Research on the effects of applying different amount of Fe element on *Solanum lycopersicum* during soilless agriculture

Extended Essay (Biology)

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Word Count: 3856

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Abstract

As the global warming threatens the word, the water sources consume and fertile lands exhaust scientists try to find new solutions to hunger. Soilless farming (hydroponics) is one of those solutions; soil becomes unnecessary in agriculture by that process. Other materials such as perlite, gravel, clay or Styrofoam is used instead of soil. Fe is an indispensable matter for plant grows as it takes place in chlorophyll synthesis reactions. Therefore it must be given to plants in an optimum ratio and different amount of Fe will cause different results in a plant. The objective of the study is to investigate whether are the different amounts of Fe effective at increasing the growth rate of *Solanum lycopersicum*, during soil less farming or not? During the experiment Fe element was given to plants within the water. Three groups developed, one of them does not contain any Fe whereas one group contains 2 mg per liter and the last one 5 mg per liter. The plants irrigated daily and observed five months in order to see the effects of different amounts of Fe element by taking measurements of the stem length and observing the color and amount of tomatoes produced.

It was found that there comes a significant difference if the amount of Fe changes during soilless farming. As the amount of Fe increases the growth rate increases; however the excess amount of Fe causes toxicity which gets us into a conclusion that there is an optimum value which gives the highest yield. Using less or more amount of Fe causes nominal yield.

Word Count: 260

Introduction

One day when I was reading newspaper I saw an article related with soilless agriculture. Then I got interested in that topic as it is hard to believe that plants can live without soil. I found out that soil less agriculture is getting more universally popular also it becomes famous in our country. As global warming threatens the world, the water resources consumes and fertile lands exhaust, therefore soil less agriculture is thought as a fine solution for that problem.

Soil less agriculture can be defined as: *"Hydroponics (soil less agriculture) is a growing medium for plants without soil, having the nutrients and minerals absorbed on solids or dispersed in water. Soil less agriculture yields produce sooner, increases production, reduces space requirements and better tasting and better quality produce is obtained. "*[1]Therefore soilless agriculture increases yield, prevents lack of space, moreover it enhance the quality of nutrients.

As I got interested in that subject I researched which plant best gives results during soil less growth and I found that *Solanum lycopersicum;* from *plantae* kingdom, *solanales* order, *solanacae* family and *solanum* genius is the best.[2] On account of it has chenille root it can absorb water and microelements from solution easily and it does not need specific conditions for living. Therefore it is the most suitable plant to use in experiments. Then I started to investigate the *Solanum lycopersicum* and found that one of the most effective substances for increasing growth is Fe. On account of Fe element is the most important material, as it causes chlorophyll synthesis and protein sythesis[3], I decided to change the amount of Fe in order to observe the effect on the growth.

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[1] http://ciftci.ksu.edu.tr/dokumanlar/topraksiz_tarim.html

[2] Prof. Dr. Rıfat YALÇIN

[3] http://www.drtarsa.com/BitkiBesleme.aspx?sayfa=izelement

Fe is usually used as a solution Fe EDTA during hydroponics, thus in order to observe the effects of different amounts of Fe element, Fe EDTA must be used and given in different amounts.

In conclusion, this paper will focus on the research question: "Are different amounts of Fe EDTA solutions effective at increasing the growth rate of Solanum lycopersicum, during soil less farming? " And will discuss experiment was planned and performed, the validity and the accuracy of the collected.

Hypothesis

The *Solanum lycopersicum* which is also known as tomato is one of the most produced fruit all over the world, which is also used greatly in our country. Moreover, Turkey ranks fourth in the world production of tomato.[4] It is also claimed that tomato fights with cancer, iron deficiency anemia which increased the consumption of tomatoes.[5, 6] Furthermore, tomato can easily produced by soil less farming which also increases the yield.[7] The ingredients of tomato also includes Fe and it is clear that Fe especially Fe (III) is effective at *Solanum lycopersicum* growth[8] as it has an important role during the chlorophyll synthesis. Fe takes place as a cofactor in the enzyme used in chlorophyll synthesis. Besides it has an important role for plants in protein synthesis, chlorophyll production, O_2 transportation, enzyme system responsible for respiration and nitrogen binding in roots.[8]

As Fe is highly reactive with oxygen element it cannot be added to plants directly it must be placed in a kind of compound such as Fe EDTA. The Fe EDTA is the most used synthetic chelating agent used for keeping Fe (III) soluble in nutrient solutions for hydroponics.[9] Therefore Fe EDTA is the most suitable matter in order to change the amount of Fe given to the plants, as it includes Fe element in a form that the plants can easily absorb the Fe element. Fe EDTA solution is containing iron element and other microelements which are necessary for tomato during hydroponics. Thus, because of tomatoes containing iron and the Fe EDTA solution includes iron beside other microelements Fe EDTA can give different results with tomato in hydroponics.

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[4] http://www.igeme.org.tr/Assets/sip/tar/tomatoproducts_07.pdf

[5] https://www.worldhealth.net/news/tomato_ingredients_fight_cancer

[6] http://www.healthcastle.com/iron.shtml

[7] http://www.aquaponics.com/InfoHydroponics.htm

[8] http://www.drt.com.tr/blog/labels/domates.html & See Appendix 1

[9] http://www.soils.wisc.edu/~barak/virtual_museum/edta/index.html

Those results can be positive or negative. For example the lack of iron causes some diseases or death whereas the excess can result with toxicity.[10]

Therefore it can be hypothesized that: **The different amounts of Fe EDTA solutions are effective at increasing the growth rate of *Solanum lycopersicum* during soil less farming.** The amount of iron affects the rate of growth of *Solanum lycopersicum* during soil less farming.[11, 12] That will cause an observable change on the *Solanum lycopersicum*. That change can be observed by the stem length and when they start to produce fruit the number of them will be counted. Moreover some qualitative data will be noted such as the size or color of the fruits, color of the leaves.

[10] http://www.ansci.cornell.edu/plants/toxicagents/iron.html

[11] http://www.springerlink.com/content/j018028678655800/

[12] http://aem.asm.org/cgi/content/abstract/AEM.02738-08v1

Method Development and Planning

Designing a suitable method in order to support or disprove the hypothesis is very important. Therefore the factors that changes the results of the experiment must be find and that must be kept under control.

In order to find the necessary microelements which will be added to the solution, the ingredients of the tomato must be carefully investigated. And as the concentrations of the Fe EDTA must be changed I must prepare the solution myself. Furthermore as there won't be any soil used plants must take all necessary elements from the solution. Therefore a detailed research for that is very important.[13] The microelements, (K, Ca, Mg, Fe, Zn, Cu), which will be given by the distilled water will be the only source the plant can take its necessary elements. (See Appendix 1)

If the soil is not used the choosing of the solid in which the plant will grow is very important. And after a detailed investigation[14] it is found that perlite is the most suitable one for the soil less farming. **Perlite** is an amorphous volcanic glass that has relatively high water content, typically formed by the hydration of obsidian. [15] Furthermore Turkey is one of the producer countries in the World (See Appendix 2) which helps me find it easily. On account of perlite is absorbing water and make the surface moist, it is a very usable material for soil less farming.

In order to try to produce equal length germs and start the experiment with them the germination of the tomatoes must be occurred under control. Thus it is decided that the experiment will be evolved in two phase. At the first phase the germination will occur in the

[13] http://www.topraksiztarim.net/

[14]http://minerals.usgs.gov/minerals/pubs/commodity/perlite/mcs-2008-perli.pdf

[15] http://en.wikipedia.org/wiki/Perlite

soil and the equal length of the same type tomatoes will be produced. (See Diagram 1) After that at the second phase the seedlings will be transferred into perlite and the investigation of the different amounts of Fe starts.

Before developing the control and experiment groups it is necessary to go to an Agriculture Faculty and take suggestions from a professional. Thus I went to Ankara University Agricultural Faculty and took suggestions from Prof. Dr. Rıfat YALÇIN. He helped me while deciding the control and experiment groups and the ratios of the ingredients which must be added.

The deciding of control and experiment groups is very important. In order to observe the difference according to Fe EDTA amount, creating three groups is the optimum. Deciding the amounts of the Fe EDTA is very important, which was investigated and asked to Prof. Yalçın. One of them will not contain any Fe EDTA, which will be the control group. The second one will contain 2 mg/L Fe EDTA which is a literature value, whereas the third one will contain 5 mg/L which have been decided by the suggestions of Prof Yalçın. As he said it would be better if twice is used in amount to get reasonable results. In order to get accurate data all groups will contain 3 pots, which gives 9 pots as a result. Each pot will contain 2 seedlings, so if one of the seedling in a pot dies, data collection could continue.

On account of sustaining optimum atmospheric conditions (light, atmospheric gases) it would be more favorable if they are placed at least 10.0 ±0.1 cm far from each other. However, that distance must be increased, when the plants grow and develop. In order to prevent shading, when the plants starts flowering and tomato formation occurs, the distance between each pot must be at least 20.0 ±0.1 cm. That would also prevent affection from moist coming from other pots. Decision for the place is vital for the experiment. Plants must absorb the sunlight

efficiently and the air circulation must be stabilized. Therefore, a balcony getting sunlight at least 6 ±0.5 hours in a day is the most suitable place for that. Our balcony orients to the south and gets the sunlight at least 6 ±0.5 hours in a day. Due to this fact the experiment could be performed in our balcony, which is also easier than performing it in a garden far away from my house.

Preparing the solutions with serious attention is very important. Plants will take all microelements from that solution, and any difference in the solution will affect the growth rate. Consequently the investigation of the amount of ingredients is vital. Those ratios of chemicals were taken from Prof. Yalçın.[17] By those ratios the solutions must be prepared carefully. Thus, first a 15 liter solution must be prepared by multiplying the ratios with 15, in a 19 liter bottle by adding all chemicals without Fe EDTA. After stirring thoroughly, that mixture must be divided into 5 liter bottles and Fe EDTA can be added at that phase. Applying this procedure will prevent the differences of other materials, moreover mixing in a bigger bottle will provide all chemicals dissolve and form a concentrated solution. It prevents precipitation as all chemicals completely dissolve.

After preparing the solution, an effective irrigation system must be created. I remembered a way which we were using in our garden, it was “trickle irrigation” .(See Photo 1)Than I tried to apply it to my project and made some investigations. I found that during hydroponics trickle irrigation is the most suitable one.[18] Trickle irrigation is one of the most popular ways in these days as it provides high yield by preventing water loss. Moreover, lots of materials used for hydroponics cannot absorb water, thus the plants must get water all the time which is provided by trickle irrigation. On the other hand usual trickle irrigation systems are produced for large fields and not suitable for micro projects like mine. Thus, I thought that aquarium

[17] See Appendix 1 and Table 1

[18] http://en.wikipedia.org/wiki/Drip_irrigation

materials can be used. By using bottles and handling the ‘water flow control’ materials (See Photo 1) under them that problem can be solved. The ‘water flow control’ materials will be connected with thin pipes and that pipes will carry the water from bottles to the pots (See Diagram 2). By that way the irrigation will be regular and there won’t be any water loss.

Diagrams:

Diagram1: Diagram illustrating the first phase of the experiment when the seeds grow in soil.

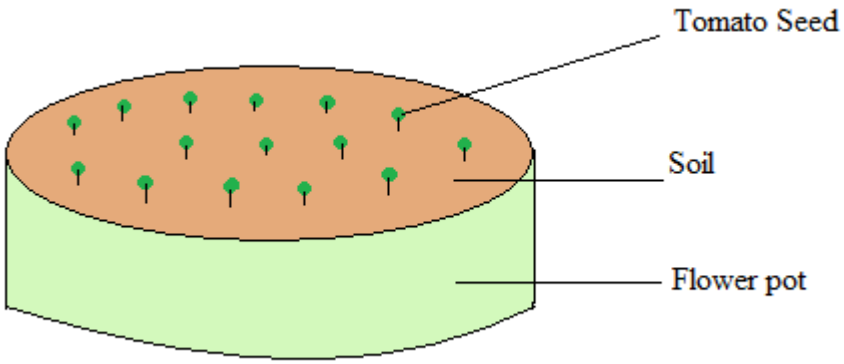
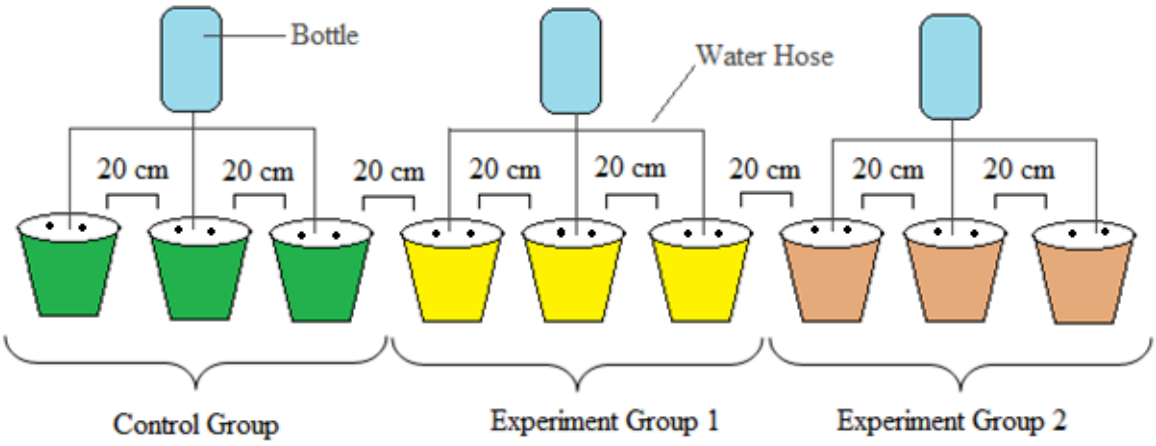


Diagram 2: Diagram illustrates the setup of the experiment in the second phase which the seeds are planted into 9 pots in order to develop 2 experiment groups and the control group. The pots are separated with 20 cm distance from each other.



Method

Materials and Apparatus:

Flower pots 3 dm^3(X9),

Flower pot 2 dm^3,

Solanum lycopersicum seed,

1dm^3 ml soil,

18dm^3 ml perlite,

Bottle 5000ml (X3),

Bottle 1000ml (X3),

3 meter water hose (thickness: 0.33 cm),

Trickle water materials (hose) (X3),

Distilled water,

Digital weight,

50 cm Ruler,

TI-84 Plus,

Labels(X9),

Pen,

$KNO_{3(s)}$,

$Ca(NO_3)_{2(s)}$,

$MgSO_{4(s)}$,

$NH_4H_2PO_{4(s)}$,

Fe $EDTA_{(s)}$,

$H_3BO_{3(s)}$,

$ZnSO_{4(s)}$,

$CuSO_{4(s)}$

1. Phase:

At the first phase of the experiment, 1 dm^3 soil was poured into a 2 dm^3 flower pot and a packet of tomato germs (which includes approximately 40 germs) added on them. The flower pot placed inside the room in order to keep the temperature constant and 22 C° is optimum for tomatoes germination which is exactly the temperature where the flower pot placed.(See Diagram 1) Than experiment continues until the seeds get longer enough (10 cm) to put into perlite, which cause nearly 1 month.

2. Phase:

After 1 month later, when the seeds get 10 ±1 cm lengths they were taken from soil and put into perlite. From now on hydroponic farming started which constitutes the second phase of the experiment. 3dm^3 (X9) pots taken and 3 groups formed. Experiment group 1 was the one which will get 2.0 ±0.1 mg/L Fe EDTA. 3 pots were taken and labeled as “Experiment group 1” then 2 dm^3 perlite poured in each of them after that the seeds planted as 2 seed had planted

in each pot. Than each pot placed 20 ±1 cm far away from each other, this prevents overshadowing. That procedure was repeated for the other 6 pots that develop the "Experiment group 2" containing 5.0 ±0.1 mg/L Fe EDTA and "Control group" not containing any Fe EDTA.

To prepare the solution that floods the plants $5dm^3$(X3) bottles were taken. By using the data given at Table 1, the necessary chemicals for tomato were measured by digital weight and mixed with distilled water and stirred thoroughly until all chemicals had dissolved.

Chemicals:	Experiment group 1	Experiment group 2	Control group
$KNO_{3(s)}$	606.30±0.1 mg/L	606.30 ±0.1mg/L	606.30±0.1 mg/L
$Ca\ (NO_3)_{2(s)}$	656.00 ±0.1mg/L	656.00 ±0.1mg/L	656.00 ±0.1mg/L
$MgSO_{4(s)}$	490.32 ±0.1mg/L	490.32 ±0.1mg/L	490.32 ±0.1mg/L
$NH_4H_2PO_{4(s)}$	115.10±0.1 mg/L	115.10 ±0.1mg/L	115.10 ±0.1mg/L
Fe EDTA$_{(s)}$	**2.00 ±0.1mg/L**	**5.00 ±0.1mg/L**	**0 mg/L**
$H_3BO_{3(s)}$	2.86 ±0.1mg/L	2.86 ±0.1mg/L	2.86 ±0.1mg/L
$ZnSO_{4(s)}$	0.22 ±0.1mg/L	0.22 ±0.1mg/L	0.22 ±0.1mg /L
$CuSO_{4(s)}$	0.08 ±0.1mg/L	0.08 ±0.1mg/L	0.08 ±0.1mg/L

Table 1: The necessary chemicals per Liter during hydroponics

Preparing an effective irrigation system is really necessary in hydroponics, as the plants cannot take the microelements and minerals from soil they take it from water. Therefore a system prepared which includes $1dm^3$(X3) bottles and 3 meters water pipes, these bottles were placed on flower pots and holes opened under them (See Diagram 2). By using trickle irrigation materials the water flow was controlled. Meanwhile, all pots were having same amount of water by that way and they were irrigated regularly. The solution prepared before were poured in that 1 dm^3 bottles every other day so the plants could get exactly 165 ±1 ml solution each day which is the optimum value. The other conditions tried to be kept under control.

The stem length of the tomatoes were measured by 50 cm ruler for four and a half months bi weekly and when they started to produce fruit the number of them were counted. Then t-test will be applied on those data. Moreover some qualitative data were noted such as the size or color of the fruits, color of the leaves.

Results

	Stem Length of Tomatoes (cm ±0.1) (Measured for 4.5 months bi weekly)											
	2009	29 March	12 April	26 April	10 May	24 May	7 June	21 June	5 July	19 July	2 August	16 August
Experiment Group 1	1.pot 1.plant	10.1	12.4	14.4	17.6	21.4	24.7	28.8	32.6	34.1	36.2	36.2
	1.pot 2.plant	9.9	12.0	13.9	16.9	21.2	23.9	28.3	32.4	34.0	35.3	35.3
	2.pot 1.plant	9.9	12.1	13.8	17.1	21.4	23.4	27.9	31.8	33.6	34.5	34.5
	2.pot 2.plant	10.0	12.3	14.1	17.4	21.1	22.8	26.7	30.1	32.8	33.2	33.2
	3.pot 1.plant	10.1	12.6	14.6	18.1	22.6	24.7	28.8	32.9	35.3	36.4	36.4
	3.pot 2.plant	9.9	11.9	13.6	17.2	21.1	24.2	29.8	34.4	38.4	39.2	39.2
Experiment Group 2	1.pot 1.plant	9.8	11.9	15.1	18.4	21.8	26.3	31.8	36.2	39.8	41.2	41.2
	1.pot 2.plant	10.1	12.1	15.4	18.6	23.1	27.8	33.1	38.0	40.5	42.0	42.0
	2.pot 1.plant	10.0	11.8	15.0	18.2	22.6	26.4	30.8	35.4	39.1	40.4	40.4
	2.pot 2.plant	9.9	11.7	14.8	17.9	22.9	27.2	31.5	36.7	40.6	42.3	42.3
	3.pot 1.plant	9.8	11.8	15.6	19.2	23.6	28.2	33.2	38.2	41.8	43.2	43.2
	3.pot 2.plant	10.3	12.2	15.3	18.6	23.1	27.4	31.6	36.1	39.8	42.6	42.6
Control Group	1.pot 1.plant	10.1	11.5	13.1	14.3	16.2	19.3	22.4	24.6	24.9	25.3	25.3
	1.pot 2.plant	9.7	11.4	13.0	14.1	15.9	18.7	21.1	23.9	24.2	24.4	24.4
	2.pot 1.plant	9.9	11.4	13.2	14.6	16.5	20.6	23.4	25.2	26.1	26.6	26.6
	2.pot 2.plant	9.9	11.1	13.6	14.9	16.8	19.7	22.2	23.9	25.0	25.8	25.8
	3.pot 1.plant	9.8	10.9	12.9	14.1	15.9	18.7	21.6	23.1	24.0	24.9	24.9

	3.pot 2.plant	10.2	12.1	14.2	15.1	16.7	18.8	21.3	24.2	25.1	25.7	25.7

Table 2: The stem lengths of the tomatoes' measured bi weekly.

	The total growth lengths of the tomatoes (cm ±0.1)		
	Control Group	Experiment Group 1	Experiment Group 2
Pot 1 Trial 1	15.2	26.1	31.4
Pot 1 Trial 2	14.7	25.4	31.9
Pot 2 Trial 1	16.7	24.6	30.4
Pot 2 Trial 2	15.9	23.2	32.4
Pot 3 Trial 1	15.1	26.3	33.4
Pot 3 Trial 2	15.5	29.3	32.3

Table 3: The mean growth lengths of the tomatoes between March and August

Total Numbers of Tomatoes Produced in 5 Months								
Control Group			Experiment Group 1			Experiment Group 2		
1. Pot	2. Pot	3. Pot	1. Pot	2. Pot	3. Pot	1. Pot	2. Pot	3. Pot
0	0	0	5	8	6	3	3	5

Table 4: Total Numbers of Tomatoes Produced in 5 Months

Unpaired sample T-Test done to compare two sets of data of experiment to see whether data can be considered to be same or not

H_0: $\mu = 0$ Null hypothesis stating that there is no significant difference between two sets of data.

H_1: $\mu \neq 0$ There is a significant difference between two sets of data.

	Control Group Total stem length grow (cm ±0.1)	Experiment Group 1 Total stem length grow (cm ±0.1)	Experiment Group 2 Total stem length grow (cm ±0.1)
Number of data	6	6	6
Mean	15.516	25.816	31.966
Median	15.350	25.750	32.100
Range	2	6.1	3
Standard deviation	0.705	2.047	1.013
Variance	0.497	4.189	1.026
Standard error	0.118	0.341	0.168
Confidence interval	0.564	1.638	0.810

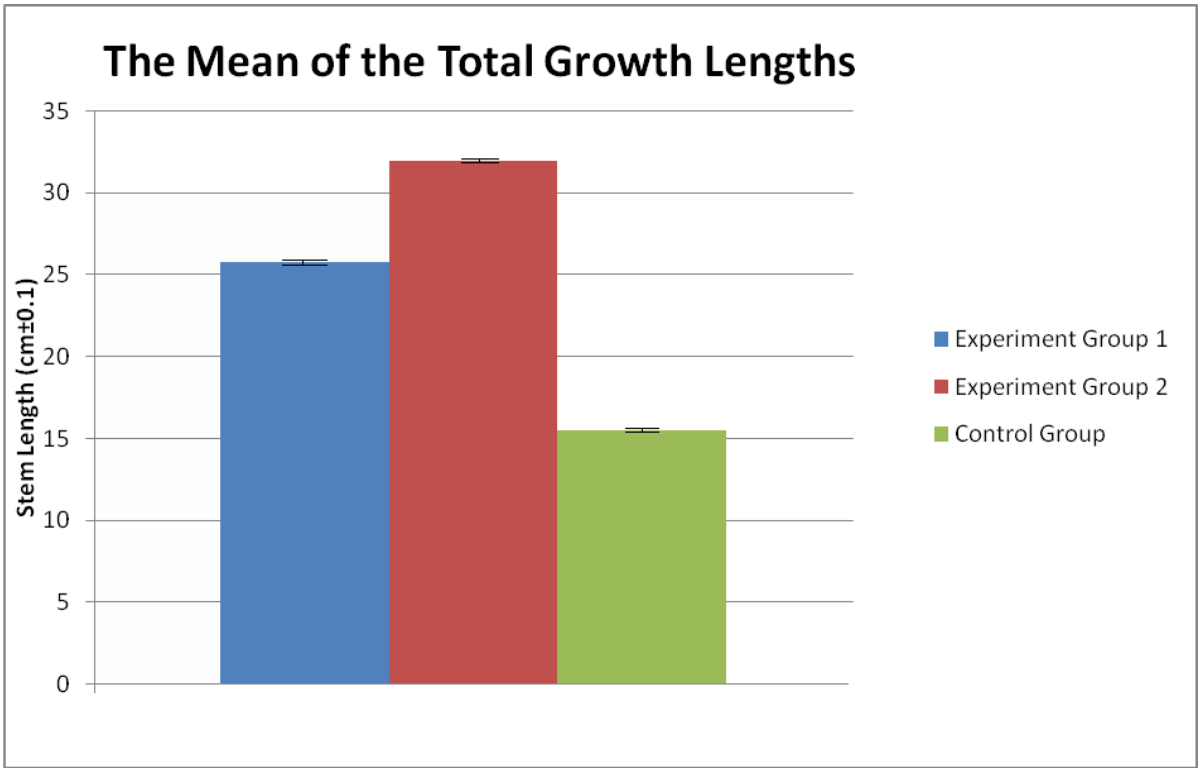
Table 5: *Statistical analysis of data collected from stem length*

T-test results: *(T- test done by using TI-84 Plus)*

Applied on Control Group and Experiment Group 1: 6.467×10^{5}

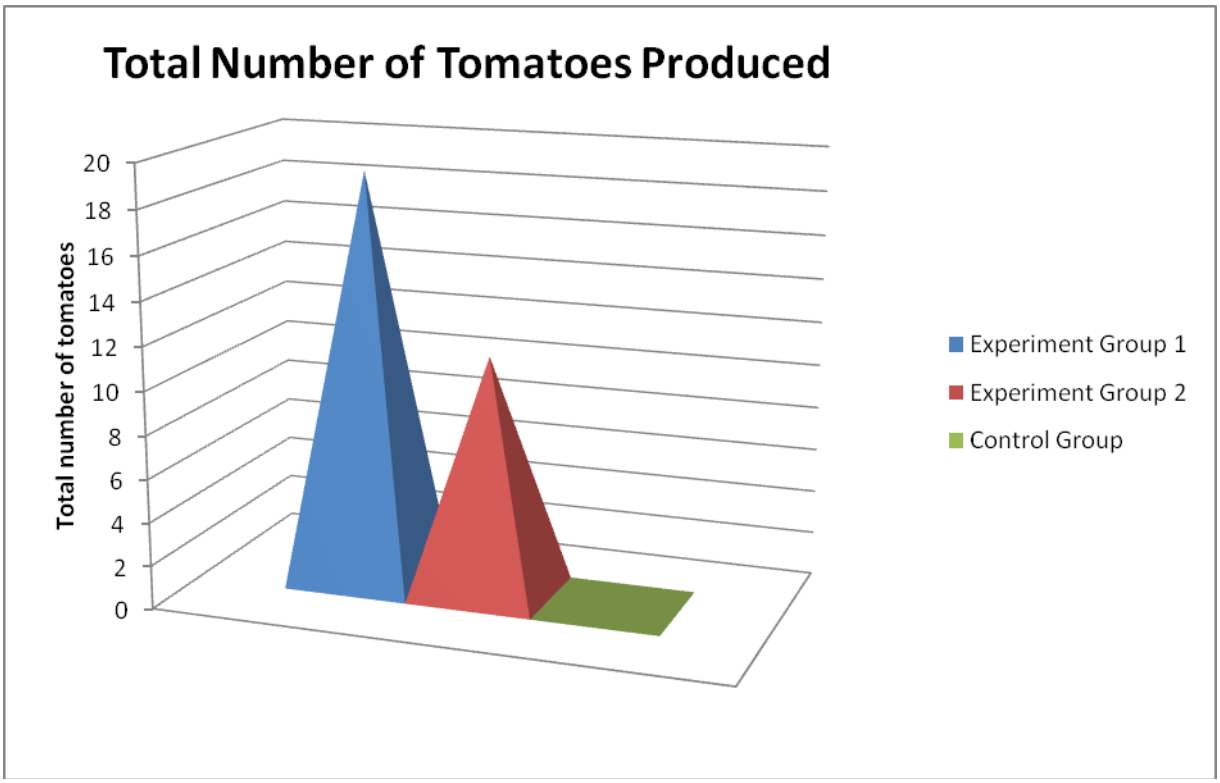
Applied on Control Group and Experiment Group 2: 7.424×10^{7}

6.467×10^{5} and 7.424×10^{7} are smaller than 0.05 and $\mu \neq 0$ so I can reject my null hypothesis. By rejecting the null hypothesis I accepted that there are significant differences between two sets of data.



Graph 1: The total growth lengths of the tomatoes

The grow lengths of stems of the plants have given in the Graph 1, when that graph is analyzed it is clear that there is a significant difference between the results of the experiment groups and the control group.



Graph 2: The total number of tomatoes produced

It is clear that there is a significant difference between groups in number of tomatoes produced. In Experiment Group 1 totally 19 tomatoes produced whereas 11 tomatoes produced in Experiment Group 2. And plants in the Control Group did not produce any.

Quantitative observations:

The color and the quality of the tomatoes were also taken in consideration during the experiment. There was not any data collected in control group as it did not produce any. Therefore only experiment groups will be compared with that data. The color of the tomatoes produced in Experiment Group 1 (See Photo 5 under Appendix 3) was red and the shape and the quality of the tomatoes were normal whereas tomatoes in Experiment Group 2 had a color of yellow and they were smaller. (See Photo 7 under Appendix 3) That poor quality occurs because of toxicity. When too much Fe accrues in plants it causes toxicity. Also the yellowish color of the leaves in Experiment Group 2 proves that.

Conclusion and Evaluation

The results support the hypothesis; the different amounts of Fe EDTA solutions are effective at increasing the growth rate of *Solanum lycopersicum* during soil less farming, that there is a change in the stem length (See Table 3) and the number of tomatoes (See Table 4). When the results have been analyzed carefully those differences can be seen easily. First of all the stem length must be taken in consideration on account of showing results related with the growth rate. The results of the stem lengths show that the different amounts of Fe EDTA changes the growth rate. As the amount of Fe EDTA increases there comes a clear difference at growth rate. However it must be discussed as it has a higher yield or not. When it is understood that Fe EDTA helps growing, it has to be get into a conclusion of why does the amount of Fe EDTA affects the growth rate. Fe EDTA includes Fe, which is one of the most important microelements for plants in photosynthesis. Fe does not used for producing chlorophyll however it has a more important role during chlorophyll synthesis.[19] It is used as cofactor for the enzymes that takes place at the chlorophyll synthesis.[20] Therefore it is impossible to produce chlorophyll or photosynthesis without Fe. When the stem lengths of the "Control Group", "Experiment Group 1" and "Experiment Group 2" compared, it is seen that the "Control Group" which does not include any Fe EDTA has value of approximately 15.51 ±0.1 cm growth lengths whereas the "Experiment Group 1" has a value of 25.81 ±0.1 cm and the "Experiment Group 2" has a value of 31.96 ±0.1 cm. Those results show that there is a significant difference between the groups, which is also supported by the t-test done on those results. On the other hand growth length does not mean having higher yield. In order to comment on yield, the number of the fruits and the quality of them must also be taken in

[19] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC426156/

[20] http://www.drtarsa.com/Eng/Nutrition.aspx?page=nutrients

consideration. The plants in the control group did not produce any tomato, which shows Fe EDTA is needed for producing fruits. When there is not sufficient Fe element, the plants cannot produce chlorophyll which prevents photosynthesis and directly prevents the growth and fruit production. However by using the little amount of Fe placed in perlite, they could grow a little but they could not produce any fruit. Control group did not produce any fruit whereas the "Experiment Group 1" produced 19 tomatoes. That shows us the amount of Fe affects the yield of fruit production. On the other hand it is not possible to claim that more Fe EDTA increases the yield. If we analyze the results of "Experiment Group 2" it is clear that they produced fewer tomatoes as they have produced just 11. Although it has more Fe EDTA added it has fewer yields, which mean excess amount of Fe EDTA can cause some problems such as toxicities. (See Photo 7) The toxicity observed clearly during the experiment, the color of the leaves and stem was yellowish; also the fruits were dark yellow instead of red. In a nutshell it can be concluded that; as the amount of Fe EDTA given to the plant increases the growth rate increases, however excess amount of Fe EDTA can cause some undesirable side effects such as toxicity.

The number of fruits used as data during the conclusion, however that data have some misleading. Experiment was done at our balcony the temperature and air conditions were optimum; however there was a huge problem in pollination. Although the plants had many flowers only a few of them could turn into fruit, because there were not any bees or other insects to help pollination. Moreover, the air circulation in our balcony was not sufficient which prevents pollination to occur by wind. Therefore the experiment can be done in another place which is close to an agricultural estate.

The content of the solution that given to the plants was prepared by me and the ratios were controlled carefully, however it was not possible to control the amount of microelements that

are already present in the perlite used. That gives an error, as perlite includes some of the microelements necessary for the plant growth plants used those microelements instead of using the controlled amount. That can be seen from the control group; although any Fe EDTA was not given to it the plants achieved to develop by using the Fe present in the perlite.

Another source of error comes from the seeds. Although all the seeds were taken from the same packet there can be genetic differences between the seeds which may cause differences in growth length and amount of fruits. Moreover as the seeds cannot be produced in perlite (because they cannot stay horizontally in perlite when they are germinating) they germinated in soil, in that process they could have absorb some microelements from soil and stock it.

As the global warming threatens the word and the fertile lands exhaust, people investigates new ways to find a solution to hunger. Soilless farming (hydroponics) is one of those solutions. During soilless farming Fe is one of the indispensable microelement and that paper investigated the effects of Fe during soilless farming. Despite the place error, the results can be seen as valid and according to the results and analyzes it is proven that the different amounts of Fe EDTA solutions are effective at increasing the growth rate of *Solanum lycopersicum* during soil less farming.

This paper focused on the effects of the amount of Fe element during soilless farming. This must be done with water instead of perlite in order to get higher yield as Prof. Rıfat Yalçın said, and a very large pot (such as 1-2 tones) must be used to balance the amount of microelements. On the other hand it is impossible to find a suitable place and materials to perform this investigation. After that investigation a scientific question can be asked, if the experiment was done in that case how would yield be affected? Further researches should be done on that topic.

Appendices

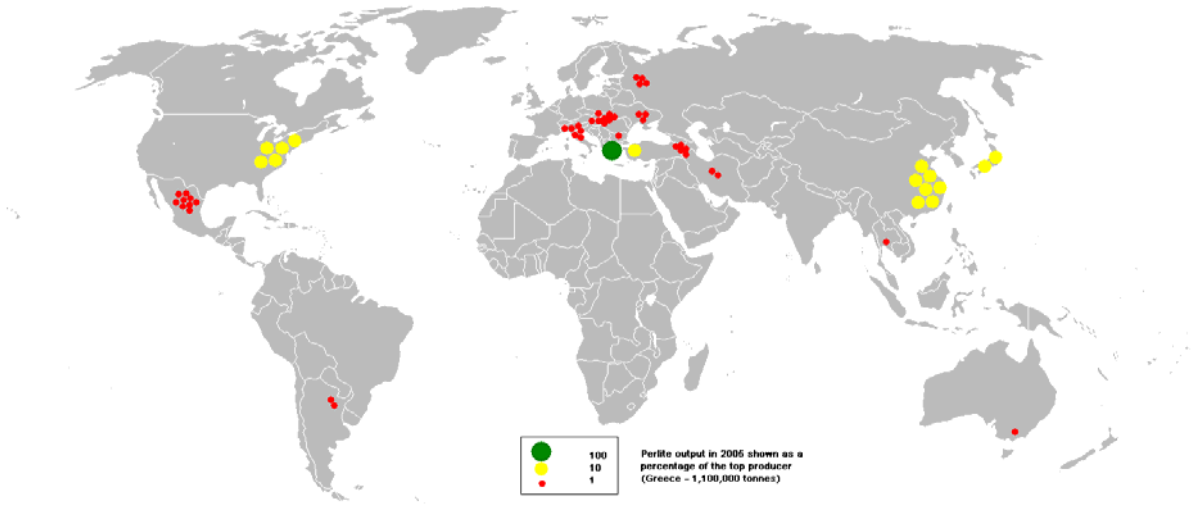
Appendix 1:

Chemicals	Needed for tomatoes mg per liter
$KNO_{3(s)}$	606.30±0.1 mg/L
$Ca\ (NO_3)_{2(s)}$	656.00 ±0.1mg/L
$MgSO_{4(s)}$	490.32 ±0.1mg/L
$NH_4H_2PO_{4(s)}$	115.10±0.1 mg/L
Fe EDTA$_{(s)}$	**2.00 ±0.1mg/L**
$H_3BO_{3(s)}$	2.86 ±0.1mg/L
$ZnSO_{4(s)}$	0.22 ±0.1mg/L
$CuSO_{4(s)}$	0.08 ±0.1mg/L

The amount of chemicals given to plants by water

Those ratios found by taking in consideration Prof. Rıfat Yalçın's advises. Those amounts must be added to perlite with water as they are the necessary amounts in order tomatoes to take microelements and chemicals needed for them.

Appendix 2:



The perlite production over world: Turkey is one of the countries which produce perlite.

Taken from: *http://en.wikipedia.org/wiki/Perlite*

Appendix 3:

Photo 1: The materials used for trickle irrigation system

Photo 2: The first phase of the experiment(germination)

Photo 3: Experiment Group 1

Photo 4: Experiment group 2 and Control Group

Photo 5: 2 samples of tomatoes from Experiment Group 1

Photo 6: 1 sample of tomato from Experiment Group 1

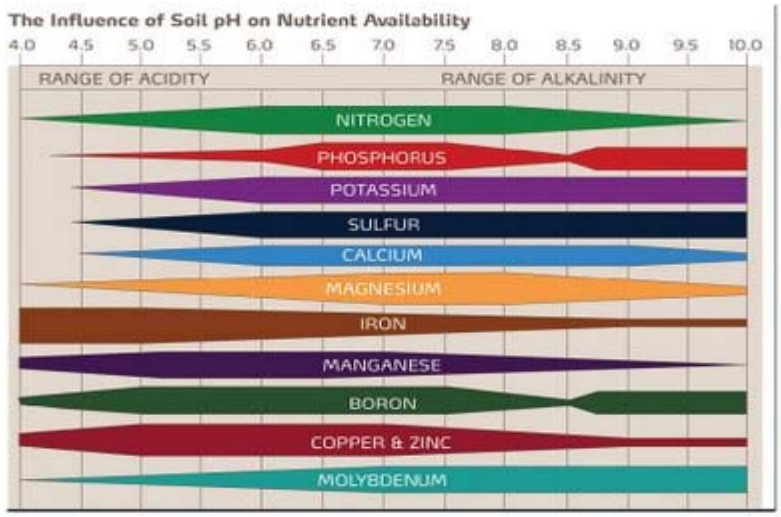
Photo 7: 1 sample of tomato from Experiment Group 2 (Toxicity can be seen from that photo)

Photo 8: Control Group which did not produce any tomato

Photo 9: 1 sample of tomato from Experiment Group 2

Photo 10: The cross section of one of the tomatoes produced in Experiment Group 2

Appendix 4:



The activity of different metals in different pH's:

Appendix 5:

Top Tomato Producers — 2007 (in tonnes)	
China	33 645 000
United States	11 500 000
Turkey	9 919 673
India	8 585 800
Egypt	7 550 000
World Total	**126 246 708**

Top Tomato Producers in 2007

Taken from: *http://en.wikipedia.org/wiki/Tomato*

*Source:*UN Food & Agriculture Organization *(FAO)*

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