RESEARCH QUESTION

How does high amount of NaCl as in the Beyşehir,Konya affect interspecific competition of Phaseolus vulgaris humilis, Phaseolus coccineus, Phaseolus lunatus, Phaseolus vulgaris dermason indicated by growth in height?

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ABSTRACT:

The purpose of this experiment was to see which type of bean is a better interspecific competitor in a salty environment which is similar to the Beyşehir,Konya and more likely to survive in the salty environment of Beyşehir,Konya. And then my research question that I came up with is: How does high amount of NaCl as in the Beyşehir,Konya affect interspecific competition of Phaseolus vulgaris humilis, Phaseolus coccineus, Phaseolus lunatus, Phaseolus vulgaris dermason indicated by growth in height? Each bean types (5 bean from each type) were put into a plastic cup and covered with cotton and given water and left for germination for 10 days. After the germination step the beans were put into a pan containing salt free soil and left for growing in the pan for 14 days. The most growing one was accepted as the best interspecific competitor one and also as the most likely one to surive in Beyşehir,Konya's salty environment. In this experiment ANOVA test is used and which proved that salt increases the interspecific competition and causes a decrease in growth of the beans since the p-value is 0,011567. In the end the best competitor and the most likely bean type to survive was found as *Phaseolus coccineus* according to the growth it has shown.

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1. INTRODUCTION

My grandfather loves dealing with farming and he owns a field in Beyşehir, Konya and next year he has an intention to grow beans in his field. He mentioned no one but me about his intention to grow beans but he also told me that he is concerned about the high amount of salt found in the soil of Beyşehir. He also said that it is important that the bean type that he will grow in Beyşehir must be a competitor when compared to the other beans. After that, I decided to make a research on beans and their resistance to salt. My researches showed me that white beans, lima beans, snap beans and dermason beans are the most common bean types in Turkey and the ones that are relatively more resistant to the salt found in the soil as well as being the most consumed types. The most important thing that pushed me was my deep interest in growing plants. And I guess my interest in growing plants is originated from my grandfather. So on the light of all these I chose to investigate the interspecific competition of beans in salty earth.

> *"Interspecific competition refers to the competition between two or more species for some limiting resource. This limiting resource can be food or nutrients, space, mates, nesting sites-- anything for which demand is greater than supply. When one species is a better competitor, interspecific competition negatively influences the other species by reducing population sizes and/or growth rates, which in turn affects the population dynamics of the competitor. Competitive interactions between organisms can have a great deal of influence on species evolution, the structuring of communities (which species coexist, which don't, relative abundances, etc.), and the distributions of species (where they occur)."* [1]

Salt amount of the habitat increases the level of interspecific competition between plants by changing the osmotic pressure of the soil. There is also a salt tolerance level for each type of plant. Some plants can tolerate a little and whereas some can tolerate high levels of salinity. For plants, a salinity level more than they can tolerate will act like drought, it will avoid the absorption of water of plants.

Water contains dissolved form of various compounds of salt such as sodium sulfate, magnesium sulfate, and calcium carbonate and the salt in water are found as ions. Up to a certain amount, the ions can be helpful to plants. During absorption and transpiration of water, plants obtain some of the ions they need to survive and grow.

Unlike animals, plants get the minerals they need from soil by the help of their roots to form more complex molecules they need for their vital activities and growth. If a plant shows a poor growth, it is generally because of a lacking in minerals in the soil. The most known elements that are essential for plants are nitrogen, phosphorus, potassium and magnesium. My researches showed me that soil of Konya has NaCl more than other salts inside and this is the main reason why NaCl salt is used is in the experiment.

Salt exists in soil as dissolved ions which mean the mineral level in the soil increases as the amount of ions present in the salt increases. However, minerals are helpful to plant's growth and survival up to a certain level. On the other hand, when there is excess of salt ions it harms plants.

The water and minerals that plants need are absorbed by the roots of plants from the soil and conducted from roots to stems first and then to the leaves. The water and minerals are taken by the roots with osmosis. Osmosis is the movement of water and minerals through a selectively permeable membrane from a region of higher water concentration to a region of lower water concentration. Excess of minerals would prevent roots to perform their osmotic activity where water and nutrients move from low concentrated area to high concentrated area. Therefore, because of the salt levels in the soil, water and minerals would not be able to move into the plant roots.

With this experiment I am trying to find out whether the high salt amount found in the soil affects the interspecific competition of the bean and to and the chance to of survival or not. It is expected that, the most competitive and growing bean type will be the most salt tolerating and competitive bean since their environment, soil of Beyşehir, Konya is salty. The bean type that shows the best growth will be the most likely bean type to survive in the salty earth of Konya and the type that my grandfather will cultivate in Beyşehir, Konya.

In order to perform a controlled and manageable investigation, the experiment will be done in room temperature and in the same medium. Different types of beans will be utilized in this experiment and each type of bean will be watered by tap water. The names of the beans are white beans, lima beans, snap beans and dermason beans. The latin names of the beans are *Phaseolus vulgaris humilis, Phaseolus coccineus, Phaseolus lunatus, Phaseolus vulgaris dermason* respectively.

"*The ability of plants to tolerate salt is determined by multiple biochemical pathways that facilitate retention and/or acquisition of water, protect chloroplast functions, and maintain ion homeostasis*." [2] This quotation also shows that the bean types that can continue their daily functions can be a better interspecific competitor and these bean types are more likely to survive in a salty earth. As a result of my researches the hypothesis for this experiment, regarding my research question is; salty soil would create a change between different types of beans in terms of growth in height due to increasing interspecific competition. Whereas my null hypothesis is; salty soil would create no difference between different type of beans in terms of growth in height due to interspecific competition.

And my research question that I decided is "How does high amount of NaCl as in the Beyşehir,Konya affect interspecific competition of Phaseolus vulgaris humilis, Phaseolus coccineus, Phaseolus lunatus, Phaseolus vulgaris dermason indicated by growth in height?"

METHOD DEVELOPMENT

2.1 Preparation of the Experiment

I took 5 of each bean type (for each bean type five trials in total) and I started this experiment by germinating the beans for 10 days in a plastic cup covered with cotton. Since I would like to be sure that the germinating conditions are all the same, observing the specific competition between them would be easy. After the beans are germinated for 10 days in plastic cups, I decided to put them into the pan covered the beans with soil and I made measurements to be sure that they were in the same depth. They were both 5 cm under the surface of the soil. I looked for the most growing bean type and I took photos in every 3 days and continued the experimental process in pan for 14 days. Putting germinated beans into a pan and covering with soil allowed me to observe the specific competition, by looking at the growth of the coleoptiles.

The experimental setup is shown in Figure 1 below. The four different types of beans are placed in the middle part of the pan as shown. The beans are equally distant from the point that water and salt minerals are added into the soil which is 4 cm. The importance of such a placement is to eliminate the affect of distance to the source of water and minerals on the interspecific competition.

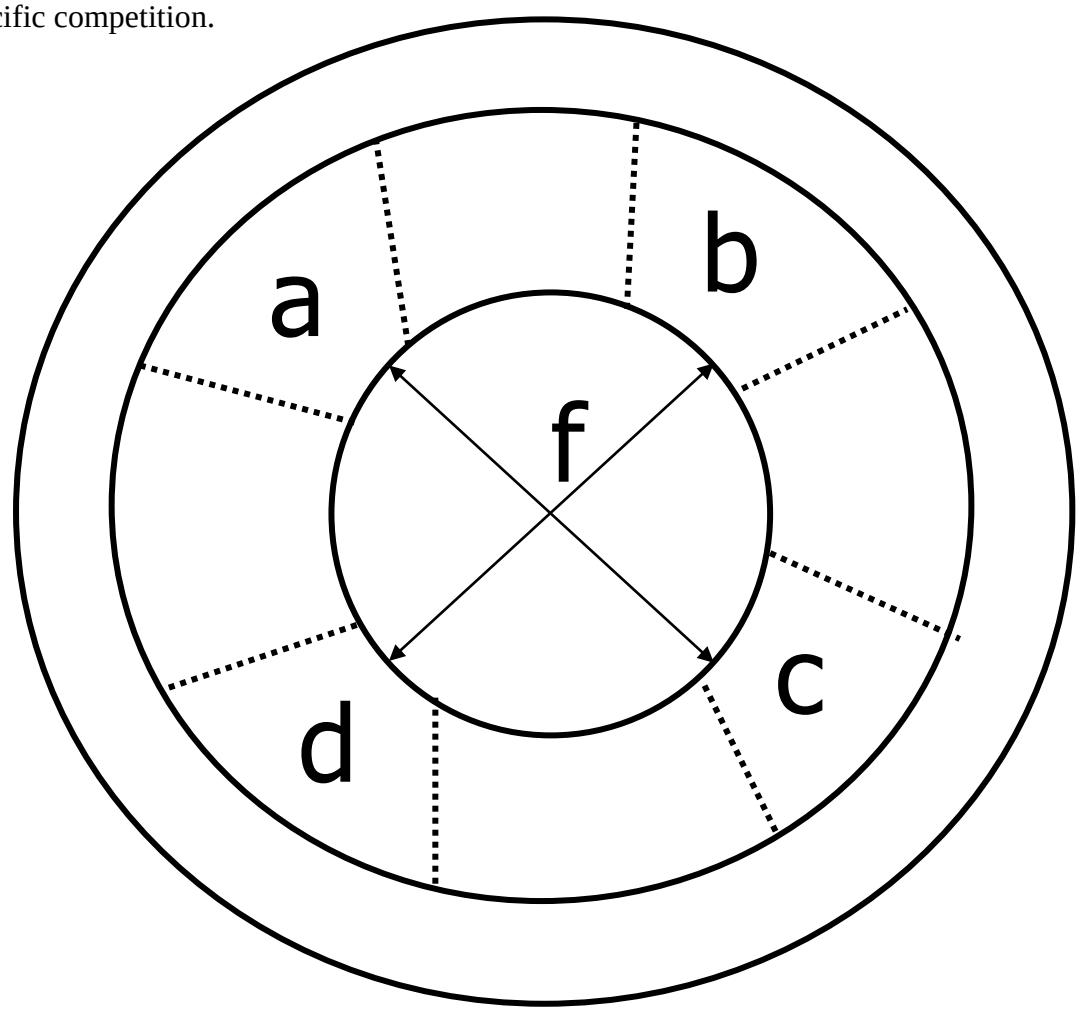


Figure 1: The experimental set-up

In this experiment the independent variable was the increased level of interspecific competition by planting beans in a single pan that has soil with high amounts of salt whereas the dependent variable was the ability to compete indicated by the amount of growth of the beans in a salt given soil. In order to observe only the affect of salt level in soil to the interspecific competition, I kept all the other factors constant.

My first constant variable was the temperature of the room which was 24.0°C. The temperature of the room was kept constant by the help of an air conditioner since temperature affects the enzymatic activities and the growth of the beans, at 24.0°C since 24.0°C is the room temperature.

The amount of cotton was another constant in this experiment during the germination of the beans of plastic cups. Each bean types were covered with 4grams of cotton below and 4 grams of cotton above.

One of my constant variables was the amount of salt given to the soil. My investigations showed that mostly found salt in the earth of Beyşehir, Konya is sodium chloride (NaCl) which is also known as table salt. Since it is an easy salt to find, I decided to use it. During the growth of the beans in soil, environment was made to be similar with the environment of Beyşehir and in order to keep it similar some amount of salt was needed to be given. Researches I made showed me that the salt tolerance needed for plants to survive in Beyşehir was measured as 4dS/m. "*Salt tolerances are usually given in terms of the stage of plant growth over a range of electrical conductivity (EC) levels. Electrical conductivity is the ability of a solution to transmit an electrical current. To determine soil salinity EC, an electrical current is imposed in a glass cell using two electrodes in a soil extract solution taken from the soil being measured (soil salinity). The units are usually given in deciSiemens per metre (dS/m*) [2] Since the dS/m was still unfamiliar with me I made more researches and got to the conclusion that $\frac{dS}{m} x\ 640 = mg/mL$. So I decided the amount of salt I should be adding to be 2.6 g with watering frequency of 2 days during the growth of the beans in both a plastic cup and in salty soil to make the soil similar to Beyşehir, Konya. The salt level in the soil in the pan was too low therefore I assumed that the soil to be salt free.

My other constant variables were light that is absorbed by the beans, amount of salt given by water, pH and the mass of beans. The amount of light absorbed by the beans were assumed same for all the beans since they were all getting the sunlight with approximately the same angle. During the experimental process pH is made constant at 7.8 by using tap water with a constant amount of table salt.

The amount of tap water given to each type of bean was another constant, so I decided to water all of the beans with 50mL of tap water when they were germinated in the plastic cups and then I gave 200 mL of tap water since giving too much water causes beans to die. I watered all the beans on alternate days.

I had some difficulties when I first planned to investigate the affect of different concentrations of salt in tap water on 4 different types of beans. However, I decided to keep the salt concentration constant since my aim was only to find out the effect of salty earth on interspecific competition between beans and the growth of beans.

The experiment is done at home. I put the beans into a pan that does not directly get the sunlight. So they are kept in shade and the room was aerated permanently during the experimental process. In a lab medium, it could be easier to control the temperature. For each type of bean, five trials are held and five samples for each species are germinated in order to get more accurate and scientific results.

2.2 Material List:

1. Temperature
2. Electrical Balance(sensitive enough to measure 0,1 gr)
3. Pan with a radius of 80cm
4. 10.4 gr of NaCl salt
5. 1,650mL of tap water
6. Ruler
7. 32 gr of cotton
8. 4 Plastic cups of 400mL
9. pH paper
10. Beaker
11. Soil(salt free) 3kg

2.3 Procedure

Part A: Germination

1. Take five clean plastic cups and cover their bases with 5 gr of cotton.
2. Put 5 beans from each bean types which are *Phaseolus vulgaris humilis, Phaseolus coccineus, Phaseolus lunatus, Phaseolus vulgaris dermason* in four different cups
3. Cover the top of each cup with 5 gr of cotton.
4. Indicate which type of bean is found in each plastic cup.
5. Water them with 50 ml of tap water on alternate days and let them germinate in the plastic cup for 10 days.

Part B: Growth in pan

6. Prepare a pan that has a salt free soil(3kg) in it.
7. Take all of the germinated beans *Phaseolus vulgaris humilis*(5beans) (a), *Phaseolus coccineus*(5beans) (b), *Phaseolus lunatus*(5beans) (c), *Phaseolus vulgaris dermason*(5beans) (d) from the cup and put them into the pan as in Figure 1. Make sure that they are 5cm below the surface of the soil.
8. Measure the length (cm) of coleoptile from the soil surface with a ruler and note this length(cm) as the initial height.

Be careful while putting the germinated beans from the plastic cup to the pan and measuring the heights of the germinated beans. Avoid damaging.

9. Add 200 ml of tap water that has 2.6 gr of NaCl salt from the watering region which is indicated as (e) in Figure 1 on alternate days.
10. After 14 days of growth in the pan, measure the length(cm) of coleoptile from the soil surface with a ruler and record this value as the final height(cm).
11. Make a initial-final height (cm) table showing the growth of each type of beans.
12. Calculate the mean growth values for each bean types. Use the mean growth values and make a column graph.

3. ANALYSIS

3.1 Raw Data Table

Table 1: Table showing the raw data including the initial heights (height of the coleoptile from the soil surface recorded immediately after germination) and final heights of the beans (the height of coleoptile from the soil surface recorded after growth in soil) and the constant variables; temperature, pH of the water, amount of water giving during germination in plastic cup and pan and the total amount of salt that is added.

Bean Types	Trials	Initial Heights in cm (±0.5)	Final Heights in cm (±0.5)	Temperature in °C (±0.5)	pH of the water (±0.1)	Amount of water given during germination in mL (± 10)	Amount of water given when beans are in pan in mL (±0.5)	Total Amount of salt added in g (±0.1)	Deepness of the beans in the soil in cm (±0.5)
Phaseolus vulgaris Humilis	1	2,5	3,5	24.0	7,8	50	60.0	2,6	5.0
	2	2,6	3,3						5.0
	3	2,8	3,5						5.0
	4	2,4	2,4						5.0
	5	2,5	3,7						5.0
Phaseolus coccineus	1	2,1	3,0	24.0	7,8	50	60.0	2,6	5.0
	2	3,0	3,0						5.0
	3	3,2	3,9						5.0
	4	3,8	4,1						5.0
	5	2,9	3,6						5.0
Phaseolus lunatus	1	22,4	40,1	24.0	7,8	50	60.0	2,6	5.0
	2	20,1	28,9						5.0
	3	20,7	30,4						5.0
	4	20,0	31,1						5.0
	5	24,4	45,7						5.0
Phaseolus vulgaris dermason	1	7,6	16,9	24.0	7,8	50	60.0	2,6	5.0
	2	11,3	17,7						5.0
	3	13,1	20,0						5.0
	4	21,2	30,1						5.0
	5	12,2	17,8						5.0

3.2 Change In Heights Of Germinated Beans

Table 2: Table indicating the initial and final heights of the germinated beans and the change in their height values.

Bean Types	Trials	Initial Heights in cm (±0.5)	Final Heights in cm (±0.5)	Change in Heights of germinated beans in cm (±0.5)
Phaseolus vulgaris Humilis	1	2,5	3,5	1,0
	2	2,6	3,3	0,7
	3	2,8	3,5	0,7
	4	2,4	2,4	0,0
	5	2,5	3,7	1,2
Phaseolus coccineus	1	2,1	3,0	0,9
	2	3,0	3,0	0,0
	3	3,2	3,9	0,7
	4	3,8	4,1	0,3
	5	2,9	3,6	1,3
Phaseolus lunatus	1	22,4	40,1	17,7
	2	20,1	28,9	8,8
	3	20,7	30,4	9,7
	4	20,0	31,1	11,1
	5	24,4	45,7	21,3
Phaseolus vulgaris dermason	1	7,6	16,9	9,3
	2	11,3	17,7	6,4
	3	13,1	20,0	6,9
	4	21,2	30,1	8,9
	5	12,2	17,8	5,6

From the table 2 above, it is seen that snap beans are the most growing bean types and the ones that have the ability to survive in a salty earth and compete with the other bean types, other organisms in order to survive.

There are two methods that can be used to analyse these data above. These possible methods are T-test or ANOVA. A t-test is used to assess whether the mean values of two groups are different or not. However t-tests are unreliable when two or more than two groups are to be compared. In contrast, ANOVA test is used to compare the mean values of more than two samples. To sum up, since my aim is to compare the heights of the four different bean types, it is more suitable to use the ANOVA test as the statistical test.

3.3 The ANOVA Table

Table 3: Table showing the ANOVA test results

Anova: Single Factor

SUMMARY

Groups	*Number*	*Sum*	*Mean*	*Variance*
Column 1	20	200,8	10,04	70,96253
Column 2	20	312,7	15,635	203,8729
Column 3	20	112,5	5,625	37,94934

ANOVA Variance Source	SS	df	MS	F ratio	P-value	F-probability
Between groups	1006,642	2	503,3212	4,827484	0,011567	3,158843
Within groups	5942,911	57	104,2616			
Total	6949,553	59				

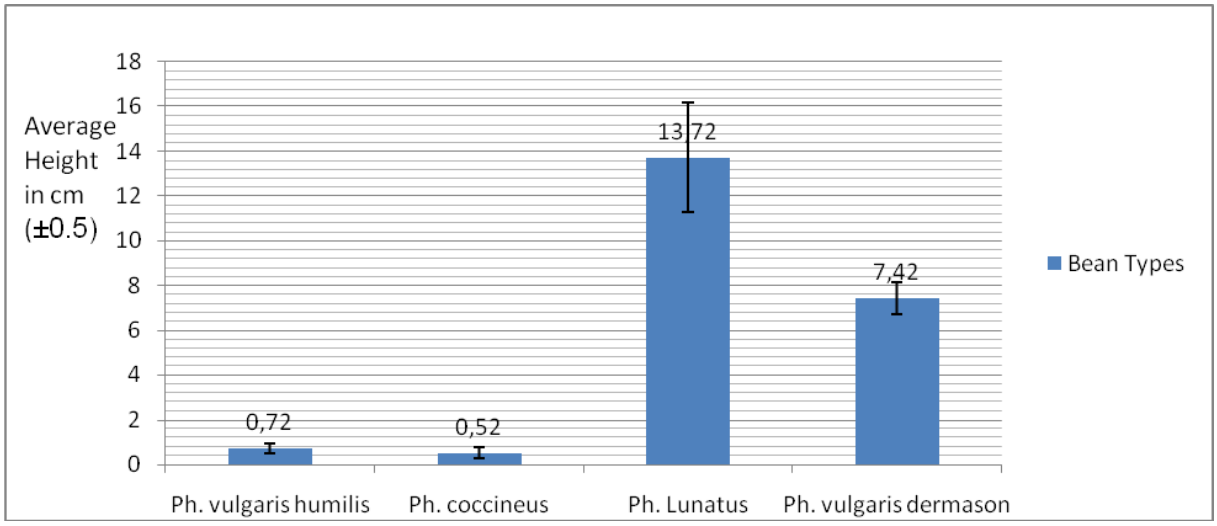
The statistical method used above is ANOVA test which is used when we have two or more different groups to compare. The P-value on ANOVA tests directs us on whether we should accept the null hypothesis, which is “salty soil would create no difference between different type of beans in terms of growth due to interspecific competition”, or rejecting it and accepting the hypothesis. The ANOVA test directs us with the P-value that is calculated by “MICROSOFT EXCEL” and when the P-value is smaller than 0,05 we reject the null hypothesis and accept the hypothesis. Since it is 0,011567 in this experiment, I accepted my hypothesis which is “Salty soil would create a change between different types of beans in terms of growth due to increasing interspecific competition”.

3.4 Descriptive Table

Table 4: Table showing the mean values, standard deviation, median and variance of the changes in the height for each bean type.

Bean types	Mean of the change in the heights of the germinated beans	Standard Deviation	Median	Variance
Phaseolus vulgaris Humilis	0,72	0,45	0,7	0,207
Phaseolus coccineus	0,52	0,51	0,7	0,258
Phaseolus lunatus	13,72	5,49	11,1	30,132
Phaseolus vulgaris dermason	7,42	1,61	6,9	2,587

The table 4 above shows the mean values of changes in the heights of the germinated beans. It can be seen that snap beans had the highest change whereas white beans had the lowest change. From this table it can be seen that it will be better if my grandfather grows snap beans since they are affected less from the salt in the soil.



Graph 1: Graph showing the mean values of the change in the heights of the germinated beans for each type of bean.

In the graph 1 above the mean values of the change in the heights of the germinated beans are labelled. The graph shows that the *Phaseolus lunatus* had the highest growth even if they are given salt during the watering action. And it also underlines that *Phaseolus coccineus* had the lowest change in their heights. From this graph the result that I got to is; *Phaseolus lunatus* have a higher level of salt tolerance and they are the most competitive type among these bean types.

2. Conclusion&Evaluation

My research question in this experiment was "How does high amount of NaCl as in the Beyşehir,Konya affect interspecific competition of Phaseolus vulgaris humilis, Phaseolus coccineus, Phaseolus lunatus, Phaseolus vulgaris dermason indicated by growth in height?" The aim of this experiment is to find out which type of bean is the most competitive and the most suitable one for my grandfather to grow in Beyşehir where soil is salty. Researches I made showed me that not every plant is salt tolerant and not all of them can continue their life functions in a salty earth. As a result of this, my hypothesis regarding my research question was "Salty soil would create a change between different types of beans in terms of growth due to increasing interspecific competition". Before growing the beans in the pan I expected some of the beans to die because of the salt in the soil and some bean types were expected to grow more than the other types.

In this experiment, I determined the affect of salt that is increasing the interspecific competition between the five different types of beans by measuring the heights of beans grown in a salty soil as in Konya. The experimental results were to be interpreted by a statistical method ANOVA test or a t-test. ANOVA is used in order to reach a reliable conclusion since there are more than two groups to be compared and ANOVA test is made by using "Microsoft Excel". In the ANOVA test the p-value allows us to accept null hypothesis and when the p-value is bigger than 0,05 it allows us to accept hypothesis. In this experiment the p-value is 0,011567 which means my hypothesis which is "Salty soil would create a change between different types of beans in terms of growth due to increasing interspecific competition" is accepted and my null hypothesis is rejected. The ANOVA test shows that the salt in the soil has an effect on survival of beans and it affects the interspecific competition between beans.

The significance of salt in this experiment is that salt increases the ion concentration in the medium which decreases the chance of plant getting water from the soil. Since the water concentration is decreased, a competition occurs between the beans. In a medium with a high amount of competition, only the best competitors can go on their life functions. In this experiment, *Phaseolus lunatus* is found to be the one that is more likely to survive.

In overall the result that I obtained from this experiment is that there the salt in soil decreases the chance of survival as it can be seen in the Table 1; one bean of the *Phaseolus coccineus* and *Phaseolus vulgaris humilis* had no growth and they discoloured,died eventually. Whereas *Phaseolus lunatus* had a mean growth of 13,72cm and *Phaseolus vulgaris dermason* had a mean growth of 7,2cm. And these results also show that the most salt tolerating and the best interspecific competitor bean type is *Phaseolus lunatus* since *Phaseolus lunatus* are the bean type that had the biggest change in their height in a salty earth. And since my hypothesis is proved, my experiment is successful according to my data.

Even if the results obtained from my experiment seems reasonable, there are some possible systematic errors. The first one is that even if the mass of beans are in controlled variables they were not same for all beans. The reason behind this was I had 5 of each bean types but not all of the beans in the same bean type were same in their sizes which also mean that they had different masses which indicate that they have different amount of organic materials in their endosperm. As far as I have been taught in biology classes as the amount of organic materials in endosperm increases the amount of growth is increased since required organic substances are present in the beans. The second one is that I assumed that they absorb the same amount of sunlight since they were not getting the sunlight directly and their distance to the light source was almost equal but since beans were not placed at the same place the angle of the coming light differs. I assumed that it is same since the angle difference is too small. Even in the same bean type beans might have different amount of chlorophyll which might be another error source. As I have been taught in biology classes chlorophyll is the organic material source of the plant and as chlorophyll amount increases the organic materials produced also increases and this results with an increased growth. Another possible error source might be the amount of photosynthetic enzymes present in the bean. Increased amount of photosynthetic enzymes means the amount of photosynthesis is greater and which enables the beans to grow more and faster. Even though these limitations cannot be solved fully the difference in the amount of organic materials in endosperm, the amount of photosynthetic enzymes and the amount of chlorophyll can be decreased by picking the beans from the same coleoptiles of the same plant.

As it can be seen from this experiment, soil that a plant is to be grown in is crucial since it affects the growth and the survival of the plants. I observed that salt in soil has different affects on different types of plants. For some of the bean types (like *Phaseolus coccineus*) a decrease in the amount of growth or even inhibition of growth is observed. On the other hand, some of the bean types (like *Phaseolus lunatus*) are not affected significantly by the salt in the soil. Another result that I obtained from this experiment is that when an excess amount of water is given to a plant, they are unable to continue their life functions. Besides, the salt in soil increases the interspecific competition between the beans and decreases the chance of survival of beans as predicted in my hypothesis. This is due to the fact that an excess amount of ions decreases the material transfer between the roots of the plants (beans) and the soil due to the osmotic pressure difference within the soil. Due to the problems such as hunger and air pollution that we encounter nowadays, the efficiency of the harvest has an even higher importance. Therefore, all possible factors affecting plant growth should be investigated thoroughly. These results highlight the importance of choosing the right soil and being aware of the optimum amount of water for the plant growth. In order to choose the right soil type or decide the right amount of water to be given, farmers must be well educated. Furthermore, to obtain the maximum profit from the harvest, education and experience are inevitable. With the well educated and experienced farmers, the efficiency of the harvest will increase.

In order to make the experiment more applicable in farming, the interspecific competition between the most competitive bean type (*Phaseolus coccineus*) and the most common herb in Beyşehir, Konya can be observed by using the local soil. And if I am to make this experiment my research question would be "*How does high amount of NaCl as in the Beyşehir, Konya affect interspecific competition between Phaseolus lunatus indicated by growth in height?* If the *Phaseolus lunatus* wins the competition, the farmers can be made to grow *Phaseolus lunatus* in the future and if I were to evaluate my this experiment I would investigate the optimum amount of water necessary to be given for *Phaseolus lunatus* to show the heighest growth.

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4. APPENDIX

Picture 1: Beans are germinated in plastic cups. The name of the beans are written to the sides of the plastic cups.

Picture 2: Picture of the 6th day of the germination process.