Internal Assessment
IB Biology
Wednesday, April 4 2018

IA Exploration

1. **Title:**

The Increasing Levels of Varying Concentrations of Potassium Chloride (0.00, 2.00, 4.00, 6.00, 8.00 mM) and how they affect the plant growth (height(inches) and biomass(grams)) of Phaseolus vulgaris in a controlled Hydroponic System.

2. **Introduction**

This experiment involves Potassium Chloride and how the growth of bean plants (Phaseolus vulgaris) is affected by it. In order to test the effects of Potassium Chloride on the plants, the experiment will contain increasing concentrations of the KCl compound, and the results will show changes in height and biomass (weight) between the plants of varying increasing concentrations. Then, the findings of this experiment will enable the access to make inferences between some kind of correlation (negative or positive) between the increasing intervals and the growth of the bean plants. The research question that will be applied and covered during the experiment is: To what extent does the amount of fertilizer added and applied in the hydroponic system affect the growth of bean seeds? According to Crop Nutrition, website verified by Mosaic Crops (leaders in crop nutrition) "Potassium Chloride, also known as KCl, is one of the most common fertilizers used for plants to overcome plants deficiencies." (Crop Nutrition, 2) This means that Potassium is one of the best nutrient supplements that could have been chosen to feed to these plants. The reason to this as Crop Nutrition also states, "Most K minerals are harvested from ancient marine deposits deep beneath the Earth's surface. They are then transported to a processing facility where the ore is crushed and the K salts are separated from the sodium salts." (Crop Nutrition , 3) I chose to test the crystalline salts of Potassium chloride due to their inexpensive state, elements in the compound and the accessibility of it. Also according to Crop Nutrition, "Potassium Chloride is 50 to 52 percent K and 45 to 47 percent Cl-." (Crop Nutrition , 3) This means that it has the perfect two components needed to apply nutrition to the plant and kill the bacteria, fungi and other pollutants in the water, both a very equal percentages to balance out their action. As mentioned before, Potassium is a very essential element needed for plant growth due to its unique role in stimulating enzymes and patching up plant deficiencies. Like the University of Minnesota states, " In plant growth, Potassium is involved with enzyme activation within the plant which affects protein, starch and adenosine triphosphate (ATP) production, regulating the rate of photosynthesis. If K is deficient or not supplied in adequate amounts, growth is stunted and yield is reduced. For perennial crops such as alfalfa, potassium has been shown to play a role in stand persistence through the winter. Other roles of K include; Increased root growth and improves drought resistance, Maintains turgor; reduces water loss and wilting." (University of Minnesota, 5) However, in an experiment that was conducted by NCBI to also test Potassium Chloride potence and effects as a fertilizer, results stated that, "A supply of surplus KCl resulted in a higher concentration of foliar potassium and negatively correlated with the biomass." (NCBI) Thus, calculations for the Potassium Chloride concentrations need to be calculated precisely.

As mentioned before, this experiment will take place in a hydroponic system. As Full Bloom, A certified website for plant growth in Hydroponic System states, "Hydroponics is a method of growing plants in a water based, nutrient rich solution. The basic premise behind hydroponics is to allow the plants roots to come in direct contact with the nutrient solution, while also having access to oxygen, which is essential for proper growth." (Fullbloom.com) Hydroponic systems are best suited in this case rather than regular soil planting because I will be testing the effects of only the nutrient Potassium as a fertilizer in soils have many different nutrients and minerals in them, which would affect my results and no exact correlation between plant growth and Potassium would be seen. The Chloride will help kill the bacteria, due to the Chlorine element. Most compounds have the downfall that there are two nutrients in the compound but in Potassium Chloride this is not the case because the Chlorine will not affect the results of the Potassium which makes this compound even more suitable for testing. NCBI also states, "It must also be taken into account that with the proper setup, your plants will mature up to 25% faster and produce up to 30% more than the same plants grown in soil. Your plants will grow bigger and faster because they will not have to work as hard to obtain nutrients." (NCBI) Due to this, the plants will only have contact with the potassium directly, making the results and correlation even more accurate.

This experiment will test vayring increasing levels of Potassium Chloride (0.00, 2.00, 4.00, 6.00, 8.00 mM). Therefore, we still do not know the results of these varying concentrations and until the data has been received and analyzed we shall know if there is a negative or positive correlation between the Potassium Chloride and Plant Growth.
correlation between the increasing levels of the temperature, light, or oxygen because I will not be changing those variables, I shall be keeping them at a constant.
This further shows the importance of Hydroponic systems and the nutrition values of Potassium in crops and the importance of crops to the world. With the results of this experiment, farmers will be benefited because they will be able to change their cropping system to a much cleaner and more productive manner, by using the hydroponic system and elements such a Potassium on their crops. The system used in this experiment could be further applied in the real-world by many and testing new variables and controls. Crops are one of the main key components in human life and have the most energy due to the energy pyramid. Plants are the first to receive energy from the sun in the process that is known as Photosynthesis. Subsequently, they are the best source of nutrients and energy and shout pesticides and failing growth, Potassium Chloride will come into action and restore the plants and crops necessary, while keeping them in a healthy and normal state. Later on, in this experiment, we will be putting Potassium Chloride to the test, and resolving the intriguing mystery that is plant growth and nutrition.

3. **Hypothesis**

Throughout the experiment, I will be measuring increasing levels of Potassium Chloride (KCl) and identify the type of correlation with the plant growth in a hydroponic system. I predict that, during this experiment, as the levels of Potassium Chloride (KCL) increase in intervals of (0.00, 2.00, 4.00, 6.00, 8.00 mM), the amount taken in by the bean plants (Phaseolus Vulgaris) will also increase, and the more Potassium Chloride, the greater the height of the bean plants after the two weeks of the estimated time that it will take the plants to grow and to collect data and analyze it, having a constant growth rate. Also, the more the bean plants grow with the increasing intervals, the greater biomass they will have after the set time (two weeks). The capacity of Potassium Chloride as a fertilizer for the beans plants will be added in grams to each of the different plastic buckets(five total), that contain the five small bean plants equally dispersed and at the same height on the top of each plastic container filled with up to 16 L of water. The concentration levels of Potassium Chloride are what I will be specifically changing on purpose to fight out the effectiveness of Potassium Chloride as a fertilizer in a hydroponic system. The growth of the plants will be measured, as briefly mentioned before, by measuring the height of the plant (inches) after 14 days,which is the estimated amount of time that it takes bean plants to grow to their mature height. The weight of each bean plant will also be measured at the end of the experiment and show the result of growth in weight as the Potassium Chloride levels increased. The weight will be measured using a scale and finding out the biomass. Which is a way of finding out that not only did the Potassium help the plant become longer, but stronger and helped it mature, which is essential for a nutrient in crop-farming. The expected change to come out in the graphs and data analysis is a constant positive correlation between both the independent and dependent variables. Therefore in this experiment the effectiveness of Potassium Chloride as a fertilizer for bean plants will be tested. Which lead to the question o what extent does the amount of fertilizer added and applied in the hydroponic system affect the growth of bean seeds?

Variables

Variables	***What they are***	***Measurements (units)***	***Concentrations (levels)***	***Additional Information***
Dependent	Height of Plant	Inches (inch)	----- (Will be the results of the experiment)	Different height for each of the five trials will vary due to the increasing levels of Potassium Chloride, this will be one of the two results that are expected from the change in independent variable. The height of the plant must change in order to be able to accept or reject the hypothesis, thus making it the dependent variable.
Dependent	Weight of Plant	Grams (g)	----- (Will be the results of the experiment)	Different weights of the plants are expected out the varying increasing levels of potassium Chloride concentrations, due to increase in growth of each plant. The weight of the plant must change in order to be able to accept or reject the hypothesis, thus making it the dependent variable.
Independent	Potassium Chloride	Millimolar (mM)	0.00, 2.00, 4.00, 6.00, 8.00	The increasing levels of Potassium Chloride will be added to the bean plants in 5 different Trials of increasing levels of concentration each. This is the independent variable because I will be changing this factor on purpose to find the dependent variables, which will give me the final data results.
Controlled	Water Type	Drinkable Purified Water Agua Azul (L)	----- (Does not have any certain concentrations or difference in levels, controlled)	Each of the containers will have the same water type that will be clean from bacteria and other nutrients that could affect the results of the data. Water will all be bought by same source of production factory.
Controlled	Environment Temperature	Degrees Celsius (‘C)	20 to 25	The same temperature shall be dispersed in the entire room where the experiment will be taking place to avoid factors like high or low temperatures to affect the growth of the plant, this way, only the concentrations are the independent variable affecting the results of the experiment.
Controlled	Light Source	Watts (W)	Same light intensity all around the room for equal light being received by each of the bean plants (15 watts in each light bulb of the room)	Each of the plants will receive the same amount of light in order for the light intensity to be controlled and to not affect the results of the experiment, due to an increase or decrease in their natural process of photosynthesis.

Controlled	Type of Seed	----- (Does not have any certain concentrations or difference in types, controlled)	Same type of seed and number in all of the five trials in each of the five containers (Phaseolus vulgaris)	Each of the containers will have the same type of seeds in order for the type of plant being grown to not affect the final results of the experiment and to actually see the effects of the different concentration levels of Potassium Chloride.
Controlled	Amount of Water	Liters (L)	16	Each of the containers will have the same amount of water in order for the amount of water in each to not affect their growth and the final results of the experiment.
Controlled	Amount of Oxygen	----- (Does not have any certain concentrations or difference in levels, controlled)	Tubing and Air system is already calculated to set off equal amount of oxygen per container.	Each of the containers will be receiving the same amount of oxygen in order for the amount of oxygen being displaced to not affect their growth and the final results of the experiment.

5. **Materials**

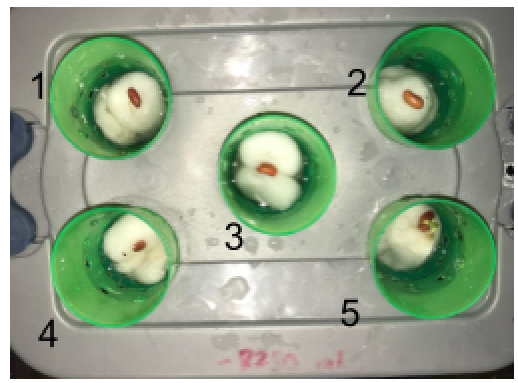
The materials needed to follow this experiment are:

- ***Phaseolus Vulgaris seeds:***
  - You will need 25 bean plant seeds firstly to add one into each of the 25 cottons damped in water and later add one to each of the cups in each of the five containers.
- ***Cotton Balls:***
  - You will need to buy 2 packets of cotton balls(medium size) or one big packet (large size) firstly to grab a very small amount of it and damp with water (medium temperature constant each) and start the growth of the bean plant (no additional variables for growth only added water to cotton). (***more in procedure.***) This will be done to avoid the seed getting to damp by adding it directly to the plastic containers. And cotton will also be used to add inside of each of the 25 cups with the holes in order to restrict the movement of the roots of the plant, and for the cotton to trap the Potassium in an area near each plant for the plant to take up the substance more easily.
- ***Iron Wire:***
  - Will need to get 6 ft of wire to regulate movement in some parts of my system (***more in procedure***) and also to hold up the bean seeds in the cups held by the plastic containers to avoid full and exaggerated contact with water.
- ***Potassium Chloride:***
  - In chemical form (crystalline powder) buy 2 jars of 500g. In order for it to dissolve into the water inside of each container (0.00, 2.00, 4.00, 6.00, 8.00 mM). Therefore, one cup will have 0, another 2, (***mM to grams more in procedure.***) and so on. These levels are measured by calculating the millimoles to grams and then displaced in each of the containers accordingly. (1.00 mM = 1.1928 g). The potassium will act as a fertilizer on the bean plants and give in nutrients for it to grow, the Chlorine will kill all bacteria in water, to maintain a safe environment for the plants. And the Oxygen will serve to benefit the plants with more oxygen for cell respiration.
- ***Plastic Storage Container***
  - You will be needing five of these, the same size, same carrying capacity (16 L), will be filled up with water and labeled according to the level of Potassium Chloride concentration that they will have. Will be located equally dispersed in the room.
- ***Plastic Storage Container Cover***
  - Five covers for one to each container (fit accordingly to top of container). Each cover will be placed on top to cover the water and will have 5 holes in them to make the five trials of levels of fertilizer of the seeds instantly in the two set weeks of time. Holes will be same size and dispersed equally in the cover.
- ***Whisper® Aquarium Air Pumps***
  - These pumps will be set up (**more in procedure**) and used to provide oxygen for the bean plants. There are two types of tubes in the system, those that get the energy, and those that take the oxygen to the plants which act like an aquarium. System only needs electricity to function.
- ***Outlet***
  - One long outlet (12 ft) will be needed to connect all electrical system for hydroponic system since the system will be dispersed in the room.
- ***Rubber Air Stone for Aquarium Tanks***
  - Air pump will disperse air into each tank equally. Oxygen will be received by the plants and converted to carbon dioxide during cellular respiration. (**more in procedure**) The oxygen is need for them to stay alive, thus the hydroponic system.
- ***Plastic Cups (Net Pots)***
  - Buy 25 cups total, they will be used as pots to place in the seeds with the wire and the cottom will be used as a barrier placed in the hole that were made in the cups) (must be hard plastic, not bendable easily.
- ***Airline Tubing***

- Standard size 3/16 inch diameter tubing comes in 2 sizes, 8 feet and 25 feet. I bought 5 of the 8 ft for the hydroponic system to put one end inside of the containers and the other connecter to the oxygen tubes , for the plants to receive oxygen

- ***Constant Source of Light***
  - You will need to get a source of light that disperses equally throughout all of the plants, to avoid a different variable affecting the results. I will choose a room without any windows to avoid another light source with 4 direct light bulbs on ceiling that are equally placed in the four corners of the room, points where the plants will be placed. (15 watts = 1 light bulb)
- ***Beaker:***
  - You will need the beaker (1000 mL) to measure the water as you add 16L of it to the plastic containers. 16 L will be 16 of the beakers filled up to 1000 mL and added to the containers. This will make your results more reliable and help to make the water a controlled variable.
- ***Water:***
  - Will be added at the beginning of the experiment to the plastic containers (16 L each), and will not be replaced or moved during the time of the experiment to make it a controlled variable and avoid errors or an outside variable affecting the results of the bean plant growth. The water's temperature will also remain the same by keeping the room in which the containers will be placed at a constant temperature throughout the entire two weeks of the experiment.

6. **Diagram of Set-Up**

Before the Experiment	*Before The Experiment*	*During The Experiment*
		
In this image you can observe the three main materials that are involved in the first stage of the experiment which includes the plastic cups, cotton and P. vulgaris seeds.	In this image, the P. vulgaris is being placed under the sun and will be added clean water every two days. This is not yet the experiment but is considered a preparation for the seeds to begin growing and later be planted into the hydroponic system.	In this image, the organization of the plants, being the same in each of the five containers with the five different concentrations, was the same.
During the Experiment	During the Experiment	After the Experiment

		
In this image the purpose is to show the growth of the P. vulgaris. These are the plants after 1 week and 1 day, under the concentration of 4.00 mM.	*In this image, the placement of the hydroponic system can be seen and how the oxygen tubes were set to point straight in the middle of the containers in order to reach all of the plants. The placement of the P. vulgaris can also be seen, they are not entirely submerged in the water to avoid the plant drawing with excess water.*	*In this image, the dry P. vulgaris can be seen, rady to measured. I chose to add on o the five plants of each of the five containers to demonstrate the growth of the plants.*

7. **Procedure/Methodology**

Before Experiment:

1. First, I will find a room in my house where the only source of light is coming from the roof lights, close the curtains to avoid contact with the sun.
2. I will establish the room temperature at 68-72, but since bean seeds grow under 60 degrees under soil then I will decrease the average degrees to 64, since it is the between of both temperatures.
3. Then, I will buy 5 plastic storage containers from the same size (with a lid cover), along with 25 hard plastic cups.
4. According, I will buy the Air pumps for the hydroponic system online and they will be shipped to me in a week. (Buy a month before the experiment to ensure that when you build and start every piece is there and no parts are damaged.)
5. Then, I will look at the instructions of the box in which they come in on how to set up the tubes and set them up accordingly.d ff
6. I will leave the lights in the room on for an entire day before to see if they are working correctly (no flickering or power outages) and each of the lightbulbs is as the same intensity and light color. ***(more in materials and variables)***
7. I will buy 2 jars of potassium Chloride
8. When the tubes are set up, I will then apply the water and wait and entire day for the oxygen to sink into the water just like they recommend in pet shops before added an organisms to a aquarium.
    a. Safety: When handling and setting up the tubes, handle with care to not break or damage any of the objects. Also when connecting the oxygen generator, be careful to not have any water from the tanks in your hands.
9. To prepare for the incoming of the seeds the iron wire need to be tied at the top of the plastic cups which are the net rods and cotton needs to be added as a sort of cushion for the tiny seed that is going to be held up there.
    a. Safety: Handle the iron wire with caution, the ends are pointy and may scratch skin if in contact.
10. Now, you are ready to start the experiment.

During the Experiment:

11. Then, I will buy the seeds of rea bean plants (Phaseolus vulgaris).
12. For a day I will damp the cotton in water and separate the cotton into 25 pieces placing one seed in each.

13. After I see a reaction that signals that the seed is growing, then I will transfer the seeds into their respective place in the net pots (cups with holes) and position them inside of each of the cups in the bed made of cotton.
14. I will add each amount of Potassium Concentration accordingly to the amount each plastic container needs.
    a. Safety: Handle the Potassium Chloride with caution and do not ingest, if possible, wear plastic hand gloves
15. Since bean plants grow fast I will be taking data every day morning at 5:30 am and every evening at 5:30pm.
16. Since there are 5 plants growing for each of the five containers which is one trials then five trials are already being made, this leads to faster results.
17. Each day for 14 days go at morning and at night to check up on the plants. (Check for bugs, fungus, how they are growing, etc)

After the Experiment:

18. Before collecting data I shall take out the plants from their tiny cuts, delicately untangle the from the cotton and let them dry for exactly 48 hours in order to get rid of water weight.
19. Then, as the plants grow I will gather both qualitative and quantitative information and data.
    a. For quantitative data of the height, I shall delicately cut off the roots of the plant because they are evidently not part of the height, and then measure all of the plants in centimeters with a ruler.
        i. This data will be noted down in my raw data tables and later be interpreted for standard deviation and means.
    b. For the quantitative data of the weight I shall take each and every plant and weigh it in a small grams scale.
        i. This data will be noted down in my raw data tables and later be interpreted for standard deviation and means.
20. Later when the plants have grown and the data collection month is over I will finish my results, analyze, interpret them, accept or reject my hypothesis with my observations and final results and finish my IA.
21. Lastly, I shall take an ANOVA test to verify my data in a systematic and precise manner.

8. **Raw Data** ***(Qualitative and Quantitative)***

Raw Data Tables:

Table 1; Raw Data of the final height(mm) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System

Increasing Concentration Levels of Potassium Chloride (mM)	First Trial (±0.5 mm)	Second Trial (±0.5 mm)	Third Trial (mm)	Fourth Trial (±0.5mm)	Fifth Trial (±0.5 mm)
0	40	37	38	40	39
2	60	60	60	60	60
4	100	100	99	100	99
6	144	146	145	144	144
8	205	204	205	205	204

Note: For each of the trial, the heights in millimeters have the uncertainties of ±0.5.

Qualitative Observations: It was observed that as the concentration of Potassium Chloride increased in the five main levels (0.00, 2.00, 4.00, 6.00, 8.00(mM)), the P. Vulgaris' stem would become stronger and longer, this is due to the potassium giving it turgid characteristics and keeping it healthy and firm.

Table 2; Raw Data of the final dry Weight(g) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System.

Increasing Concentration Levels of Potassium Chloride (mM)	First Trial (±0.01 g)	Second Trial (±0.01 g)	Third Trial (±0.01 g)	Fourth Trial (±0.01g)	Fifth Trial (±0.01 g)
0	0.2	0.1	0.2	0.1	0.1
2	0.4	0.3	0.3	0.3	0.3
4	0.7	0.5	0.5	0.6	0.6
6	0.9	0.8	0.8	0.7	0.9
8	1.3	1.0	1.0	1.2	1.3

Note: For each of the trial, the weight in grams has the uncertainties of ±0.01.
(Each Trial represents the number of the plant labeled the respective number in each of the five containers)
EX: Trial 1 represents plant 1 for each of the five containers)

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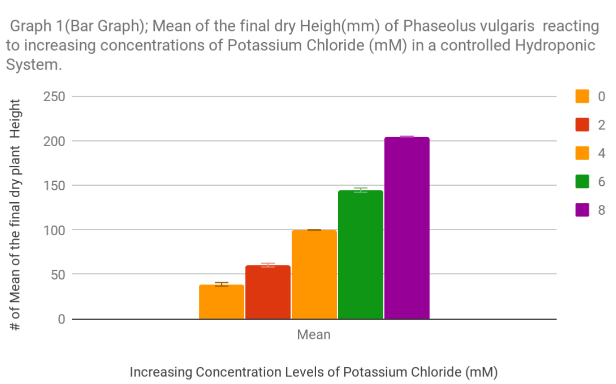
Table 3; *Raw Data of the Mean and Standard Deviation of the final dry height of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System*

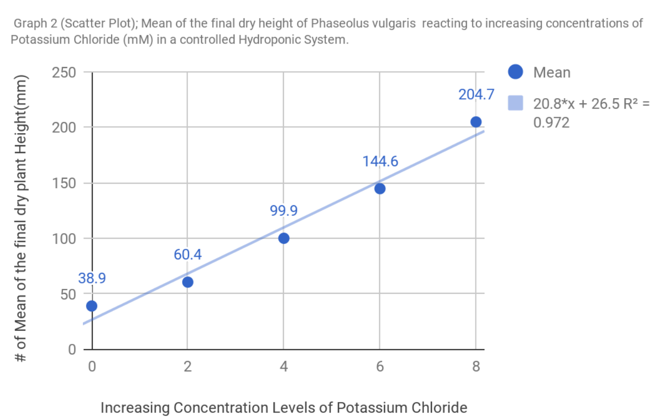
Increasing Concentration Levels of Potassium Chloride (mM)	Mean	Standard Deviation
0	38.9	1.1
2	60.4	0.2
4	99.9	0.1
6	144.6	0.2

Qualitative Observations: *As can be observed, in the first Potassium chloride concentration that has 0.00 mM of the compound, the standard deviation is approximately 1.14 and therefore greater than 1, meaning it has a high standard deviation and has a big error bar. This means that the results of the height of the P. vulgaris varied a lot, this is due to the plants having no concentration of the Potassium Chloride fertilizer, and therefore there growth being random and natural.*

Table 4; *Raw Data of the Mean and Standard Deviation of the final dry Weight of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System.*

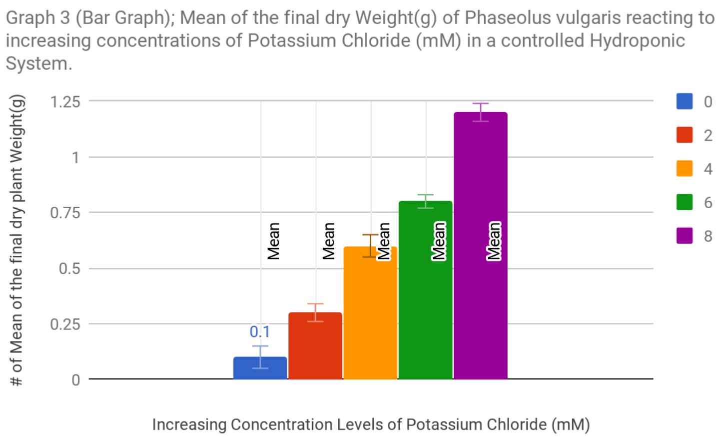
Increasing Concentration Levels of Potassium Chloride (mM)	Mean	Standard Deviation
0	0.1	0.1
2	0.3	0.0
4	0.6	0.1
6	0.8	0.1
8	1.2	0.2

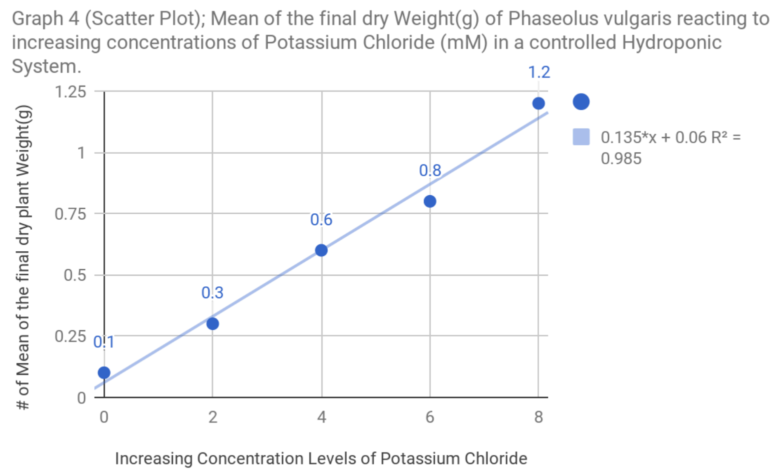




Graph 1; Is a Bar Graph that shows the Mean of the final dry height of the Phaseolus vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System

Graph 2;Is a Scatter Plot that shows the Mean of the final dry height of the Phaseolus vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System





Graph 3; It is a Bar Graph that consists of the Mean of the final dry Weight(g) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 (mM)) in a controlled Hydroponic System.

Graph 4; It is a Scatter Plot that consists of the Mean of the final dry Weight(g) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 (mM)) in a controlled Hydroponic System.

ANOVA: Results

The results of a ANOVA statistical test performed at 14:14 on 7-MAR-2018

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
between	8.9058E+04	4	2.2265E+04	6.4200E+04
error	6.936	20	0.3468	
total	8.9065E+04	24		

The probability of this result, assuming the null hypothesis, is 0.000

DRY P. VULGARIS HEIGHT (WITHOUT ROOTS)

Critical value is 2.87
Degree of Freedom (d.f.) : 4 and 20
F- Value: 6.42
Probability of same End Results: 0.000
Null Hypothesis: Has not been approved or followed, therefore, my research study's hypothesis is being supported.

ANOVA: Results

The results of a ANOVA statistical test performed at 07:01 on 10-MAR-2018

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
between	3.202	4	0.8006	97.63
error	0.1640	20	8.2000E-03	
total	3.366	24		

The probability of this result, assuming the null hypothesis, is 0.000

DRY P. VULGARIS WEIGHT

Critical value is 2.87
Degree of Freedom (d.f.) : 4 and 20
F- Value: 97.63
Probability of same End Results: 0.000
Null Hypothesis: Has not been approved or followed, therefore, my research study's hypothesis is being supported.

Data Processing Analysis

After the detailed and calculated process of collecting my entire raw data, I then analyzed the results briefly, and saw a pattern of incrementing heights and weights of the P. vulgaris. It was until I gathered the mean and standard deviations of the height and weight that I saw the true results and pattern of my experiment. The process of Analysis began by transferring my mean and standard deviation. calculations of both the height and weight on separate graphs to interpret a trend in an organized manner. I decided to make two types of graph for each (height(mm) and weight(g)) for various reasons. To represent the Mean of the final dry height of the Phaseolus vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System, I chose a Bar Graph. Further on, when customizing my graph (Graph #1), I applied the standard deviation for each of the means manually to demand exact calculations. The reasons I chose my first graph to be a bar graph were because it is a simple way to track data, widely used and shows a visible variation between the intervals of increasing Potassium Chloride concentrations. In this graph I chose to show the error bars to efficiently and visually analyze the size of my standard deviation results. I also chose to show a linear trendline and an R^2 value for the same reason to show confirm the positive correlation in my analysis that I had made that the two independant and dependant variables (Height(mm) and increasing levels of Potassium Chloride did in fact share a positive and direct correlation. For my second graph (Graph #2) of the same dependant variable of the height(mm) of the P. vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System, I chose a scatter plot to also represent my findings. The reason to this decision were that the range of the data flow (maximum and minimum) can be determined in a straightforward manner, and shows a direct variation between two variables. Also, since I was testing to reject of accept my hypothesis and did not know the final extent of the effect on the P. vulgaris yet, it was an easy method for graphing linear or nonlinear trends. In this scatter plot I did not choose to have error bars because they had already been stated and could be interpreted in the bar graph but I did choose to have a linear trendline rather than a polynomial because of the constant change and direct change in my results as the Potassium Chloride concentrations increased. I also chose to show an R^2 value in order to determine the positive or negative correlation (in this case positive) between my two variables and later verify its application and reliability with the R^2 result. For the next and last dependent variable, the final dry weight(g) of the P. vulgaris, I chose to represent the mean in the graphing method of a bar graph (Graph #3). As aforementioned, bar graphs are a simple, globally-used, and visually direct method of interpreting data therefore they were one of the best choices to use in my experiment. But one of the most important factors that took part in my decision was the fact that when processing data, it would not be easy, nor efficient to have my first dependent variable (the height(mm) to be in a different graphing method than my second variable because when comparing results, only the same graphing type would give results with exactly the same manner of analysis and correlation. I also chose to apply error bars to my bar graph to visually see the size of the error bars and compare them to the graph columns of the means of the final dry weight. Moreover, I also chose to apply a linear trendline and R^2 value to confirm the positive trendline that I obtained visually in a mechanical and organized manner. Lastly, to confirm to positive correlation results in (Graph #4) when measuring the Mean of the final dry Weight(g) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 (mM)) in a controlled Hydroponic System, I chose to also show a scatter plot. Another reason for this decision was that scatter plots show an effective and direct nonlinear or linear trendline and due to this you can accept or reject your results immediately. Scatter plots, as mentioned before, show the range of the data flow (maximum and minimum) can be determined in a straightforward manner. In my scatter plot I decided to apply a linear trendline because it suited the style of the positive correlation between the two variables and later the R^2 value confirmed this with its percentage in high accuracy with the actual means of the weights(g). When I finished my graphs and there analysis, I decided to run two ANOVA tests, for the height and weight means. The purpose of running these tests was the confirmation as a whole of my results in a more mechanical manner. Just like Research Optimus states, "An ANOVA will find out if the means differ or are related significantly, serving excelently for hypothesis testing." (Research Optimus) The ANOVA helped my accept or reject my hypothesis, by providing many accurate and effective ways to analyze my data, all with the same conclusions. Referring to all of the above mentioned, these are the reasons as to why I chose the specific methods of Bar Graphs, Scatter Plots and ANOVA tests to analyze the means of the height(mm) and weight (g) of the P. vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System.

Conclusion

To finalize and finally conclude my results, as can be logically observed within the general area of the results, my hypothesis has been accepted and not rejected. The hypothesis that states as the levels of Potassium Chloride (KCL) increase in intervals of (0.00, 2.00, 4.00, 6.00, 8.00 mM), the amount taken in by the bean plants (Phaseolus Vulgaris) will also increase, and the more Potassium Chloride, the greater the height and weight of the dry bean plants after the two weeks of the estimated time that it will take the plants to grow and to collect data and analyze it, having a constant growth rate. This statement can be verified and validated by the graphs and tables comparing the Mean of the final dry height and final dry weight of the Phaseolus vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System. The first detailed analysis can be made when observing Table 1. The First table consisted of the raw data for the final height(mm) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride. The trials were set up and labeled depending on the five different tanks for the hydroponic system. In Each of the containers there were five plant each labeled in order from one to five, and as mentioned before briefly in the table sections, trial one represents all of the plants labeled one for each of the cfive containers with the five different concentrations. And as the table states, as the Potassium Chloride concentrations rose, the dry height of the plants, without counting the roots, also rose. It was also observed through qualitative data that as the concentration of Potassium Chloride increased in the five main levels (0.00, 2.00, 4.00, 6.00, 8.00(mM)), the P. Vulgaris' stem would become stronger and longer, this is due to the potassium giving it turgid characteristics and keeping it healthy and firm. This qualitative data is needed to support the additional information briefly stated in my introduction when the University of Minnesota stated, “ In plant growth, Potassium is involved with enzyme activation within the plant which affects protein, starch and adenosine triphosphate (ATP) production, regulating the rate of photosynthesis. If K is deficient or not supplied in adequate amounts, growth is stunted and yield is reduced. Other roles of K include; Increased root growth and maintains turgor; reduces water loss and wilting.” (University of Minnesota, 5) Therefore, this also serves as a confirmation for the other physical characteristics of the P. vulgaris, such as turgurness and healthy state. Additionally, there is also a Table for the other measuring method being tested which is weight. Table 2 shows the raw Data of the final dry Weight(g) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) and as can also be observed from this data is that is support that of Table 1 and restates the fact that as the concentrations of Potassium Chloride increased, so did the dry weight of the plants, and therefore this table also serves as a confirmation to the hypothesis. As mentioned in the introduction along with my hypothesis, Crop Nutrition, website verified by Mosaic Crops (leaders in crop nutrition) stated that, “Potassium Chloride, also known as KCl, is one of the most common fertilizers used for plants to overcome plants deficiencies.” (Crop Nutrition, 2) This event can be clearly seen and supported by the weights of the P. vulgaris since they increased constantly as the Potassium Chloride concentrations also increased. The more Potassium the healthier and stronger the plants were (Images can be seen in the data collection above), this is due to the Potassium being and excellent supplement for many nutrients due to its effect on the state of plants. The plants with the highest concentrations of Potassium Chloride

(Concentrations 6 and 8) had the heaviest weights and this is due to them fully growing out deficiencies, in contrast to the first concentration level of 0mM, that had the lightest weights. Furthermore, the next two tables that were created (Table 3 and 4) consist of the mean and standard deviations of the height(mm) and weight(g) of the P. vulgaris reacting to Potassium Chloride. After studying even further the relationship between the independent variable and the two main dependent variables through creating two extra tables including the means and standard deviations, the statement of Potassium Chloride having a direct relationship with P. Vulgaris growth can be further supported. After gathering the raw data and converting the trails of varying weights and heights of the P. vulgaris into standard deviations and means, subsequently, I created four graphs to represent and convert this data into visual images. These graphs can also be used as supporting details to add to the confirmation of the hypothesis. Graph number 1 is a Bar Graph that shows the Mean of the final dry height of the Phaseolus vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System. This bar graph serves to only show the mean and manually added standard deviations in a visual and captivating method. Aforementioned, when customizing my graph (Graph #1), I chose to show the error bars to efficiently and visually analyze the size of my standard deviation results. As I have learned from previous experiments, if the standard deviation is >1 then the results have a high probability of having errors in them, and as can be observed when seeing my standard deviation for the first graph, only the first trial had a great standard deviation which was of 1.1. The errors that could have been made when calculating this will be further explained in the evaluation. Concerning the means of Graph #1, as Potassium Chloride concentrations so did the increasing mean of the dry heights of the P. vulgaris. And the means did not vary from the original raw data meaning that the five plants for each of the five containers grew accordingly to their concentration and at the same rate as the other plants from its same level. In the First Graph, I also chose to apply a linear trendline because it was the best suited for what looked like the positive relationship in my analysis that I had made that the two independant and dependant variables (Height(mm) and increasing levels of Potassium Chloride did in fact share a positive and direct correlation. As Smart Fertilizer Management states, "Both uptake of water through plant roots and its loss through the stomata are affected by potassium." (Fertilizer Management) This statement is supported by the results seen in Graph #1 comparing the mean in dry P. vulgaris' heights. The heights were affected by this specific characteristic that Potassium provides that is to improve the absorption rate of the plant and , the direct proof of this is the long stems that the plants with the highest concentrations had (6 and 8 mM). The longer stems made absorption efficient. The second graph (Graph #2) consisted of the same dependant variable of the height(mm) of the P. vulgaris reacting to increasing concentration levels of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 mM) in a controlled Hydroponic System. For the second graph of the same information I chose a scatter plot to also represent the findings. Also, since I was testing to reject of accept my hypothesis and did not know the final extent of the effect on the P. vulgaris yet, it was an easy method for graphing linear or nonlinear trends. The equation of the line since it is a linear trendline shows that the information when put together to be analyzed as a whole has a positive slope. As mentioned in my data analysis, in this scatter plot I did not choose to have error bars because they had already been stated and could be interpreted in the bar graph but I did choose to have a linear trendline rather than a polynomial because of the constant change and direct change in my results as the Potassium Chloride concentrations increased. I also chose to show an R^2 value in order to determine the positive or negative correlation (in this case positive) between my two variables and later verify its application and reliability with the R^2 result. Since the R^2 value was 0.97 then it is a very high value and means that the data had a 97% chance of following the positive linear trendline, supporting my hypothesis due to stating that the Potassium Chloride did in fact share a direct relationship with the dry height of the P. vulgaris. For the following dependent variable, the final dry weight(g) of the P. vulgaris, I chose to represent the mean in the graphing method of a bar graph (Graph #3). I also chose to apply error bars to my bar graph to visually see the size of the error bars and compare them to the graph columns of the means of the final dry weight. The error bars representing the standard deviation in this graph were also <1 and therefore there were little errors done when weighing the plants due to the accuracy of the instrument. The scale had the uncertainties of ±0.01, and as can be interpreted, the uncertainties are very low which supports the solid data given by the scale. Lastly, to confirm to positive relationship between my variables to support my hypothesis results in (Graph #4) when measuring the Mean of the final dry Weight(g) of Phaseolus vulgaris reacting to increasing concentrations of Potassium Chloride (0.00, 2.00,4.00,6.00,8.00 (mM)) in a controlled Hydroponic System, I chose to also show a scatter plot. In my scatter plot I decided to apply a linear trendline because it suited the style of the positive correlation between the two variables and later the R^2 value confirmed this with its percentage in high accuracy with the actual means of the weights(g). Since the R^2 value was 0.98 then it is a very high value and means that the data had a 98% chance of following the positive linear trendline, supporting my hypothesis due to stating that the Potassium Chloride did in fact share a direct relationship with the dry weight of the P. vulgaris. After finishing and analyzing my graphs, I decided to run two ANOVA tests, for each the height and weight means. The purpose of running these tests was the confirmation as a whole of my results in a more mechanical and systematic manner. As mentioned before in my data analysis, Research Optimus states, "An ANOVA will find out if the means differ or are related significantly, serving excelently for hypothesis testing." (Research Optimus) The ANOVA test helped me accept or reject my hypothesis, by providing many accurate and effective ways to analyze my data, all with the same conclusions. Lastly, in the ANOVA chart, the results read that the F value is higher than the Critical Value, therefore this means the data is considered significantly different. Stating that the independent variable (Potassium Chloride concentrations (0.00, 2.00,4.00,6.00,8.00 mM)) actually made a difference in the dependent variables (dry height(mm) and weight(g) of P. vulgaris). In the first ANOVA test of the dry P. vulgaris height (without roots) the critical value is 2.87 and the degree of freedom was 4 and 20. And when following the instruction on how the read to the charts of the ANOVA test the

f- value was 6.42. Probability of same End Results: 0.000 and the null hypothesis was not been approved or followed, therefore, my research study's hypothesis is being supported. Since the f-value is greater than the critical value then it means that my results are significantly different and that my independent variable did have an effect on the independent variables. In the second ANOVA test of the dry weight of the P. vulgaris the critical value was 2.87 and the degree of Freedom was 4 and 20. The F- Value: 97.63 Probability of same End Results: 0.000 and the null hypothesis was not been approved or followed, therefore, my research study's hypothesis is being supported. The null hypothesis is the opposite of my hypothesis which would state that the increasing concentrations of Potassium Chloride did not have an effect on either of the two dependent variables, and it is not accepted meaning that our results have a 100% chance of being significant, real, and accepted. Since the f-value is greater than the critical value then it means that my results are significantly different and that my independent variable did have an effect on the independent variables. Therefore, statistically the results are different based on the different concentrations of Potassium Chloride. The results were evidently not due to just chance, there was an actual effect and a visible change. It actually made sense because the independent variable, (Potassium Chloride) which is the actually made a change in the dependent variable, which is the change in height(mm) and weight(g) of the Phaseolus vulgaris. Therefore, as the information above mentions, the null hypothesis is rejected and there is 0.000 probability of it being accepted.

Evaluation	***Improvements***

One very significant error that could have been made was that when measuring the amount of Potassium Chloride for different containers of varying concentrations. Although I did effectively turn the millimolar measurements to grams for each of the five concentration intervals, when actually measuring the grams of the Potassium Chloride in the measuring tool due to the accuracy of the scale and the crystalline form of the Potassium Chloride being in chunks and adding more mass to the weight, but actually it was less than what the scale said that they measured.	In order to avoid this in the recreations of this experiment, buy a new container of Potassium Chloride and make sure that the pieces are evenly split to avoid miscalculations or hard times when taking out the fertilizer supplement. Also, if your Potassium Chloride is still in chunks, you can crush it with specific crushing utensils (not with eating utensils) and leave it in the crystalline small rock form that it is meant to have, ready for measuring.
As mentioned before in the Raw Data Tables Section, it can be observed, in the first Potassium chloride concentration that has 0.00 mM of the compound, the standard deviation is approximately 1.14 and therefore greater than 1, meaning it has a high standard deviation and has a big error bar. This means that the results of the height of the P. vulgaris varied a lot, this is due to the plants having no concentration of the Potassium Chloride fertilizer, and therefore there growth being random and natural. This might have affected the first trials of heights of the dry P. Vulgaris, with no fertilizer supplement because their growth is completely up to nature and themselves.	Various improvements can be made to have a more modified and equal growth between the twenty-five P. vulgaris plant trials. Firstly, when picking out the seeds of the plants that will be testing on the experiment, it must also be taken into account the size of the seed. The size and physical state of the seed affects the way it will grow and if it will grow. Therefore, same size seed should be a controlled variable in order to have more precise results and not having this influence your results. Therefore, healthy and equal sized seeds need to be obtained and put into the experiment.
Secondly, the week before the experiment, in which the been has not been added the fertilizer supplement but is still growing in the cup with water and cotton balls, do no add so much water and sink the plant deeply into the cotton. This may lead to too much absorption and some plants might be lower in position than other or higher, and this may lead to different absorption rates and varying sizes of plants at the beginning.	As mentioned before, starting with the same starting position and state for each of the plants is very important, and therefore various improvements can be made to correct the "random" growth of the first week internal of the seeds growing without the fertilizer supplement. To avoid this specific error in growth, all bean seeds need to be place at the same height from the water inside the cup (Halfly sunken, barely touching the water). This would prevent even further flaws to reach to the seeds and kill them. Also to avoid the deaths of some seeds affecting your variables, plant 12 seeds extra with the same requirements as the others and replace any of the main twenty-five seeds that die.
For Graphs 3 and 4, For each of the trial, the weight in grams has the uncertainties of ±0.01. This could have lead to a problem because there was still uncertainty in the results and therefore results were not as precise as could have been.	For further experimentation, to avoid having error in the reliability of the data, a more accurate instrument needs to be chosen and applied to further develop the results of the data. The medium sized scale that was used to measure the grams could have been replaced for scare used to measure smaller things, also in grams. (Smaller Scale, smaller uncertainties, and therefore would lead to more accurate results).
For each of the trial, the heights in millimeters have the uncertainties of ±0.5. This could have lead to a problem because there was still uncertainty in the results and therefore results were not as precise as could have been.	For further experimentation, to avoid having error in the reliability of the data, a more accurate instrument needs to be chosen and applied to further develop the results of the data. The rule used to measure the height of the plants without taken in account the roots, instead of being in millimeters could have been a more accurate measuring tool. In future will evaluate other better tools.

Extension to Research Question

Research Topic: To what extent did increasing Levels of Varying Concentrations of Potassium Chloride (0.00, 2.00, 4.00, 6.00, 8.00 mM)affect the plant growth (height(inches) and biomass(grams)) of Phaseolus vulgaris in a controlled Hydroponic System?

As can be supported from the graphs, tables, and ANOVA testing methods above, the increasing concentration levels of the fertilizer supplement Potassium Chloride affected the growth in height and weight of the P. vulgaris to a great extent. Each in their own way, the data analysis methods used to interpret the mean and standard deviations of the heights and weights of the plants, and efficiently gave the results while also accepting the hypothesis stated at the beginning of the experiment which stated that during this experiment, as the levels of Potassium Chloride (KCL) increase in intervals of (0.00, 2.00, 4.00, 6.00, 8.00 mM), the amount taken in by the bean plants (Phaseolus Vulgaris) will also increase, and the more Potassium Chloride, the greater the height of the bean plants after the two weeks of the estimated time that it will take the plants to grow and to collect data and analyze it, having a constant growth rate. This further means that Potassium Chloride can be used as an excellent fertilizing supplement for P. vulgaris in a Hydroponic System. The Potassium will in fact strengthen the plant and help it grow, while maintaining a balanced homeostasis for the plant's well-being. Although it can be inferred and deduced that the independent variable (Potassium Chloride) did have an effect on the growth of the Phaseolus vulgaris, it also has to be taken into consideration that this same fertilizer cannot be directly applied to other plants. Or for the same matter, the Potassium chloride cannot be substituted by another chemical compound containing Potassium and expect the same results. Subsequently, for future research investigations I would like to evaluate which other chemical compounds containing Potassium could also have the same direct relationship with the growth of P. vulgaris and to what extent? Some examples of these chemical compound can be Potassium Hydroxide, Potassium Fluoride, Potassium Iodate, etc. I would also like to evaluate if this same chemical compound, Potassium Chloride, would have the same direct growth effects that it had on the Phaseolus vulgaris plant like on other plants and which types? And of course, also making these experiments of Hydroponic system t not have other factors like soil and its minerals or other plants to affect the results, this system would enable a controlled environment. The results to these following future experiments and analysis would enable me to look at the effects of Potassium within a holistic view and determine its role as a fertilizer for plants. As in fact, plants are human's greatest source of energy due to the energy pyramid and are considered producers. Which is why these experiments erve for the greater good of all humans, especially farmers looking to receive the best crops to sell and eventually feed to the population.