TED ANKARA COLLEGE FOUNDATION HIGH SCHOOL

BIOLOGY EXTENDED ESSAY

Investigating the intraspecific competition for the water between the plants from the same genus and different species; *Capsicum frutescens* and *Capsicum annuum* under the same conditions

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OUTLINE

ABSTRACT

This experiment is about the competition among plants. Competition is the most common event that could be observed in the nature. All plants and animals are performing different kinds of competition and the results are causing the variety of some species on the some terrestrial parts of the world. Research question of the experiment is; "How does the intraspecific competition for the water between the plants from the same genus and different species; Capsicum frutescens and Capsicum annuum under the same conditions."

Plants were germinated and planted into pots for competition as experiment group and for single growth as control group. Both plants showed a growth but in different rates. Measurements were done every few days for a short period of time. Total time of the experiment was around 70 days and at the end Capsicum frutescens grew 16.9 cm and Capsicum annuum 17.9 cm for the experiment group. The difference was not as expected as when I started the experiment. The reason for that result is that both plants shared the resources present in the environment. Hypothesis was suggesting that the most common species will be the dominant one; however, there was not a dominant species on the experiment. Both plants were able to successfully grow on the experiment group.

I concluded that there is not a competition among those two plants depending on the results of my experiment. If the experiment was performed in more different conditions, the results would differ and more competition could be observed but for my experiment the competition was not observable.

INTRODUCTION

There is competition in plant kingdom just like animals. They are in need of air, foods and other organic and inorganic material. Even they are not capable of mobility like animals, they have their way to compete with each other. Their own way is not like chasing each other but it is like growing on top of each other to take advantage of the resource. Even they are not complex living creatures like human, and even they don't have a brain to control them, they can take advantage of each other naturally. This condition attracted me when I first saw it on Ecology lessons and left a question mark on my mind: "Plants do not have a brain to control them yet they can compete with each other, how is that possible?" So I decided to choose this topic as my biology extended essay topic.

Competition is defined as an interaction between individuals, brought about by a shared requirement for a resource, and leading to a reduction in the survivorship, growth and/or reproduction of at least some of the competing individuals' concerned[1]. Competition occurs naturally between living organisms which co-exist in the same environment[2] and there are types of competition. The competition type that was covered in this extended essay is "Intraspecific competition".

Intraspecific competition is the particular form of competition in which members of the same species compete with each other for the same resource in an ecosystem (e.g. food, light, nutrients, and space). This can be contrasted with interspecific competition, in which different species compete.[3]

There are several conditions for competition to occur in an environment. The most important of them is; there should be a limited source so that only one of the individuals gets benefit of it while the other one won't be able to use it. Since the demand of the individuals from the same species will be similar, they will compete with each other for the same resource and if there is not enough resource for both of them, one of them will fail to get the required resources while the other one acts so greedy to collect all the resource for itself. So, the amount of resources in an environment is the most important factor for intraspecific competition and so as my extended essay experiment.

There are several resources that plants can compete for; they can compete for water, minerals on soil, space to live, sunlight, fertilizer, etc… While the plants are competing with each other for a resource, which is water for my experiment, there are several observable physical changes occurring in the competing plants compared to the same plants that are growing alone. One of the plants in the experiment group is expected to grow shorter as

[1] http://www.montana.edu/wwwbi/staff/creel/bio303/Biol%20303%20plant%20competition.pdf
[2] http://mashable.com/follow/topics/competition/page/26082/
[3] http://en.wikipedia.org/wiki/Intraspecific_competition

height compared to the one in the controlled group of the same plant. Since I am doing this experiment with peppers I don't assume to observe that much of a growth like 1-2 meters but the difference in the height will be easily measurable. While one of the plants takes all the useful parts for itself, the other one will watch the growth of dominating species.

Those interesting facts made me to extend a study about intraspecific competition on plants and I chose pepper since it is easy for me to germinate, cultivate and observe. I have cultivated tomatoes a few years before I decided my experiment and they require similar care and conditions[4] to cultivate. Those plants need to be planted after all danger of frost is over and the weather is warm[5] to be grown properly and by the time I had to decide my plant, it was after winter, so peppers were a good choice for my extended essay experiment. I could easily cultivate them in the warm weather and also easily observe their competition.

At the end of the thinking process, my decision was made to study "Investigating the intraspecific competition between the plants from the same genus and different species; *Capsicum frutescens* and *Capsicum annuum* on the same environment."

[4] http://www.cosmicchile.com/xdpy/kb/growing-chile-peppers.html
[5] http://www.wvu.edu/~agexten/hortcult/homegard/peppers.htm

HYPOTHESIS

Same plants live in the same habitat and they use the same resources that are present in the environment. When two individuals from the same species are living together, they are not able to take advantage of the resources in the environment completely, so that one of the individuals will occupy the resources of the other one and at the end one of the plants will eliminate the other one from the environment and start using the resources only by for itself.

Capsicum annuum is the most common species of the pepper in the world[6][7][8] and it is not hard to say that, the common species will dominate over the uncommon one as they grow together. The resource that they will be fighting for will be water since for the growth of every plant; water is the most essential material. As I keep giving the constant amount of water to the plants, *Capsicum annuum* will use the water more efficiently and *Capsicum frutescens* will be dehydrated.

My hypothesis is that, as the time passes by and two plants begin to live together, one of the plants will dominate the other and as a result of the competition, one plant will not be able to grow like the other one and eventually die in the long term. I assume that *Capsicum annuum* will dominate *Capsicum frutescens*.

[6] https://en.wikibooks.org/wiki/Cookbook:Chiles
[7] http://www.livestrong.com/article/134005-types-capsicum/
[8] http://www.thechileman.org/guide_species.php

METHOD DEVELOPMENT AND PLANNING

I need a method that will make the process much easier for me to prove my hypothesis. I can not only grow the plants in the same pot like a random gardener. There are many details that needed to be kept constant in order to have a scientific experiment with correct values at the end. There are some points that are really important in the method of this experiment, including mainly the details with growing the plant.

First of all, I bought package of seeds of *Capsicum frutescens* and *Capsicum annuum* from the gardening part of the local supermarket and asked the employee there how to grow those plants. The information I get from that person as the basic information that I need for my experiment. Then I had to germinate those plants from their seeds in separate places. For this process, I preferred saucer, cotton lumps and tap water, which is healthy for humans as well as plants. After I set down the conditions for germination, which is a place receiving light and in room temperature[9], I waited till my seeds germinate. The cotton above the seeds kept them away from direct sunlight and made the environment more natural for germination.

After the seeds were germinated, their time to be planted had arrived. Both species of plants need to be planted in the same pot because I need them to compete with each other for a several source while one from each plant will be planted separately as the control group to observe the actual growth of the plants. On my containers there were big and small ones, the volume of the small ones are nearly as the half of the bigger ones. The reason for that is; the volumes of the containers had to be constant for my experiment, so, the twice of the volume of the small ones should give the volume of the bigger one. I searched containers that provide such situation and finally found them. The volume of the big container is 50x12x16 = 9600 cm3 so the volume of the smaller ones should be 4800 cm3. The actual volume of the smaller ones is πx132x9 = 4778.4 cm3 which is so close to the number that I need.

The volume of the containers was really important since I had to keep the growing space constant. I needed to calculate the volumes before beginning the experiment. If the sizes of the pots are too small, there might not even be enough room for them to grow and my experiment would fail. After I planted them inside soil, I placed them in my balcony to provide the best possible environment for their growth since it was warm outside[10], *Capsicum* genus likes heat and summer was the exact condition for those plants to grow. I could be doing indoor growth for those plants but it will not be the best environment for them to grow since they cannot get as much oxygen as they do when they are outside. Growing a plant is not an easy process; it is like taking care of an individual as I found out. They are needed to be

[9] http://www.kew.org/science-research-data/kew-in-depth/msbp/seed-banking-technology/environmental-conditions-seed-germination/index.htm
[10] http://www.cosmicchile.com/xdpy/kb/growing-chile-peppers.html

watered from time to time and even twice a day if it is too hot outside[11] and if you want them to grow wilder; you even need to communicate with them. All in all, good words don't harm anybody or anything.

I found the best way to grow plants from online and by asking the employer at the place where I bought the seeds. I watched some videos about how to plant and take care of the seeds and I also took my mother's help since she has been cultivating plants for years in our garden. By time I planted those germinated seeds into the soil, my experiment had officially begun.

While everything was going just the way they should be, we went on one week vacation and by the time we got back, we saw that my balcony was invaded by birds, there was a bird's nest right in front of my peppers. I researched the time for the birds to leave my balcony and found that time is too much and I decided to repeat all the process. I re-germinated my plants and re-planted them in soil but this time, to avoid such an event, I placed them inside the house. It may not be the best environment for my plants to grow but it is certainly a better way to keep them safe.

There will be two groups of plants, one experiment group and one control group. In the experiment group one from each plant will be growing together in a bigger pot and they will the ones competing with each other. In the control group one from each plant will grow separately to observe the actual growth of the plants without any competition. I gave the same amount of water to each container, big and small to observe the competition more clearly. For example if 50mL of water is required for one plant to grow separately on its own, when we keep the amount of water constant but add another plant from different species near that plant, one of the plants will use that water to grow while other one gets only a few amount of water. This was the thing that I tried to perform on my experiment. On my experiment I gave 500 mL of water on every container.

It was an unpleasant job to work with soil on the planting process. The soil that I used was turf with humus and it got a pH of 6-7 (written on the package). Additionally, while planting the plants, the distance between seeds was important, to keep that distance, I planted them in the equal distance between the sides of the containers. In every container there were enough space for each plant to grow separately from each other, I can tell this because I have seen the final conditions of peppers and compared to those plants, the space was enough for my seeds.

The observation process will last until the end of the experiment. The experiment will end when there are some peppers or flowers on my plants. Until that time I will keep my eye on them and write my readings in a piece of paper.

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11 http://www.bbc.co.uk/gardening/basics/techniques/growfruitandveg_growing_aubergines_chillies_peppers1.shtml

There was a point that I went through a lot of conflict before I start measuring the heights, which is; fertilizers. To grow my plants faster and healthier, using fertilizers seems to be good but it will not make the experiment process natural. So I decided not to use them but if I had used them, there will also be some kind of competition for the materials inside fertilizers which was good for my experiment but since the environment was enough for plants to grow, it is always better to keep things natural.

I decided to observe the height of plants because it is the most obvious quantitative data. I could also count the number of leaves or the peppers at the end but those results can be tricky since it changes from plant to plant. Even though they are similar plants, one of them can have more leaves as its nature rather than the other. I am planning to use those data as the secondary observations to support my results at the end of the experiment.

I did the experiment only once but with 4 plants so that my results would be more accurate.

MATERIALS

8 saucers (12 cm of diameter)

20 kg of turf with humus

Cotton (10 grams)

Water

Package of Vilmorin brand *Capsicum frutescens* and *Capsicum annuum* seeds

One big container (50 cm length, 12 cm depth and 17 cm width)

Two small cylindrical containers (13 cm of diameter and 9 cm of depth)

Tape measure

Ruler

Paper

Marker

Pencil

Photo machine

Graduated cylinder (500mL)

METHOD

PART 1: Germination

All of the eight saucers were filled with 5 grams of cotton which is already wet and seeds planted between two layers of cottons. In each saucer there were 5 seeds to make sure that there will be more germinated seeds for me to use if something goes wrong while planting. The thickness of cotton layer was not more than 3 mm. I mark each saucer not to mix which seeds were in them. In each saucer there was only one type of seed. They were put indoors where they can receive light and I watered them with 10-20mL of water when they went dry. This germination process took nearly a week and when they were about 2-3 cm tall as germinated seeds, I was ready to plant them into soil in bigger container than saucers.

PART 2: Planting

I placed soil inside each container one by one. Big container required 10 kg of soil to fill and smaller ones required 5kg per each to fill. First I watered the empty soil to moisturize with a 1L of water on the big and 500mL of water on smaller ones. I measured the amount of water by the graduated cylinder and since it was capable of measuring only 500mL I had to make 2 runs for the bigger container.

For the experiment group germinated seeds of *Capsicum frutescens* and *Capsicum annuum* were planted in the big container. Two seeds from each individual; as a total number of 4 seeds were planted in the big one with 50 cm length, 12 cm depth and 17 cm width. For the control group in one small container with 13 cm of diameter and 9 cm of depth two seeds from *Capsicum frutescens* and in other small container two seeds from *Capsicum annuum* were planted.

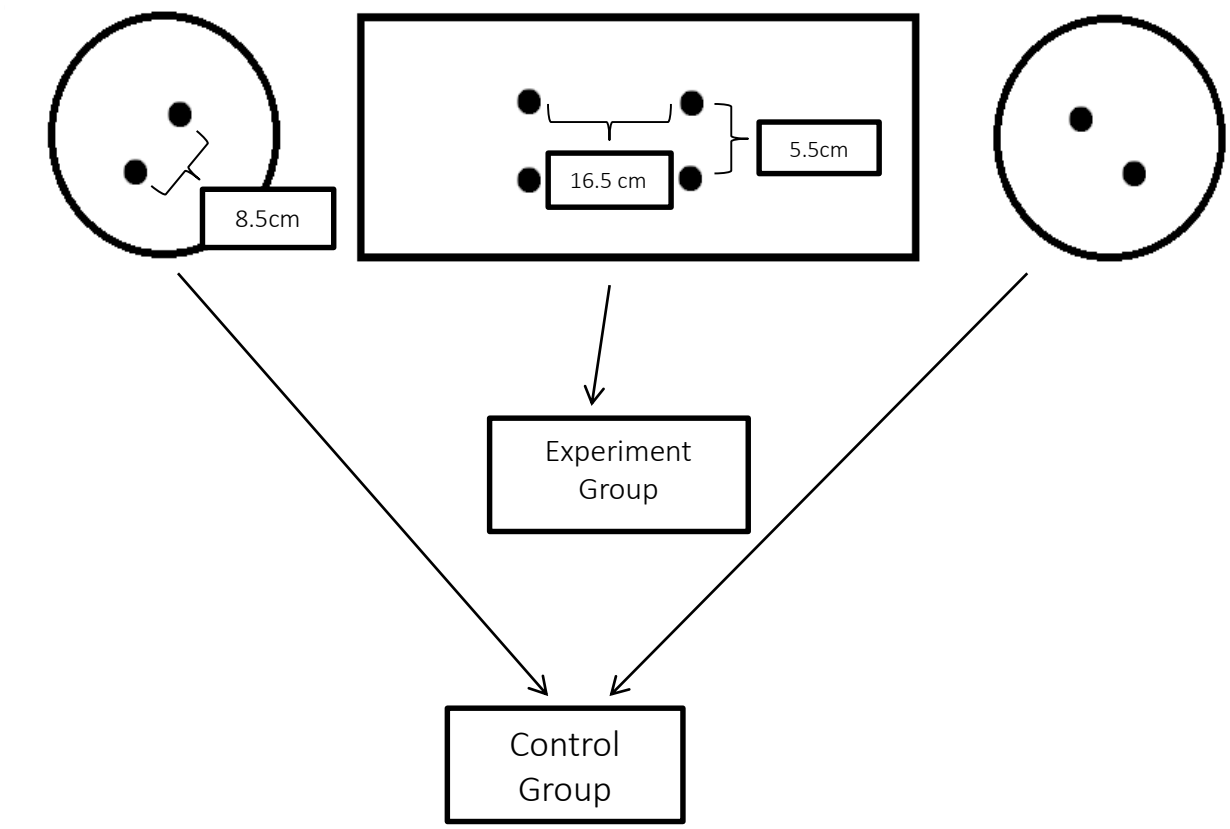


Figure 1: Top view of the beginning of my experiment

PART 3: Growth

The containers were placed near the window and to make them all in the same height, 3 cm of paper was placed under the small containers; this would make them receive the same light from the window. They were all standing next to each other so the temperature factor was self-stabilized on my experiment. Those waters do not require extreme amount of water so I watered them for 500mL of water almost every week. Since I will be observing the effect of water on the growth of the plants, I gave the same amount of water on each of the containers, big and small ones. I watered the plants at the same time and tried to prevent soil from being dry.

Measurements of the heights of the plants were done each two weeks and recorded in a piece of paper to keep the rate of growth constant and also photos have been taken while measuring the heights.

RESULTS AND DATA ANALYSIS

	Type of the plant	Code of the plant	Heights of the plants (± 0.5 cm) on dates written (dd/mm/yy)				
			10.06.2012	25.06.2012	14.07.2012	30.07.2012	20.08.2012
Experiment Group	C. Fru	1	3.4	7.3	14.3	18.4	20.3
		2	2.9	6.9	12.9	17.6	19.8
	C. Ann	1	3.0	7.1	14.6	19.3	20.7
		2	3.2	7.2	13.5	18.5	21.2
Control Group	C. Fru	1	2.8	7.8	16.8	25.6	28.7
		2	3.1	7.6	15.6	27.8	31.2
	C. Ann	1	3.4	7.9	17.2	29.3	33.1
		2	3.3	7.4	19.1	30.2	35.3

Table 1; the data collected during the experiment by the measurements of the heights of *Capsicum frutescens* and *Capsicum annuum* on specific day intervals for both experiment and control groups' plants

Time	Type of the plant	Code of the plant	Change in the height of the plant (Δh ± 0.5 cm) EXPERIMENT GROUP	Change in the height of the plant (Δh ± 0.5 cm) CONTROL GROUP
10.06.2012 - 25.06 .2012 (15 days)	C. Fru	1	3.9	4.0
		2	4.0	4.4
	C. Ann	1	4.1	4.5
		2	4.0	4.1
25.06.2012 - 14.07.2012 (19 days)	C. Fru	1	7.0	9.0
		2	6.0	8.0
	C. Ann	1	7.5	9.3
		2	6.3	11.7
14.07.2012 - 30.07.2012 (16 days)	C. Fru	1	4.1	8.8
		2	4.7	12.2
	C. Ann	1	4.7	12.1
		2	5.0	11.1
30.07.2012 - 20.08.2012 (22 days)	C. Fru	1	1.9	3.1
		2	2.2	3.4
	C. Ann	1	1.4	3.8
		2	2.7	5.1

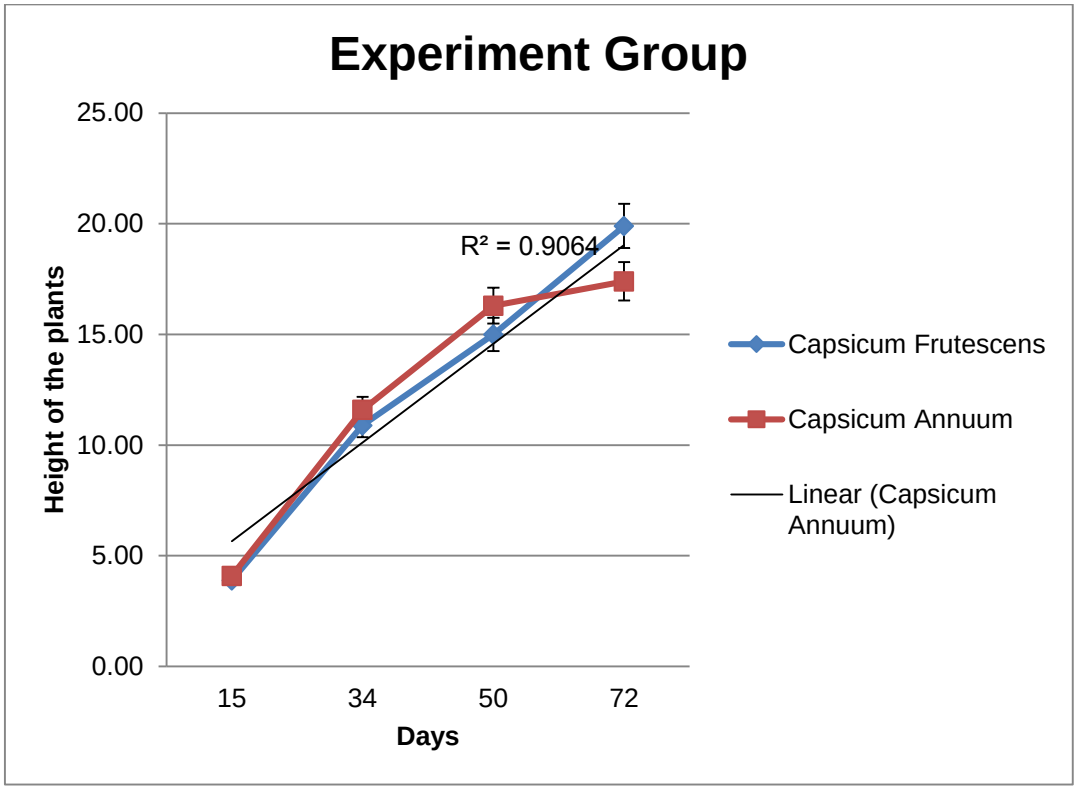
Table 2; the change in the heights of the plants for experiment and control group

	Type of the plant	Code of the plant	Total change in the heights of the plants (Δh ± 0.5 cm)
Experiment Group	C.Fru	1	16.9
		2	16.9
	C. Ann	1	17.7
		2	18.0
Control Group	C.Fru	1	25.9
		2	28.1
	C. Ann	1	29.7
		2	32.0

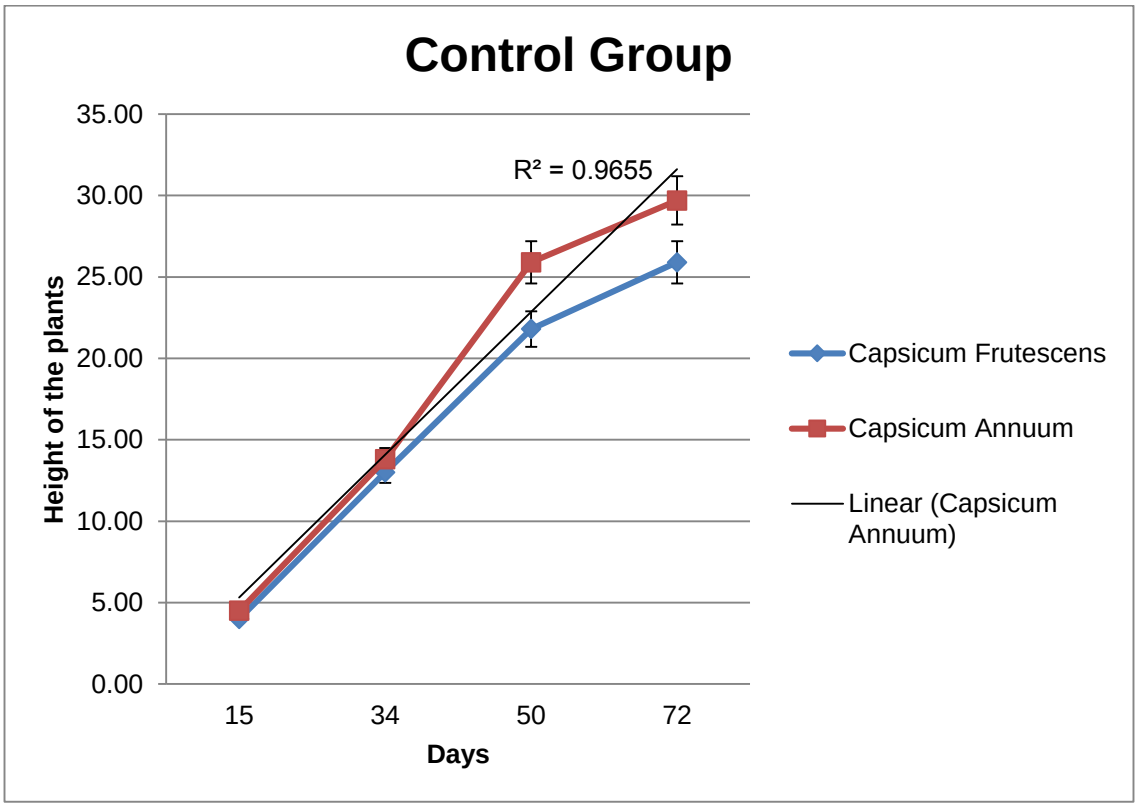
Table 4; total change in the heights of plants at the end of the experiment of 72 days

	Type of the plant	Average change in the height (± 0.5 cm)
Experiment Group	C.Fru	16.9
	C. Ann	17.9
Control Group	C.Fru	27.0
	C. Ann	30.9

Table 5; average change in the heights of the plants at the end of the experiment of 72 days



Graph 1; the growth rate of the plants in the experiment group during 72 days period



Graph 2; the growth rate of the plants in the control group during 72 days period

STATISTICAL ANALYSIS

T-Test: Paired Two Sample for Means performed to compare the two sets of results from *C. Fru* and *C. Ann* to see whether they can be considered to be the same.

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t-Test: Paired Two Sample for Means
(EXPERIMENT GROUP)

	C. Fru	*C. Ann*
Mean	16,9	17,85
Variance	0	0,045
Observations	2	2
Pearson Correlation	#DIV/0!	
Hypothesized Mean Difference	0	
df	1	
t Stat	-6,3333333	
P(T<=t) one-tail	0,04984793	
t Critical one-tail	6,31375151	
P(T<=t) two-tail	0,09969585	
t Critical two-tail	12,7062047	

P for two-tail is greater than 0.05 ($p > 0.05$) so it can be assumed that there is no significant difference between the results of *C. Fru* and *C. Ann* when they grow together.

EVALUATION

The research question of my experiment is; "How does the growth rate of different plants from same genus but different species differ when they compete for water as resource."

My results that I gathered from the experiment do not support my hypothesis that *Capsicum Annuum* will be the dominant species and it will overcome the other plant while they were growing together. The p value being 0.099 also indicated that there is no significant difference between two sets of data and the variation between the results can be due to chance.

Both plants were able to grow together without any effect of domination and on the long term of both plants, they were able to produce flowers. During my experiment, no sign of competition effect was observed among two different species. The only result that I could gather from the experiment was that; when there were an increased number of individuals growing in the constant amount of space but same amount of water with a less number of individuals, there will be a decrease in the growth of the individuals as the number increases. The competition did not occur among my plants because they were able to manage the water and share it equally with each other, so that both species and all plants were able to grow but the growth rate would be different. It is possible to state that both species and all plants were affected by the competition but this affect was nearly equal to each other, so there were no dominant species in my experiment. Their niches were overlapping[12], they both required water to maintain their development but they were able manage using the water efficiently among each other.

On the graph which shows the growth of experiment group plants (Graph 1) there is no sign of competition to observe, they both live and grow while interacting with each other, if the time was increased, there may be a sign of competition to observe since there is a decrease in the rate of *Capsicum Annuum* at the end but during the time of my experiment, no competition as observable. But when the growth rate of both plants on the experiment group were compared to the growth rate of the ones in the control group (Graph 2), it is obvious that there is a height difference in the both species at the end of their growth. The reason for that is the cooperation of the plants for the same resource; water. They were able to use if efficiently among each other to make it enough for growth but it was not enough to grow like the ones in control group.

[12] *Biology, A guide to the natural world* by David Krogh

The r^2-value on the Graphs 1 and 2 are both close to 1 with values of 0.9064 and 0.9655. It is based on linear regression. So the relation between time and the height of the plants are significantly relevant with each other. The r^2-value on the Graph 2 is closer to 1 with value of 0.9655 and this shows that when the plants do not compete with each other the relation between the time and their height is more significant.

The difference in the growth of the plants due to the sharing of the resource is visible. The ones sharing the resource were able to grow less than the ones who don't require sharing. The final data from the experiment on the Table 5 is also a proof that when they were growing together they were growing less than they should be due to their competition. The failure of the experiment is that there wasn't an observable dominant species on contrary to my hypothesis and expectations.

Even I tried to minimize the errors; there were still some errors that had minor effects on the experiment and can't be eliminated by repeating the experiment. Major one of them is the parallax error, even I tried to measure the heights with a right angle to the surface; there still was an effect which I tried to cover up by the uncertainty of ±1. The soil was not totally flat due to its nature and while measuring it caused some problems that can be ignored. The seeds may not have exactly the same genetic properties which are hard to prevent. The plants were not covered with anything so they were open for an assault of any kind of insect.

All of the research was enough for me to have the knowledge about the competition among plants and design my experiment in the best ways to observe that competition. Even there were no previous experiments done on my exact subject, the information that I was able to reach was quite sufficient for me to decide a hypothesis and test it.

It is not hard to say that the setup of the experiment was appropriate when we consider the results but if the time could be longer, the results may have a little bit difference than my current experiment. The time did not allow me to observe an obvious example of a dominant species but it showed me how plants share the resources that are present to survive.

With errors, I received a result, which is not related with my hypothesis, but without errors it is not quite possible to state that results would be different.

CONCLUSION

At the end of the experiment my result was that; when *Capsicum frutescens* and *Capsicum annuum* are allowed to grow together when light intensity, pH, space to grow and time of growth is constant, they share the water that is present in the environment for the growth of both species. There is not a dominant species among those two plants and they grow less than their natural growth rate when they are growing together.

To develop the method, adding more samples of plants to compete on different cups can be beneficial. Since there was not a dominant species for me to observe, it can be the effect of the plants that I chose. As the number of plants to compete increase, there may be a more obvious competition occurring during the experimental process.

To develop the data collection process, the time could be increased. As the time increases, the competition could get more obvious than the one I observed. Even I saw peppers on both of the plants at the end; more time may have led them to a competition among the space to grow, which was not the variable that I was checking.

A further question can be directed as "What would be the result if the experiment was performed on animals rather than plants to observe the competition among animals?"[13] There were experiments performed on this topic and for a further research, I would like to perform one of those.

There had been experiments done on the interspecific competition subject on plants and there were many different results obtained; some of them include a dominant species while some of them don't. For further investigation on the plants field can be "the other factors effecting the interspecific competition among plants"[14] or most probably the same experiment with different plants and species can be performed.

At the end of this essay, the interspecific competition effect of the plants was observed and the results were gathered. The whole process was really reliable and scientific for an extended essay. The competition is a part of life and I was able to observe the model of competition in the nature on this whole experimental process.

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[13] Experiment on Grasshoppers:
http://www.nd.edu/~underc/east/education/documents/JJeffers2003ExperimentonInterspecificCompetitionBetweenTwoSpeciesofGrasshoppersMelanoplusfla.pdf

[14] http://www.jstor.org/discover/10.2307/2461233?uid=3739192&uid=2129&uid=2&uid=70&uid=4&sid=21101550190747

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