see if the desired TDS was achieved. If the water had a TDS of above 0, then the water was poured through a double reverse osmosis pressure system to reduce the parts per million to zero.
3) The waters parts per million was tested using a TDS meter and noted.
4) Step 2 and 3 were repeated until the water reached the desired TDS of zero.

- **1000+ parts per million (ppm) TDS Solution:**

1) 1.5L of water was poured into a container.
2) 3 grams of salt was added to the water to raise the water's total TDS level.
3) The solution was stirred and mixed until the salt was completely dissolved.
4) The solution's TDS was then measured using a TDS meter and noted.
5) Steps 2, 3, and 4 were repeated until the solution reached the desired TDS of 1000+ ppm.

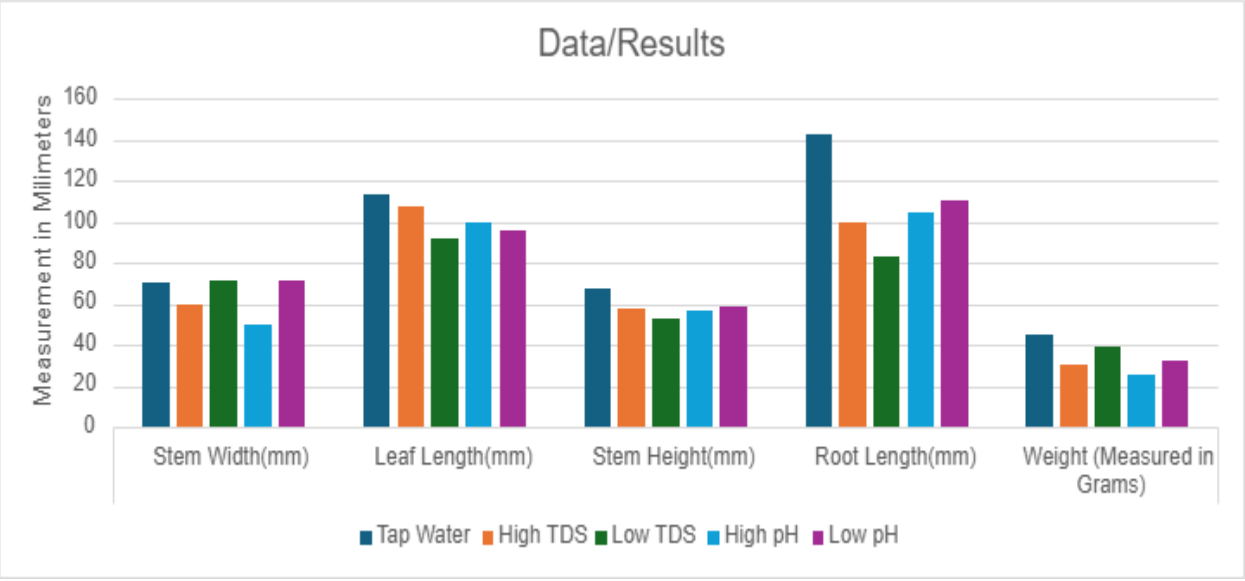
- **Experimental Setup:**
    1) 6 containers were prepared for each radish group to be grown in.
    2) Each container was clearly labeled to differentiate which water solution the container was receiving (on the labels ex. Group 1: 1000+ ppm TDS Solution).
    3) Soil was prepped in each container. Each container received the same amount of soil and the same quality of soil.
    4) One radish seed was planted for every container at the same depth to ensure the same quality.
    5) All containers were placed in the same location to ensure equal exposure to light and a consistent temperature.

- Watering and Maintenance:
    1) Each container was watered with a specific, measured amount (60mL) of its assigned water source at regular intervals (3 times a week). A consistent watering schedule and amount was ensured.
    2) 60mL of each water solution was applied to the waters assigned group at each interval (making a total of 180mL per week).

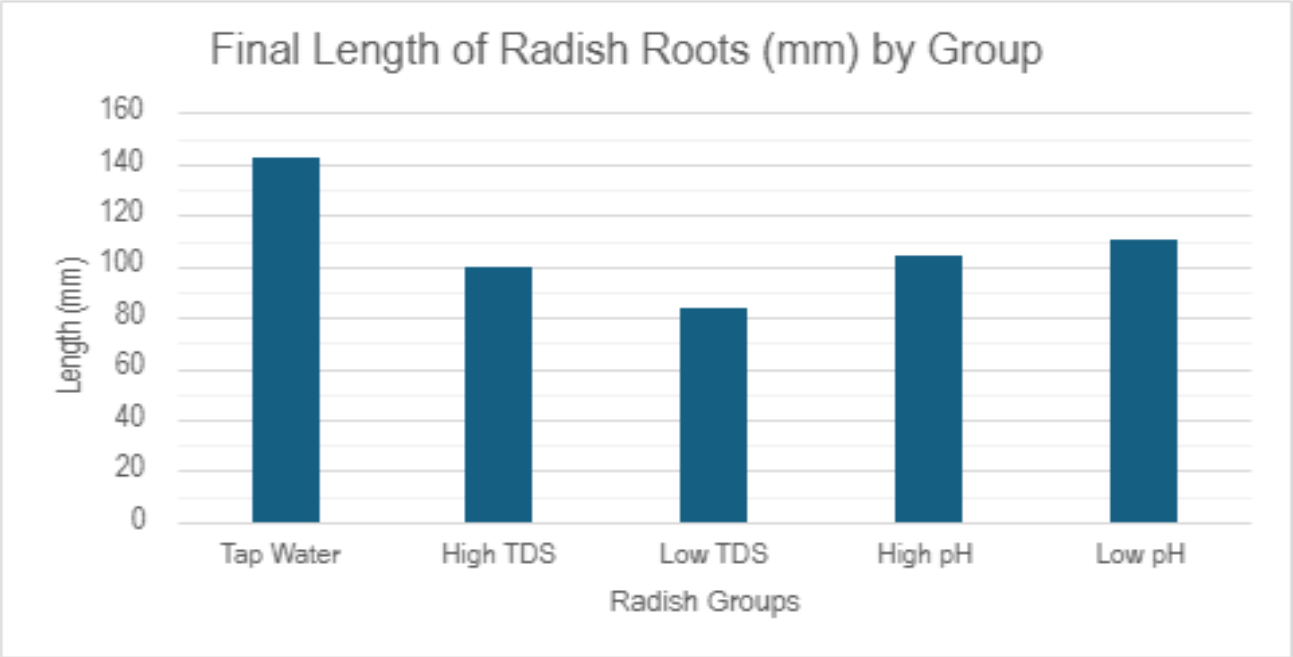
Data Analysis and Discussion

The differing water solutions had varying results on the growth of radishes across all groups. The data showed that the tap water solution had the best growth results for its radish group. In categories such as the final average root length of each radish group, tap water was found to have a71% higher stem length than that of the Low TDS group. This trend held true through most of the measured categories, with tap water having 30% higher germination rate then that of the worst (being the High pH solution), a 23% longer largest leaf length then the lowest (being Low TDS solution), and a 77% larger mass than the lowest group(being High pH).

The tap water trend of performing the best in all measured categories does not hold true in the stem width. The group with the largest average stem width was Low TDS, followed by Low pH and then tap water. However, this does not take away from the general idea that tap water may be the best solution in the overall growth of the radishes. Graph



Graph



This shows the length of the root of the radish. Showing the necessary cause for the length to grow for better consumption of the solutions and nutrients deeper down in the soil, being an evolutionary cause. With the tap water group having the longest roots, which was to be expected. However the Low ph was not too far behind in the average. Most likely due to the cause of trying to find better soil better away from the solution used to water, to explain the trend shown.

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In conclusion the thesis of the original thoughts, have been proven wrong. We have the common belief that low TDS would be the most effective, due to the lack of minerals and nothingness inside the Water with a TDS of 0. However on the contrary It was proven in the data that the tap was the most effective due to that very concept. With the mixed bag of tap water, Tucson's tap water has a TDS of around 400+, being safe for consumption and allowing enough minerals in the water for optimal plant growth. The evidence states the fact that the tap water

was just superior in all trails. With a 70% germination rate compared to the 60& of the low TDS water. And then along with other factors like total weight and size when compared to one another. With the Tap water holding over both in both categories, disproving the thesis but allowing for the consistent evolution of agriculture.

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Ideals for further research have many and numerous potential options, especially with the whole field of agriculture being on the table for further research. However the use of agricultural simulations have potential to create this very same project on a much larger scale of production. Urban and industrial run off simulations could be a great example of this very idea, with testable favors of microplastics, heavy metals, and water runoff in Urban and industrial settings on the effect of radish or other vegetables. Another possible field of research could be the effect of the water solutions behaviors when tested for its effects on other plants. Like testing the concentrations of the organic solutions which best could boost the nutrients absorption of the soil.

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Just want to say Thank You to anyone who had to put into and effort into this project. I know better than anyone that large projects are never easy. They take a lot of time, effort, stress and money for the people who have to complete them. So thank you crew, for going on this journey with me. And thank anyone else who has read this.

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