Effects of N-P-K ratios on Plants

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Abstract

The purpose of this experiment is to find the optimal fertilizer using the NPK ratio to increase the yield of bean plants. By 2050, the human population will not be able to sustain enough food for everyone due to the population surpassing 9.1 billion people. It is necessary to take the proper steps to have a sustainable environment for the future. Fertilizers are a common and useful way of increasing the food production of a plant at a faster rate. However, there are many fertilizers on the market, so which one should be used? In this experiment, four groups were tested: 3-2-1, 10-10-10, 24-8-16, and the control group (0-0-0). Each IV group had eight plants tested with the same fertilizer to increase the accuracy of the data. The constants in this experiment were the light source, which were 2 luminescent light bulbs, the water source, 1.5 cups every 3 days, and the location, which was a residential home in Louisville, Kentucky. This whole experiment took 10 weeks to complete. The dependent variable in this experiment is the amount of beans the plant grows, so this was tracked every week and noted down in a spreadsheet. It was hypothesized that the 3-2-1 fertilizer would outperform the other fertilizers, which was statistically proven to be correct. The 3-2-1 fertilizer grew an average of 0.975 beans per week. The 10-10-10, 24-8-16, and the control group grew 0.388, 0.388, and 0.238, respectively.

Keywords: N-P-K Ratio, fertilizer, beans

Introduction

Eating food is a daily activity that is a part of our life, but most of society doesn't appreciate it well enough. Most people do not think of where their food comes from and how it was made. Nowadays, it is slowly becoming a very crucial topic in our lives. “By 2050, food will not be able to supply everyone as the population will surpass 9.1 billion people.” (Sohgen, 2017) 2050 seems very far away, but it is much closer than people think. How will humanity be able to support future generations? If people only think of the food supply for this generation, the world won’t thrive. This is why society needs to care more about the future because there is a sufficient amount of knowledge, teaching humans by planting their own food and letting them grow it will benefit massively. In ancient times, farmers used to plant their plants at the side of rivers because it had the most fertile soil for plants to grow properly. One thing that could improve plant growth and yield was fertilizers. Use fertilizers because it gives plants more nutrients to increase the health and performance of the plant. However, be careful to not use too many fertilizers because it can lead to the release of greenhouse gasses and eutrophication, which is excess of nutrients in a lake or water. This usually occurs from runoff on the land. Fertilizers were founded 2,000-3,000 years ago but according to future research, they may have been found 8,000 years ago. Back then, manure was used as fertilizer. Scientists think that farmers knew how to use manure as a fertilizer due to plant growth in certain areas where animals gathered. Wherever animals gathered, they would do their natural things and plants would grow faster and grow a larger yield. Farmers used different minerals, wood ash, and guano as substitutions for fertilizers. There are many different fertilizers out there and it can be confusing to many on which one to use. Fertilizers are differentiated into a ratio of 3 different chemical fertilizers. The 3 are

nitrogen, phosphorus, and potassium. For example, a fertilizer could have a ratio of 3-2-1. This is the ratio of all these elements so the nitrogen would have 3 parts, phosphorus has 2 parts, and potassium with 1 part. The ratios are also considered as a percentage of weight. Here is an example: A fertilizer bag has a NPK ratio of 20-14-2 and the weight is 50 pounds in all. The bag has 20% nitrogen, so 0.2*50=10, so the fertilizer has 10 pounds of nitrogen. This applies to the same thing for the phosphorus and potassium numbers. There would be 7 pounds of phosphorus in the fertilizer and 1 pound of potassium in the fertilizers. The order of the ratio will always be nitrogen-phosphorus-potassium, or shortened to N-P-K. Justus Von Liebig was responsible for figuring out these 3 ingredients are necessary for healthy plant growth. However, this theory didn't include the various ingredients that are also in the fertilizer which are important such as sulfur, hydrogen, oxygen. His theory was right, but the major flaw was leaving out the other major supplements in fertilizers. One major problem that occurred was the excess use of fertilizer which explained before, causes eutrophication and the release of greenhouse gasses. This overall makes fertilizers actually bad for the environment if not used properly. All of the elements in the fertilizer play their role in helping the plant. The project will be testing 3 different fertilizers with varied N-P-K ratios and determining which fertilizer helps the height of the plant. The NPK ratio makes it so much easier to categorize fertilizers into different groups so people know which one would be the right one for their plant. The hypothesis in this experiment is that the 10-10-10 fertilizer will grow higher than the other fertilizer ratio groups. This fertilizer has the same amount of potassium, phosphorus, and nitrogen which concludes that there will be a better blend and mixture of the fertilizer. 30% of the fertilizer will be made up of the N-P-K ratio so it doesn't overpower the other ingredients in the fertilizer because all are important. This experiment isn't meant to be the only way to solve food shortages and world hunger. The goal is

to find multiple ways to prevent food shortages from happening. The hope of the project is to get a better understanding of how plant growth works and how to be able to improve it in future science fair projects.

Methodology

This experiment took place in a residential home in Louisville, Kentucky. First, pour 1.5 cups of soil into styrofoam cups placed into 4 different trays. Next, use an index finger to make a whole that's 2 inches deep and 1 inch wide so the seed can be instilled in it. This process occurred 32 times for each plant seed. After planting the seed, cover it up with the soil around it. After one week, start applying the fertilizers at the same time. This experiment involves 4 different groups being tested. The first group is the control group, which will have no fertilizer in it and just only has regular soil. The second group is the fertilizer with a NPK ratio of 10-10-10, which means it has 10% of nitrogen, phosphorus, and potassium. The third group is the fertilizer with a NPK ratio of 24-8-16 and the fourth group is the fertilizer with a NPK ratio of 3-2-1. In each group, the constants were the soil which was measured in the same cup each time (1.5 cups), amount of water (25 mL), amount of light, and the way of measuring the height of the plant. The light source will be 2 luminescent light bulbs which are placed 2 feet above the plants. Every 3 days, check the plants for any changes and record new data. After that, water the plants to make sure they are receiving enough nutrients to survive and to produce more beans. When applying the 10-10-10 fertilizer, place the fertilizer around the top 1-3 inches of the soil. After applying it, water over it so the fertilizer can continuously release nutrients. When applying

fertilizer for the 24-18-6 group, apply around ¼ of a tablespoon to each plant around the top 1-3 inches as well. As the fertilizer is being applied, try spreading everything out so the nutrients can be dispersed evenly. The same concept is applied to all the fertilizers. When applying the 3-2-1 fertilizer, press the pump slightly so there isn't an excess in fertilizer. This could lead to a disturbance in the uptake of water from the roots of the plant which ends up damaging it. Next, the data will be entered into a table in Google Sheets so the information will be organized. After entering all the data in the table, convert it into bar graphs so it will be easier to tell which group on average grew the most beans. Pie charts are also a useful way of showing which group had the highest average height. After reviewing and finalizing the data, compare the results to the original hypothesis.

Data and Results

Table 1: Raw Data (beans)

	Control	3-2-1	24-8-16	10-10-10
Week 1	0	0	0	0
Week 2	0.25	0.625	0	0.125
Week 3	0.375	1.75	0.375	0.375
Week 4	0.125	1.625	0.875	0.625
Week 5	0.375	1.25	0.25	0.25
Week 6	0.625	0.5	0	0.375
Week 7	0.25	1	1	0.5
Week 8	0.625	0.625	0.5	0.5
Week 9	0.375	0.375	0.125	0.75

Week 10	0.25	2	0.375	0.375

The raw data table above shows the amount of beans on average each group produced every week.

Fig 1:

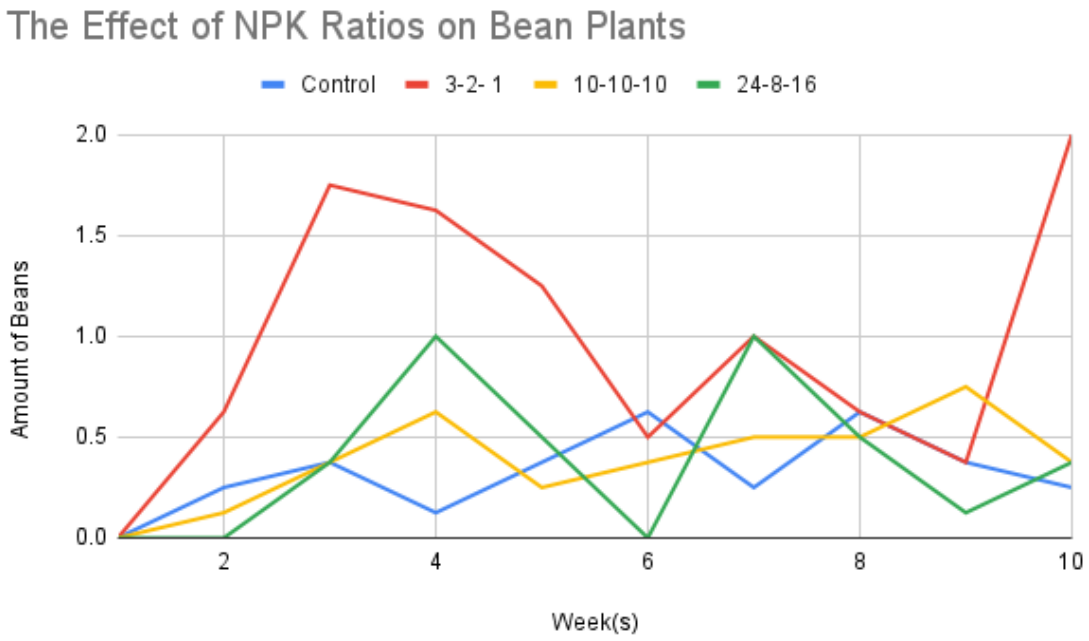


Fig 1: The graph above represents the amount of beans grown for each of the 4 groups being tested. Each group consisted of 8 plants. To find the amount of beans for each group per week, add all the beans grown in that group and divide by the number of plants in the group. The hypothesis for this experiment was that the 3-2-1 fertilizer would grow the most beans on average, which is proved to be right. Looking at the red line on the graph, 3-2-1, there are considerable peaks in the graphs, such as in week 3 and 10. In all the other groups, there aren't noticeable differences besides the fact that the plants that were grown with fertilizer grew a little more beans than the control group, with no fertilizer.

NPK Ratios on Fertilizers

Table 2: Descriptive Statistics for the amount of beans grown by each NPK Ratio

IV Levels	Control (no	3-2-1	10-10-10	24-8-16

	fertilizer)			
Mean	0.238	0.975	0.388	0.388
Variance	0.039	0.437	0.050	0.128
Standard Deviation	0.197	0.661	0.224	0.357
1 SD	0.041 - 0.435	0.314 - 1.636	0.164 - 0.612	0.031 - 0.745
2 SD	0 - 0.632	0 - 2.297	0 - 0.836	0 - 1.102
# of trials	8	8	8	8
Results of t test **Df = 7** **Alpha = 0.05**		T = 2.980 P < 0.05	T = 0.662 P < 0.05	T = 0.462 P < 0.05
	Control Group Comparison	Significant	Not significant	Not Significant
	3-2-1 Group Comparison		T = 2.662 P < 0.05 Significant	T = 2.438 P < 0.05 Significant
	10-10-10 Group Comparison	T = -2.438 P < 0.05 Significant		T = 0 P < 0.05 Not significant
	24-8-16 Group Comparison	T = -2.438 P < 0.05 Significant	T = 0 P < 0.05 Not significant	

The table above are the descriptive statistics tables for the amount of beans grown. Analyzing the data in the table, there were a few observations made. The mean of the 10-10-10 fertilizer and the 24-8-16 fertilizer for the exact same, rounded to the nearest thousandth. However, the variance and the standard deviation obviously had varied. However, the 3-2-1 fertilizer has a larger margin than the other groups. The 3-2-1 produced more beans than the other groups which was the directional research hypothesis in this experiment. For this experiment, there was a one-tailed uncorrelated test to test a null hypothesis at a 0.05 level of significance. In this experiment, the null hypothesis was that the 10-10-10 fertilizer would

produce the same amount of beans as the 3-2-1 group, which was rejected. The alternative hypothesis was also correct which supports the directional research hypothesis. In the statistical analysis, the control group and the 3-2-1 fertilizer group had a standard deviation of 0.197 and 0.661, respectively. However, the control group and the 10-10-10 fertilizer group had a close standard deviation. Another comparison with a pattern was that T = 0 because the mean was the same for both groups, 24-8-16 and 10-10-10. Figure 1 shows the data better visually and the difference between the amount of beans grown per week.

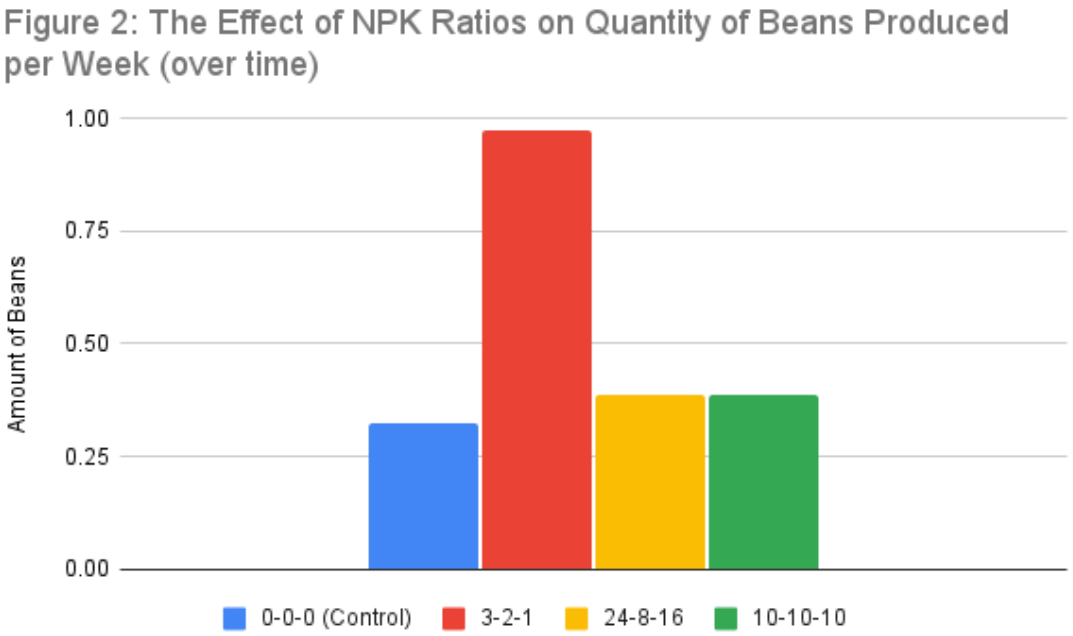


Fig 2: The graph shows the 3-2-1 fertilizer being statistically more significant than the other groups. There is a pattern where 24-8-16 and 10-10-10 grew the same amount of beans over the whole 10 weeks.

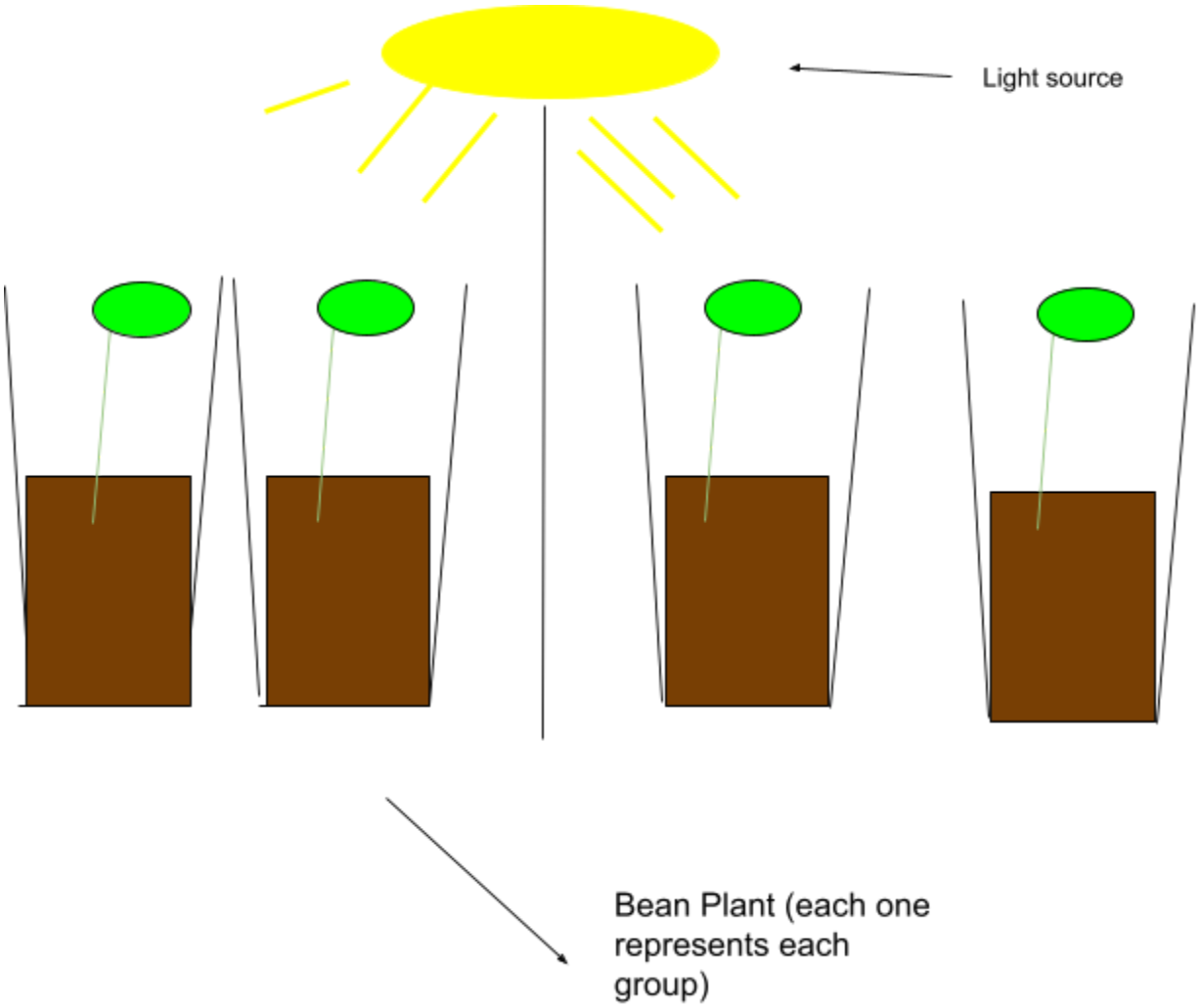
Conclusion

The purpose of this experiment is to find the perfect fertilizer using the NPK ratio to increase the yield of bean plants. By 2050, the human population will not be able to sustain

enough food for everyone due to the population surpassing 9.1 billion people. Three fertilizers and one control group were tested in this experiment, which were 3-2-1, 10-10-10, 24-8-16, and 0-0-0 (control). The hypothesis was that the 3-2-1 fertilizer would produce more beans overall in the 10 week process. After the whole experiment, it was concluded that the hypothesis was proven correct. The comparison between the 3-2-1 and the control group resulted in $t= 2.980$ and $p<.05$, indicating that this was significant. The comparison between the 10-10-10 and the control group resulted in $t= 0.662$ and $p< .05$, which was proven non-significant. Lastly, the comparison between 24-8-16 and the control group resulted in $t= 0.462$ and $p<.05$, which was also proven not significant. There were several patterns noticed, such as the mean being the exact same between the 24-8-16 fertilizer and the 10-10-10 fertilizer. This has the possibility of some error in the data collection or a pure coincidence in the data. Another analysis made was that the 3-2-1 fertilizer was the only fertilizer to grow an average of 2 beans in a week, strengthening the hypothesis. In conclusion, fertilizers do have an impact on the yield, and using the 3-2-1 fertilizer will maximize the benefits of using it and increase the yield. The explanation of the 3-2-1 fertilizer giving the most yield is because of the balance and quantity. This fertilizer has 3% of its weight as nitrogen, 2% of its weight as phosphorus, and 1% of its weight as potassium. All of the ingredients are important for the fertilizer to grow, and they each have their own benefits. Nitrogen is vital for the building blocks of proteins in plants. Nitrogen is an important material of energy-transfer compounds, such as ATP. Amino acids are a part of protein and nitrogen makes up amino acids. Without nitrogen, amino acids wouldn't exist. Phosphorus is a critical part in ATP, which forms during photosynthesis. Phosphorus is important for capturing the sun's energy and converting it for its growth. Lastly, potassium is critical for the movement of water throughout the plant and is also helpful for improving the growth of the plant. Potassium

controls the water loss by opening and closing the stomata in the leaves. However, these components only make up 6% of the weight of the whole fertilizer. What about the remaining 94%? This 94% is also extremely important regarding the growth of the plant. An important nutrient that was included in the fertilizer but not in the NPK ratio was sulfate. Sulfate is used for forming important enzymes in plants, but in low amounts. This is also one of the main reasons why sulfate isn't considered in the NPK ratio due to the low amount being used in the fertilizer. Some modifications that could've been made include having a stronger light source, which has the possibility of changing yield patterns. Another modification could be the number of trials because, when analyzing the standard deviation ranges, they quickly go negative, meaning they may need more trials. Possible sources of error were applying the fertilizer differently according to the instructions. Different applications of fertilizers could have an effect on the impact of plants and how they utilize the fertilizer in their growth. There are several different ways this experiment can be improved upon and can be taken to the next level. One way would be to have more IV groups to test from. The limited four groups of data being tested only show one fertilizer as being better than the other two. There could be fertilizers out there on the market that perform a lot better than the 3-2-1 fertilizer. According to the Texas A&M Agrilife Extension, they state that 10-20-10 is the best fertilizer used for plants. Another way this project could be improved is by increasing the time of data collection. The limited 10 weeks show some data about the plants, but a longer time period of data collection would've really pictured the effects of fertilizer. A longer data time collection would include more patterns and has a possibility of changing the outcome of the project as well.

Appendix



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