EXTENDED ESSAY

ENVIRONMENTAL SYSTEMS AND SOCIETIES

EFFECT OF THE DIFFERENT SUBSTANCES ON GROWTH OF BEANS (PHASEOLUS VULGARIS) IN TERMS OF LENGTH

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Abstract

Agriculture is one of the most important activity for a country by providing enough food for the people that lives in that country. It also plays a significant role in the life of economy as being a source of national income and some of the citizen relies on agriculture as a mean of living since it's their source of livelihood. In agriculture they use fertilizers in order to improve plants growth and yield. Nitrogen, potassium and phosphorus are the most used substances in those fertilizers. This experiment focused effects of these substances in the length of plants and which one of them will be more efficient in the length of it. From this the research question formed as, "How does the different type of substances (KSO_4, $NaNO_3$, NH_4SO_4 and N-P-K mixture) affect the growth of beans *(Phaseolus vulgaris*) in terms of height (cm) while the soil quality, pH, temperature and pressure of the environment is tried to be constant during the experiment?" The plant used in this experiment was *Phaseolus vulgaris.* Five groups has been made, each group contained 5 pots and identical *P. vulgaris.* are placed into those identical plastic pots. During the experiment only tap water, KSO_4, $NaNO_3$, NH_4SO_4 and N-P-K mixture has been used. Each group of plants been watered with their own substances respectively for once in each day. Group 1 is only watered with tap water, group 2 with KSO_4 concentration, group 3 with $NaNO_3$ concentration, group 4 with NH_4SO_4 concentration and group 5 with N-P-K mixture. The volumes of those concentrations were equal (25 ml per each pot) The experiment were observed for 10 days.

The results showed that the difference in the growth of *P. vulgaris* in terms of lengths can be seen clearly on each different groups of *P. vulgaris.* Also from the results it can be seen that my hypothesis turned to be true and longer *P vulgaris* measured on the group which watered with the NH_4SO_4 concentration.

Word count: 327

Introduction

While I was searching about a topic that I can use for my extended essay my little sister were planting beans for her science homework. It took a week for her to get results and she did pretty well with looking after them. In the end of the week all of the plants looked so healthy and tall. It made me remember my old memories from elementary school that how we also did the same thing and how we had a responsibility on them. I know that plants need nutrients in order to live and grow just like the other living creatures. Nitrogen, phosphorus and potassium are the major nutrients for plants and they also being used in agriculture area by converting them into fertilizer. [1] It made me think about which of the major nutrient has the biggest role on plant growth in terms of length and the effect of the type of substances on the growth. I chose beans *(Phaseolus vulgaris*) (Figure 1) because it has a fast growth rate in a limited time and it was the perfect choice for me under these circumstances.

Phaseolus vulgaris

A variety of the common bean with flat pods

[1] "Essential Nutrients." *Soil Management*. Ctahr, Web. 21 March. 2014. http://www.ctahr.hawaii.edu/mauisoil/c_nutrients.aspx

Scientific classification	
Kingdom:	Plantae
Order:	Fabales
Family:	Fabaceae
Subfamily:	Faboideae
Tribe:	Phaseoleae
Subtribe:	Phaseolinae
Genus:	*Phaseolus*
Species:	*P. vulgaris*

Figure 1: *Phaseolus vulgaris* in general terms.

Fertilizer

Fertilizers are sources of nutrients that may include the minerals which will be deficient in the soil during receiving nutrients from soil for the plants [2].

To increase the productivity for plants fertilizers are the compounds which are added to soil. They are the combination of nutrients for the plants which must have it in order to keep growing and live. To access these nutrients fertilizer makers usually convert them in a form they can use. Nitrogen (N), phosphorus (P) and potassium (K) are the primary ones in fertilizers.[3] They are often combined into an NPK mixture. Secondary nutrients are needed in smaller amounts for a normal plant growth.

[2] "How Products Are Made." *How Fertilizer Is Made*. Madehow, Web. 21 March. 2014. http://www.madehow.com/Volume-3/Fertilizer.html
[3] "About Fertilizer." *About Fertilizer*. Canadian Fertilizer Institute, Web. 22 March. 2014. http://www.cfi.ca/whatwedo/aboutfertilizer/

Micronutrients are also needed but it's not very necessary for the plants. They don't have a major role in growing not like the macronutrients. These plant nutrients can be supplied through organic fertilizers such as livestock manure, rotten plants, or through mineral fertilizers [4].

As plants keep growing, they need to emit nutrients from the soil by the help of their roots. Farmers harvest those type of nutrients when they harvest crops. Fertilizers, whether mineral or organic has a role by returning essential mineral nutrients.

Plants generally need more nitrogen than phosphorus or potassium. Because of that nitrogen is the major component among fertilizers. Phosphorus is usually necessary for the plant in world's equivalent of carbohydrates. It provides energy for plants to succeed. Potassium helps plants fight with diseases and it provides stalks to grow and be strong.

Anyone can obtain those fertilizers from nature. Most nitrogen in mineral fertilizers is drawn from the air and then highly pressurized to convert the nitrogen to ammonia. The ammonia is then converted to various nitrogen-based fertilizers like liquid ammonia. Phosphorus, potassium and most secondary nutrients are mined from the ground.

Fertilizer in agriculture

Agriculture has constantly assumed a key part in maintaining human life. A vital piece of human development, agribusiness has seen new turns with continually climbing human society. Change of way of life, engineering and majorly the mechanical upset have assumed an essential part fit as a fiddle of rural qualities. Each agricultural process has been redefined in today's scientific light and each technique has been illuminated with the effects of new machines and a major invention that has lured the facilitators of farming to step into the golden era. The golden era of agriculture which has been redefined with the help of newly designed machines and the productive fertilizers. The

[4] "Micronutrient Requirements of Crops." *Micronutrient Requirements of Crops*. Agriculture.Alberta, Web. 09 Nov.2014.
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex713

introduction of agricultural fertilizers has marked the new agricultural revolution and has poised to break all records and start anew.

Most compost that is usually utilized as a part of agribusiness contains the three essential plant supplements: nitrogen, phosphorus, and potassium. A few composts additionally contain certain "micronutrients, for example, zinc and different metals, that are fundamental for plant development. Materials that are connected to the area principally to improve soil qualities (as opposed to as plant nourishment) are normally alluded to as soil changes.

Nitrogen

Nitrogen is considered as the most vital supplement among the greater part of alternate supplements. It organizes protein which makes up an immense measure of tissues in the greater part of the living animals and that is the reason it considered as the most critical one. All livings must have it to survive. It can be found in the air since environment is about %78 nitrogen by volume. However in this structure it is insoluble which means plants can take the nitrogen they require from the air specifically. Characteristically they take it from soil as an aftereffect of nitrogen cycle. With the assistance of different soil microscopic organisms which changes over nitrogen to usable structure for plants. It does that by joining basic nitrogen wit hydrogen and oxygen. This procedure known as mineralization and it makes nitrogen usable for plants. The other route for plants to get to nitrogen is through manures, fertilizers. Fertilizer creators change over nitrogen to smelling salts with joining nitrogen with hydrogen from common gasses. Smelling salts is utilized as a nitrogen manure and connected specifically to yields. To disentangle like the human body, plants need nitrogen so as to develop. Nitrogen additionally helps plants to be green and has significant part in boosting yields. [5] [6]

[5] "Nitrogen." *Nitrogen in Plants*. Cropnutrition, Web. 17 Nov. 2014. http://www.cropnutrition.com/efu-nitrogen#nitrogen-in-plants
[6] "Agriculture." *HSC Online*. Web. 17 Nov. 2014. http://hsc.csu.edu.au/agriculture/production/3363/nitrogen.htm

Phosphorus

Phosphorus is an alternate essential supplement. It has basic parts being developed of plants. Most paramount among them is photosynthesis, the process that plants change over daylight to usable vitality. Phosphorus is likewise has part on cell division, cell advancement, breath, vitality stockpiling and exchange of vitality. Phosphorus is useful for right on time plants with plant wellbeing and root development. It has obligation in seed germination and it gives the vitality which needs plant to development. Phosphorus is additionally contains in all living cells and it important to all manifestations of life. The most widely recognized phosphorus compost items are phosphates. There are various types of phosphate by responding phosphate rocks with diverse sort of acids. Phosphorus which is a part in compost originates from fossilized stays of old life found in people stores and it prepared to make a water solvent compound. This will make phosphorus usable to plants as supplement. [7]

Potassium

Potassium which is also called potash is one of the three supplements alongside nitrogen and phosphorus required by plants. Plants normally utilize potassium amid photosynthesis and water utilization. Potassium much the same as nitrogen helps plants produce protein as they develop. It has a vital part like starch storage, to make plants oppose to wiling longer. It is a vital substance, plant supplement and it needs to be in extensive adds up to legitimate development in plants. It is considered as the second most required supplement for plants directly after nitrogen. It influences the shape, texture, shade and strength of the plant and on account of that they considered, known as "quality supplement". Plants transmit potassium in its ionic structure $K+$.[8]

[7] "Phosphorus Uptake by Plants: From Soil to Cell." *Phosphorus in Plants*. Plantphysiol, Web. 16 Dec. 2014. http://www.plantphysiol.org/content/116/2/447.full
[8] "Potassium in Plants." *Potassium*. Smart!, n.d. Web. 16 Dec. 2014 http://www.smart-fertilizer.com/articles/potassium-in-plants

Research Question

How does the different type of substances (KSO_4, $NaNO_3$, NH_4SO_4 and N-P-K mixture) affect the growth of beans (Phaseolus vulgaris) in terms of height (cm) while the soil quality, pH, temperature and pressure of the environment is tried to be constant during the experiment?

The question will be answered through the data that is collected from the experiment by measuring the growth of beans in the end of ten days.

Hypothesis: Nitrogen is mostly effective on the length of plants, so that the results in the end of the experiment by the term of lengths should be measured higher in NH_4SO_4 group. From this the hypothesis would be " **The *P. vulgaris* given water which has NH_4SO_4 concentration will be longer in terms of length in body "**

In this study, KSO_4, $NaNO_3$, NH_4SO_4 and N-P-K mixture were used as substances to measure the effect of them on the Phaseolus vulgaris in terms of height (cm) rather than using only tap water. Potassium sulphate was used as a potassium source, Sodium nitrate as phosphorus and Ammonium sulphate as nitrogen.

Method Development and Planning

Type of Variables	Factors;	Kept controlled by;
Independent	Type of substances used in this experiment	-
Dependent	Length of the plant after 10 days	-

Type of Variable	**Factors;**	**Kept controlled by;**
Controlled	Temperature of the environment	Using the same area for all specimens during the experiment. (1 atm, 25^0C)
	Pressure of the environment	
	Amount of the soil	Using same type (mixed garden soil) and same amount (4.0l total) of soil
	Type of the soil	
	Amount of the substances	Using 4.5gr substances in total. (1.5x1.5x1.5)
	Amount of light received by the plants	Placing all of the plants in front of the same window in the same place during the experiment
	Size of the pots	Using plastic pots which has same size and volume 7 cm length, 10cm width (identical)
	Volume of the pots	
	Material of the pots	

	Texture of the seeds	Using the same texture (1.2±0.1cm), shape and mass of phaselous vulgaris seeds.
	Mass of the seeds	
	Shape of the seeds	
	Type of the seeds	
	Watering method	Using a needles injector during the watering
	Angle of the watering	90^0C
	Amount of water	Using 6250ml (25ml for each cup 625ml in total in a day) tap water
	Type of water	
	Size of the injector	Using the same injector for every specimen after cleaning it.
	Time of watering	Watering at 14:00 in every two days
	Number of leaves	Leaves been cut until each of the plants have 2 leaves
	Duration of measurement	Keeping the period in 10 days for every specimen

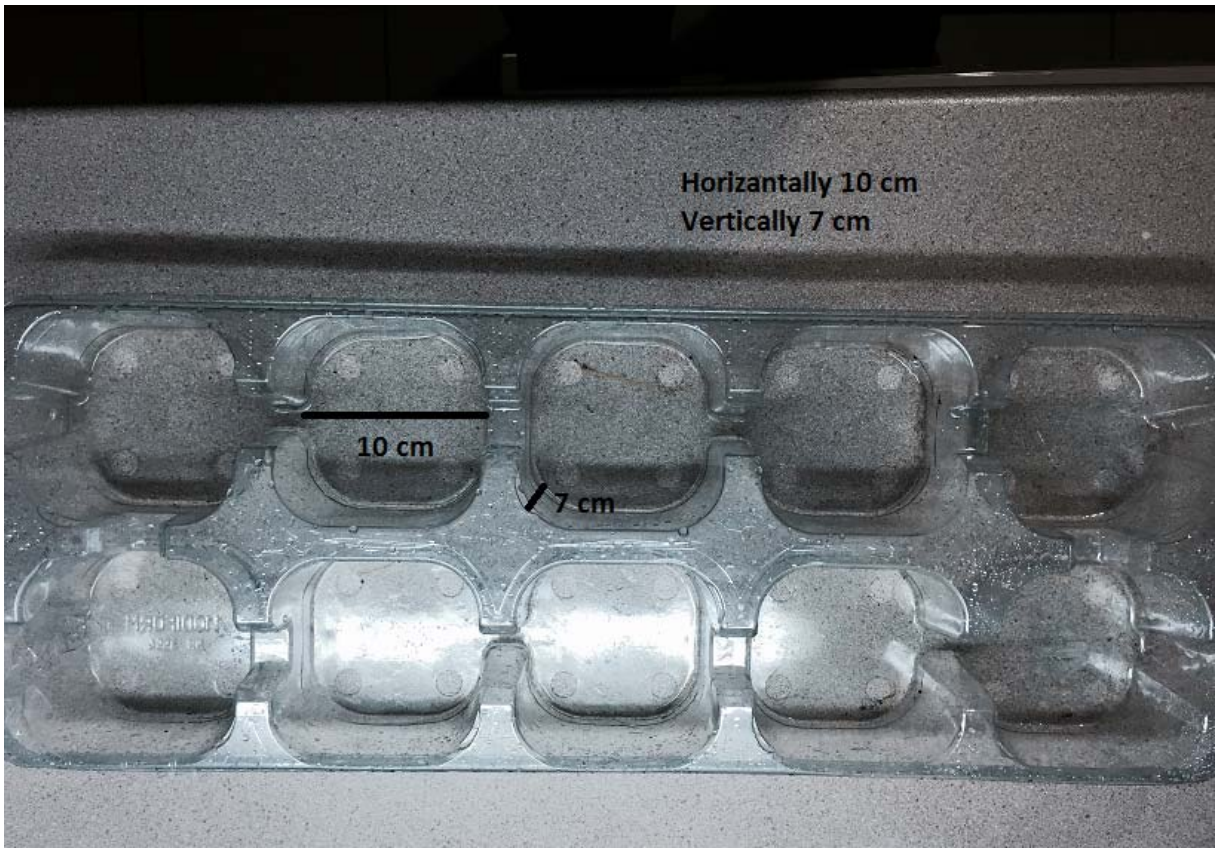


Figure 2: Pots that used during the experiment. (Size in cm ±0.1)

Materials:

- Plastic pots (x25)
- Phaseolus vulgaris seeds (x25)
- Ruler (±0.1cm)
- Spoon
- Weighing machine
- Pen and notebook
- Tap water (6250ml)
- Mixed garden soil (4.0L)
- Needless injector

Substances used:

- Nitrogen (0.3g per each pot / 7.5g in total) (Ammonium sulphate)
- Phosphorus (0.3g per each pot / 7.5g in total) (Sodium nitrate)
- Potassium (0.3g per each pot / 7.5g in total) (Potassium sulphate)
- N-P-K mixture (0.1g+0.1g+0.1g per each pot /7.5g in total)
- Tap water (25ml per each pot / 6250ml in total)

Figure 3: Substances used during the experiment.

Procedure

1. Prepare 25 identical pots with 7cm length and 10 widths.
2. Fill the pots with 160ml (0.16 l) of soil for each cup.
3. Put an identical P.vulgaris seed on each pot with same depth (2.0cm)

4. Set the room temperature as 23^0C
5. Cut the leaves of every plant to until every of it reaches the same number.(Keep cutting as long as the number of leaves will be constants as 2 pieces)
6. Use only tap water for 1 group
7. Add 0.3g ammonium sulphate into water
8. Mix well
9. Repeat the steps 7 and 8 with other substances (*KSO_4, $NaNO_3$* NH_4SO_4,*)* for the 3 groups.
10. For the rest group which will be watered N-P-K mixture add 0.1g of each substances (*KSO_4, $NaNO_3$,)*
11. Mix well before watering.
12. Start watering each group, each pot.
13. Don't forget the water for every day until 10 days pass.
14. After reaching to 10^{th} day stop the experiment and compare the data, the growth in bodies in terms of length (cm)
15. Record your data and fill your raw data table.

Methods

Preparation of the pots

25 identical plastic pots and 4.0L (25x160) of soil are prepared for the experiment. The type of the soil is not important since it has no any effects on the experiment because it is a controlled variable. However it doesn't mean that we can use any kind of soil with any conditions. We should make sure on the soil consistently mixed to provide every pot can receive the same ingredient just like the others. Before starting to experiment the soil needs to be mixed. After that the mixed soil divided to be added to each pot as 160 ml. All the pots are filled with 160 ml of soil and the contrivance was ready for the

beans. In order to access same amount of sunlight, pots placed at balcony, in front of the same window. All of the plants kept in the same temperature and pressure by keeping them in the same place. The formation of pots is divided in 5 groups to observe easily and marked with the pen. (Diagram 1)

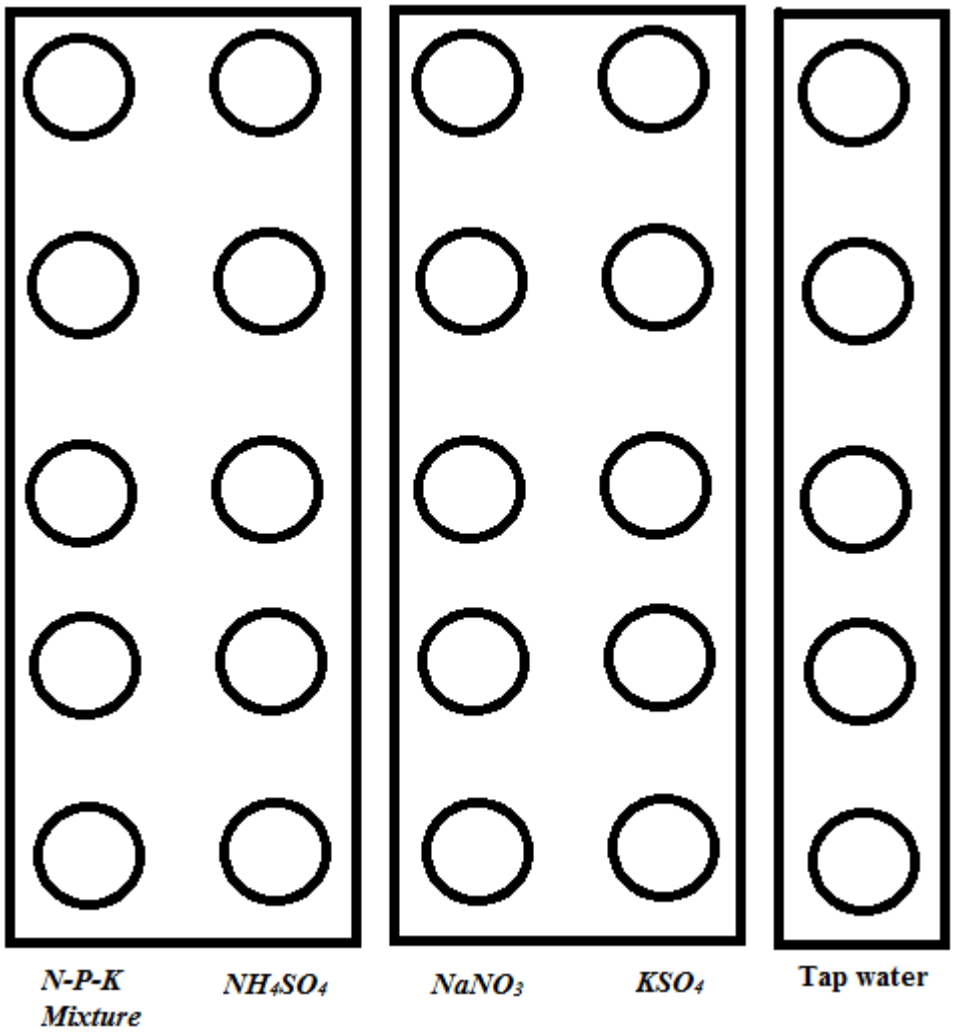


Diagram 1: The system made in the experiment. 25 of the pots divided into 5 groups.

Planting the seeds:

In total 25 seeds of *phaseolus vulgaris* used in this experiment. In order to prevent the random errors and alliteration on the results, the texture and shape of the seeds had to be same. 25 seeds are divided equally to 25 pots. (Diagram 2) 1 seed is planted in each pot. To prevent the effect of depth, all of the seeds are planted in the same depth, 2.0cm below the surface. Not any pressure had been applied on it while covering the seeds with soil.

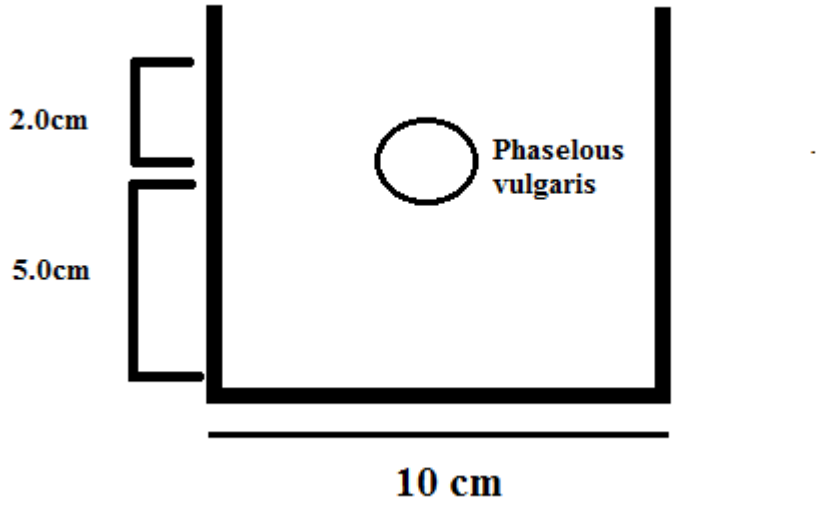


Diagram2: Diagram shows one of the prepared cup (experiment contained x25) (±0.1 cm)

Preparation of the water concentration:

Since the types of substances are the independent variable in this experiment it has the major role. In total there are 7.5 grams per each substance; ammonium sulphate, potassium sulphate, sodium nitrate, N-P-K mixture and 6250ml of water used. For the first group of five pots there were no any substances used while mixture since it resembles the control group of the experiment. (Only 25ml water per pot is used for this group of pots.

For the other pots preparation on the concentration with substances are very important. It needs to be mixed well with a help of spoon or stick until there are no any particles remains after mixture is done. 1.5g ammonium sulphate is mixed with 125 ml water and divided to 5 pots. This process is also valid for the other substances like potassium sulphate, sodium nitrate, and N-P-K mixture. In the end of the watering there are 1.5grams of substances used for each trial (1.5x4) and 625 ml of water (125x5) in total for that day.

Figure 4 The material used during the preparation of water concentration.

Preparation of the N-P-K mixture.

In order to get the N-P-K mixture I used KSO_4, $NaNO_3$, NH_4SO_4 substances and tap water. N-P-K mixture contains 0.1g of every one of the substance along with the 25ml of water. (It's only for 1 cup for 1 day) Make sure to mix well to get rid of the every particle and let them dissolve in the tap water. This process will continue during the entire experiment.

Watering the plants:

Time and the amount of watering are important. High or less amount of water will cause plant to die so better be preparing the amount by considering that. The watering of the plants happened once in two days at 14:00 with the help of a needless injector. Every plant has been watered 25ml each during the experiment once in two days. The experiment took 10 days to get the results.

Aluminium	2.39 µg/L
Ammonium	<0.02 mg/L
Chloride	0.53 mg/L
Colour	Suitable
Conductivity at 20°C	72.1 µS/cm
pH	7.90
Iron	< 1.0 µg/L
Manganese	< 1.0 µg/L
Odour	Suitable
Oxidizability	0.42 mg/L O2
Sulphate	5.73 mg/L
Sodium	1.74 mg/L
Taste	Suitable
Colony count at 22°C	0 / ml
Coliform bacteria	0 / 250 ml
Turbidity	Suitable

Table 1: Chemical properties of the water used during the experiment. (Erikli natural spring water)[9]

[9] "Erikli Natural Spring Water 500Ml." *Nutrition*. Tesca, n.d. Web. 22 Jan. 2015. http://www.tesco.com/groceries/product/details/?id=280611183

Results and Analysis

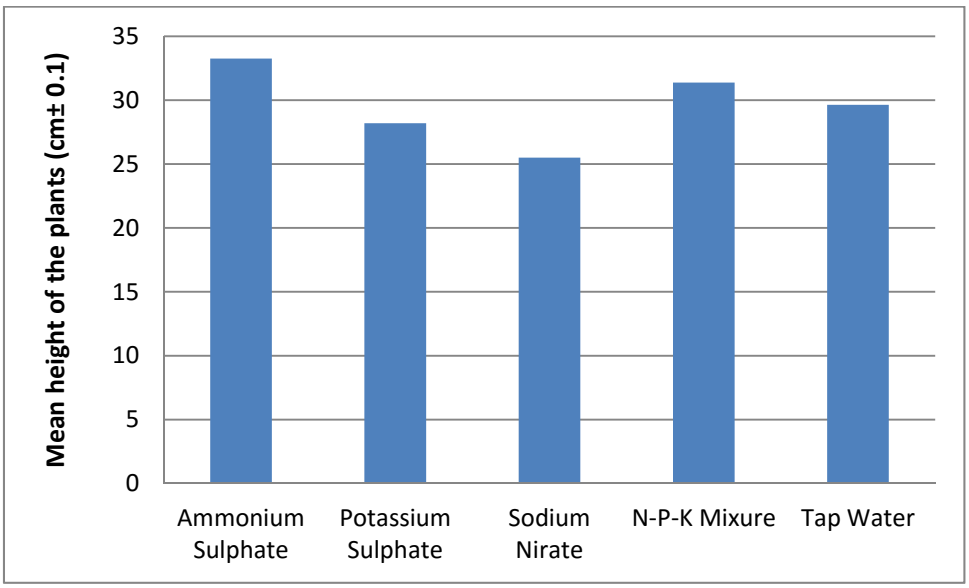
		Trials				
Type of the substance		1	2	3	4	5
	Day	Length of the plant (±0.01cm)				
Tap Water	1	0	0	0	0	0
	2	1.2	0.5	0.9	1.0	0
	3	4.3	3.5	4.2	3.9	2.3
	4	8.9	7.5	6.5	5.0	5.2
	5	13.4	12.5	11.1	12.5	10.5
	6	18.5	18.5	17.6	16.2	15.7
	7	22.8	23.0	21.0	20.8	19.9
	8	27.6	25.9	23.5	24.2	22.3
	9	30.0	28.5	25.9	26.0	25.8
	10	32.5	30.5	27.9	28.8	28.5
N-P-K Mixture	1	0	0	0	0	0
	2	1.5	1.5	0.7	0	0.3
	3	5.2	5.5	4.5	3.8	3.0
	4	8.7	10.8	7.9	5.4	7.0
	5	13.2	14.5	10,9	9.6	15.9
	6	17.8	19.9	15.7	13.7	18.2
	7	22.1	23.0	19.5	17.3	20.6
	8	23.9	25.1	21.8	22.5	24.2
	9	27.5	30.7	24.0	26.8	28.5
	10	31.4	34.5	28.9	29.7	32.4
KSO_4	1	0	0	0	0	0
	2	1.8	1.1	0.5	0.5	0.8
	3	3.3	2.9	3.7	3.2	3.5
	4	7.5	6.3	6.8	5.0	8.1
	5	9.2	8.8	14.5	7.3	15.5

	6	14.3	12.6	17.5	11.7	17.9
	7	16.8	15.9	19.8	15.5	20.5
	8	18.9	18.5	22.2	18.2	23.5
	9	23.9	25.3	25.9	22.7	27.2
	10	26.5	28.9	27.5	26.3	31.8
NH_4SO_4	1	0	0	0	0	0
	2	2.6	0	0	0	1.5
	3	6.0	0	4.7	5.0	5.7
	4	8.7	6.4	6.7	7.2	9.8
	5	14.5	9.8	10.0	9.5	12.4
	6	18.3	14.7	15.8	14.5	15.7
	7	23.2	16.9	18.0	17.9	18.9
	8	27.7	20.5	23.1	22.4	23.4
	9	32.0	26.3	27.9	27.0	28.1
	10	37.8	32.6	32.5	29.7	33.7
$NaNO_3$	1	0	0	0	0	0
	2	0	1.5	1.8	0	0
	3	0	2.9	3.5	2.1	1.9
	4	3.9	5.3	5.5	4.9	4.8
	5	6.4	8.9	10.0	8.8	9.5
	6	12.8	13.2	14.5	12.9	13.4
	7	14.5	15.3	16.5	14.4	15.9
	8	17.9	17.5	19.1	18.5	18.8
	9	20.0	21.4	23.5	21.7	20.2
	10	25.3	26.5	26.3	24.9	24.5

Table 2 (includes page 19 and 20): Raw data that shows the results measured length of the plants at different days with different substances and trials.

Type of substances	Mean Values	Standard Deviation
Ammonium sulphate	33.26	2.936495
Potassium sulphate	28.2	2.260531
Sodium nitrate	25.5	0.87178
N-P-K Mixture	31.38	2.221936
Tap Water	29.64	1.867619

Table 3: Mean and standard deviation values of final growth in terms of lengths (cm ±0.1) in different substances.



Graph 1: Final height of the plants (cm) in each different group (5x5) treated with different types of substances.

Group 1: Tap Water/ Group 2: N-P-K Mixture/ Group 3: Potassium sulphate/ Group 4: Ammonium sulphate/ Group 5: Sodium nitrate

Analysis of Variance (One-Way)

Summary

Groups	*Sample size*	*Sum*	*Mean*	*Variance*
Tab Water	5	148,2	29,64	3,488
N-P-K Mixture	5	156,9	31,38	4,937
KSO4	5	141,	28,2	5,11
NH4SO4	5	166,3	33,26	8,623
NANO3	5	127,5	25,5	0,76

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*p-level*	*F crit*
Between Groups	176,6776	4	44,1694	9,6364	0,00016	3,73125
Within Groups	91,672	20	4,5836			
Total	268,3496	24				

.**Table4:** ANOVA results.

Observing the table shows that the experiment is based on collecting data to find the mean values for heights with different substances. The plants that watered with NH_4SO_4 gave the best results and higher mean values than the other consequences. (To check the information look at the Table2)

Adding substances to water and mixture of them didn't always give the higher mean values and this made the trials which been watered only by tab water by 3rd higher in mean values. (Check Table3) Also N-P-K mixture which balanced by all other three substances couldn't pass the substance which content only Nitrogen and it made it 2nd in higher mean values. This shows the requirement of the Nitrogen of plants in growth is the most and it is much essential than the others. (Table3)

Anova Analysis

P-level: 0.00016 < 0.005 (the ANOVA test was applied on the data and found 0.00016)

In order to find out significance of the effects of the independent variable on controlled variables, the ANOVA test is made on the data. (Table4) The result measured as 0.00016 and according to the test any p-level variation that is measured above 0.005 reduces the effects insignificant. The value of p-level variance is measured as 0.00016 after the data applied. This means it has been confirmed that the substances used in the experiment rather than only tap water has considerable effect on the growth of *P. vulgaris*

Discussion, Conclusion and Evaluation

The hypothesis was "**The *P. vulgaris* given water which has NH_4SO_4 concentration will be longer in terms of length in body"** and it is proved in the end of the experiment by the collecting data which is growth in terms of length (cm). The growth of plants was higher with using of substance which contains only nitrogen. This shows nitrogen is the most essential substance with plant growth in terms of length among the others. The N-P-K mixture which balanced and contains each one of the other substances couldn't also reach and pass it. The effect of it started to show itself as the days passed and it became more visible. The plants that were given a mixture of water and $NaNO_3$ substance is measured as 25.5, KSO_4 as 28.2, NH_4SO_4 33.26 and N-P-K mixture as 31.38cm in mean height. The plants been watered by only tab water is reached to 29.64. This result of the experiment reflects on height of the plants and the effects can be significantly visible between all of the trials with different substances.

In the experiment five groups of *P. vulgaris* were planted individual plastic flower pots into soil. Each four group has been watered with mixture of tap water and substances and the rest group been watered only with tap water. The experiment lasted for ten days and in this time period the

growth of the plants was observed and in the end of the each day the growth of plants measured and noted simultaneously.

Photosynthesis is an important factor at growth of plants. In order to control it the number of leaves been cut as long as no matter what the plant had only two piece of leaves left in each. Therefore the amount of photosynthesis of each plant makes became closer and the fact of photosynthesis on growth been tried to prevent its effect to the experiment.

The procedure had contained both random and systematic errors. Firstly, all of the measurements contain error because in the experiment they were all measured by rulers and watered by injectors which are non-sensitive equipment. These random errors also include false measurements of plants height due to human factor, non-accurate amount of water and soil use to the plants. Also there are some systematic errors occurred as well like water left in the degraded cylinder and injector and the high temperature of daytime caused evaporation of water. If the mixture wont mix well, the substances left in the water will cause errors to occur in the experiment and it will change the data unexpectedly. Some of the plants were late to start growing than the others because of a factor of random error caused by uncontrollable variables. Though these trials have mean value it doesn't mean there is no connection between the other trials.

To conclude, in this experiment I tried to find out which one of the major nutrients in plants as nitrogen, potassium and phosphorus or even all in equal amounts or just tap water will be more effective in the growth of plants in terms of lengths. In the end NH_4SO_4 which is using in produce of nitrogenous fertilizers turned out be give the longer data in terms of lengths. From my ESS lessons I already knew that role of Nitrogen in the growth of plants in terms of lengths and the experiment showed that in order to get longer results in lengths the fertilizers which contain mostly Nitrogen would be a better choice.

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